Characterization and assessment of distribution schemes for food supply and distribution systems considering environmentally sensitive demand

Laura Vanessa Palacios Arguello

N° d'ordre NNT : 2019LYSEM018

THESE de DOCTORAT DE L'UNIVERSITE DE LYON
opérée au sein de
L'Ecole des Mines de Saint-Etienne

Ecole Doctorale N° 488
Sciences, Ingénierie, Santé

Spécialité de doctorat : Génie Industriel
Discipline : Logistique

Soutenue publiquement le 17/07/2019, par:

Laura Palacios-Argüello

Characterization and assessment of distribution schemes for food supply and distribution systems considering environmentally sensitive demand

Caractérisation et évaluation des schémas de distribution pour les systèmes d'approvisionnement et de distribution alimentaire en tenant compte de la demande sensible à l'environnement

Devant le jury composé de :

Ballot, Eric	*Professeur Mines Paristech, France*	*Rapporteur*
Pinto, Roberto	*Professeur University of Bergamo, Italie*	*Rapporteur*
Sanchéz-Díaz, Ivan	*Enseignant-Chercheur Chalmers University of Technology, Suède*	*Rapporteur*
Frein, Yannick	*Professeur Université Grenoble Alpes, France*	*Examinateur*
Morganti, Eleonora	*Maître de Conférences, University of Leeds, Royaume-Uni*	*Examinatrice*
Gondran, Natacha	*Maître Assistant HDR, Mines Saint-Etienne, France*	*Co-directrice*
González-Feliu, Jesús	*Maître Assistant HDR, Mines Saint-Etienne, France*	*Co-directeur*

Spécialités doctorales	Responsables :	Spécialités doctorales	Responsables
SCIENCES ET GENIE DES MATERIAUX	K. Wolski Directeur de recherche	MATHEMATIQUES APPLIQUEES	O. Roustant, Maître-assistant
MECANIQUE ET INGENIERIE	S. Drapier, professeur	INFORMATIQUE	O. Boissier, Professeur
GENIE DES PROCEDES	F. Gruy, Maître de recherche	SCIENCES DES IMAGES ET DES FORMES	JC. Pinoli, Professeur
SCIENCES DE LA TERRE	B. Guy, Directeur de recherche	GENIE INDUSTRIEL	N. Absi, Maitre de recherche
SCIENCES ET GENIE DE L'ENVIRONNEMENT	D. Graillot, Directeur de recherche	MICROELECTRONIQUE	Ph. Lalevée, Professeur

EMSE : Enseignants-chercheurs et chercheurs autorisés à diriger des thèses de doctorat (titulaires d'un doctorat d'Etat ou d'une HDR)

ABSI	Nabil	MR	Génie industriel	CMP
AUGUSTO	Vincent	CR	Image, Vision, Signal	CIS
AVRIL	Stéphane	PR2	Mécanique et ingénierie	CIS
BADEL	Pierre	MA(MDC)	Mécanique et ingénierie	CIS
BALBO	Flavien	PR2	Informatique	FAYOL
BASSEREAU	Jean-François	PR	Sciences et génie des matériaux	SMS
BATTON-HUBERT	Mireille	PR2	Sciences et génie de l'environnement	FAYOL
BEIGBEDER	Michel	MA(MDC)	Informatique	FAYOL
BLAYAC	Sylvain	MA(MDC)	Microélectronique	CMP
BOISSIER	Olivier	PR1	Informatique	FAYOL
BONNEFOY	Olivier	PR	Génie des Procédés	SPIN
BORBELY	Andras	MR(DR2)	Sciences et génie des matériaux	SMS
BOUCHER	Xavier	PR2	Génie Industriel	FAYOL
BRODHAG	Christian	DR	Sciences et génie de l'environnement	FAYOL
BRUCHON	Julien	MA(MDC)	Mécanique et ingénierie	SMS
CAMEIRAO	Ana	MA(MDC)	Génie des Procédés	SPIN
CHRISTIEN	Frédéric	PR	Science et génie des matériaux	SMS
DAUZERE-PERES	Stéphane	PR1	Génie Industriel	CMP
DEBAYLE	Johan	MR	Sciences des Images et des Formes	SPIN
DEGEORGE	Jean-Michel	MA(MDC)	Génie industriel	Fayol
DELAFOSSE	David	PR0	Sciences et génie des matériaux	SMS
DELORME	Xavier	MA(MDC)	Génie industriel	FAYOL
DESRAYAUD	Christophe	PR1	Mécanique et ingénierie	SMS
DJENIZIAN	Thierry	PR	Science et génie des matériaux	CMP
BERGER-DOUCE	Sandrine	PR1	Sciences de gestion	FAYOL
DRAPIER	Sylvain	PR1	Mécanique et ingénierie	SMS
DUTERTRE	Jean-Max	MA(MDC)		CMP
EL MRABET	Nadia	MA(MDC)		CMP
FAUCHEU	Jenny	MA(MDC)	Sciences et génie des matériaux	SMS
FAVERGEON	Loïc	CR	Génie des Procédés	SPIN
FEILLET	Dominique	PR1	Génie Industriel	CMP
FOREST	Valérie	MA(MDC)	Génie des Procédés	CIS
FRACZKIEWICZ	Anna	DR	Sciences et génie des matériaux	SMS
GARCIA	Daniel	MR(DR2)	Sciences de la Terre	SPIN
GAVET	Yann	MA(MDC)	Sciences des Images et des Formes	SPIN
GERINGER	Jean	MA(MDC)	Sciences et génie des matériaux	CIS
GOEURIOT	Dominique	DR	Sciences et génie des matériaux	SMS
GONDRAN	Natacha	MA(MDC)	Sciences et génie de l'environnement	FAYOL
GONZALEZ FELIU	Jesus	MA(MDC)	Sciences économiques	FAYOL
GRAILLOT	Didier	DR	Sciences et génie de l'environnement	SPIN
GROSSEAU	Philippe	DR	Génie des Procédés	SPIN
GRUY	Frédéric	PR1	Génie des Procédés	SPIN
HAN	Woo-Suck	MR	Mécanique et ingénierie	SMS
HERRI	Jean Michel	PR1	Génie des Procédés	SPIN
KERMOUCHE	Guillaume	PR2	Mécanique et Ingénierie	SMS
KLOCKER	Helmut	DR	Sciences et génie des matériaux	SMS
LAFOREST	Valérie	MR(DR2)	Sciences et génie de l'environnement	FAYOL
LERICHE	Rodolphe	CR	Mécanique et ingénierie	FAYOL
MALLIARAS	Georges	PR1	Microélectronique	CMP
MOLIMARD	Jérôme	PR2	Mécanique et ingénierie	CIS
MOUTTE	Jacques	CR	Génie des Procédés	SPIN
NAVARRO	Laurent	CR		CIS
NEUBERT	Gilles			FAYOL
NIKOLOVSKI	Jean-Pierre	Ingénieur de recherche	Mécanique et ingénierie	CMP
NORTIER	Patrice	PR1	Génie des Procédés	SPIN
O CONNOR	Rodney Philip	MA(MDC)	Microélectronique	CMP
PICARD	Gauthier	MA(MDC)	Informatique	FAYOL
PINOLI	Jean Charles	PR0	Sciences des Images et des Formes	SPIN
POURCHEZ	Jérémy	MR	Génie des Procédés	CIS
ROUSSY	Agnès	MA(MDC)	Microélectronique	CMP
ROUSTANT	Olivier	MA(MDC)	Mathématiques appliquées	FAYOL
SANAUR	Sébastien	MA(MDC)	Microélectronique	CMP
SERRIS	Eric	IRD		FAYOL
STOLARZ	Jacques	CR	Sciences et génie des matériaux	SMS
TRIA	Assia	Ingénieur de recherche	Microélectronique	CMP
VALDIVIESO	François	PR2	Sciences et génie des matériaux	SMS
VIRICELLE	Jean Paul	DR	Génie des Procédés	SPIN
WOLSKI	Krzystof	DR	Sciences et génie des matériaux	SMS
XIE	Xiaolan	PR0	Génie industriel	CIS
YUGMA	Gallian	CR	Génie industriel	CMP

Mise à jour : 30/08/2018

Supervisors

Natacha Gondran, Mines Saint-Étienne, France
Jesús González-Feliu, Mines Saint-Étienne, France

Jury

Yannick Frein, Université Grenoble Alpes, France
Eric Ballot, Mines Paristech, France
Roberto Pinto, University of Bergamo, Italy
Ivan Sanchéz-Díaz, Chalmers University, Sweden
Eleonora Morganti, University of Leeds, UK

Opponent

Laura Palacios-Argüello

Contact information

Department of Environmental & Organisation Engineering
Institut Fayol, Mines Saint-Étienne
158 cours Fauriel, F-42023 Saint-Étienne cedex 2, France

Email address: webmaster@emse.fr
URL: https://www.mines-stetienne.fr/
Telephone: +33 (0)4 77 42 01 23
Fax: +33 (0)4 77 42 00 00

To Julián, thank you for all your love and support ...

France, July 2019
Laura Palacios-Argüello

Acknowledgements

Many people have contributed to making this thesis possible. To all of you, I would like to express my deepest gratitude.

First, I would like to thank the members of the jury for the valuable inputs and reflections on my work. I also would like to thank all the companies who helped me to understand the school catering system, indeed, this research would never have been possible without their invaluable cooperation. Especially, I would like to thank Bio A Pro, the first Food Hub with I had a contact and who share with me the most useful contacts for this work.

Then, I would like to thank Natacha and Jesús for their guidance and for providing me with the necessary tools for conducting and completing this thesis.

I am very grateful to Jesús, who was the first on trusting in my work and who allowed starting a PhD at Ecole de Mines. Jesús, thank you for the endless discussions and for introducing me to the logistics community.

I would also like to thank Natacha, who made it possible for me to continue my PhD in here and who agreed to co-advise my work even after the 6 months I started. Natacha, thank you for your advice and for introducing me to the conscious of environmental care.

I am very grateful to Iván for our useful discussions and the good time spent in Sweden. Ivan, thank you because you have been always very generous with your time and ideas.

I would like to thank all my colleagues on the third floor, those who shared pleasant moments during the coffee break, especially to Omar. I would like to dedicate a special thanks to Fabien who helped me with Annona by integrating my case studies, for our interesting discussions and the pleasant working environment.

I would like to thank my friends, Safia, Martha and Andrés who were always there: Safia, thank you for being there every time that I need, your smile, your positive comments, your happiness and of course for making me laugh every day!. Martica, you were unconditional, especially during the difficult times of the PhD, thank you for every coffe and our useful discussions about the PhD. Andrés, thank you for being the best of the friends, for our very useful discussions on the right way to make a PhD, and defiantly I owe much gratitude to you for helping me to improve my technical skills during the PhD.

I am truly grateful to my family that has supported me in this thesis process: Mom, dad, karenza, aunts, uncles, cousins.. thanks for your encouragement, confidence, love and everything! You have been supporting me in all my choices! Mom and Karenza, thank you for the support you have given me during my many years of study. Nico, thank you for the time you spent reading this thesis and for your helpful comments that helped me improve it.

Julián, this would not have been possible without you, and I want to thank you for your constant support over these years, for patiently listening to me as I blew off steam, for always boosting my self-confidence, for helping me to conceive my thesis from the broader perspective of life, and for being the best part of our team with Ecko! Both of you are the sunshine of my life and make me cherish every passing moment.

France, July 2019
Laura Palacios-Argüello

Abstract

This thesis addresses the research question of how demand requirements for eco-responsible and local products may impact the food supply distribution configuration. In other words, how to configure urban food systems to satisfy a demand for eco-responsible food products. Therefore, the purpose of this research is to explore how to estimate the relationship between a demand for eco-responsible and food distribution configuration considering economic and environmental issues.

The thesis is a compilation of three phases:

- Eco-responsible food demand: It seeks to identify the product's environmental quality criteria that impact product demand and how these demand's characteristics can be used to describe the requirements of logistic schemes for sustainable distribution.
- Food supply chain configuration: Considering these new requirements, this phase aims to describe the food supply chain strategies that achieve a sustainable food distribution addressed in the literature, and to analyse how these strategies identified impact logistic decisions in the supply chain.
- Food supply chain assessment: It attempts to analyse the estimation of economic and environmental indicators that may represent the impacts generated in the configuration of the different food distribution schemes proposed.

The results highlight a framework proposal, aiming to understand how changes in a current food distribution system can be identified and quantified (in a logic of before-after scenario assessment). This framework includes: (i) Logistic decisions to be considered in the distribution system at strategic and tactical level. (ii) Food system characterization to define an initial situation (stakeholders, demand and supply characterization), and the demand and supply estimation; (iii) Scenario construction to analyse scenarios to be tested; and (iv) Scenario assessment to identify and assess economic and environmental impacts of the food distribution system, including tests and expert feedback to validate the scenarios proposed.

General Terms:
Food supply chains, eco-responsible demand, demand models, supply models, urban food distribution

Additional Key Words and Phrases:
Organic and local product, Institutional catering

Résumé

Cette thèse questionne la façon dont les exigences de la demande de produits écoresponsables peuvent influencer la configuration de la distribution de l'approvisionnement alimentaire. En d'autres termes, elle interroge la configuration des systèmes alimentaires urbains pour satisfaire une demande de produits alimentaires écoresponsables. Par conséquent, son objectif est d'explorer comment estimer la relation entre une demande écoresponsable et une configuration de distribution alimentaire en tenant compte des enjeux économiques et environnementaux.

La thèse compile trois phases:

- Définition d'une demande en produits agro-alimentaire écoresponsables: identifier les critères de qualité environnementale du produit qui ont un impact sur sa demande et comment les caractéristiques de cette demande peuvent être utilisées pour décrire les exigences des systèmes logistiques pour une distribution durable.
- Configuration de la chaîne d'approvisionnement alimentaire: compte tenu de ces nouvelles exigences, cette phase vise à décrire, à partir de la littérature, les stratégies de la chaîne d'approvisionnement alimentaire qui permettent d'atteindre une distribution durable, et analyser l'impact de ces stratégies sur les décisions logistiques dans la chaîne d'approvisionnement.
- Évaluation de la chaîne d'approvisionnement alimentaire: Identifier et construire des indicateurs économiques et environnementaux que représentent les impacts générés dans la configuration des systèmes de distribution alimentaire proposés.

Les résultats permettent de formuler une proposition de cadre métodologique afin d'identifier et quantifier les changements dans le système actuel de distribution alimentaire (dans une logique d'évaluation de scénario avant-après). Ce cadre comprend : i) les décisions logistiques à prendre en compte dans le système de distribution aux niveaux stratégique et tactique. ii) la caractérisation du système alimentaire pour définir une situation initiale (parties prenantes, caractérisation de l'offre et de la demande) et l'estimation de l'offre et de la demande ; iii) l'élaboration de scénarios pour réaliser des tests ; et iv) l'évaluation de scénarios pour identifier et évaluer les impacts économiques et environnementaux du système de distribution alimentaire.

Mots clefs: Chaînes d'approvisionnement alimentaire, Demande écoresponsable, Distribution alimentaire urbaine, Produits biologiques et locaux, Restauration collective, Impacts économiques et environnementaux.

Table des matières

Introduction

La part croissante de la population qui s'installe en milieu urbain a créé de nombreux défis pour les autorités municipales et les opérateurs logistiques, notamment en ce qui concerne la circulation, la qualité de vie et l'utilisation des sols. L'un des défis les plus importants consiste à nourrir la population urbaine de manière efficace et au bon moment, ce qui a plusieurs implications en termes de durabilité environnementale, d'équité sociale et de développement économique. En conséquence, les villes ont besoin d'une plus grande quantité de nourriture et d'un meilleur transport de marchandises pour la livrer, d'où la nécessité émergente de promouvoir de nouvelles politiques en matière de transport urbain de marchandises et de distribution alimentaire (Morganti, 2011).

L'objectif de parvenir à une société durable a suscité un intérêt accru chez les consommateurs, qui deviennent plus conscients de l'origine des denrées alimentaires, de la manière dont elles sont produites, transformées et distribuées, devenant ainsi des consommateurs plus exigeants envers des critères environnementaux à remplir par les produits qu'ils consomment.

Par ailleurs, les décideurs publics et privés se sont également intéressés à la durabilité des chaînes d'approvisionnement alimentaire (Nicholson et al., 2011). En effet, plusieurs villes ont commencé à réfléchir à la manière d'améliorer leurs systèmes d'approvisionnement locaux en mettant en place des systèmes logistiques urbains permettant d'améliorer l'approvisionnement par des producteurs de proximité .

De plus en plus de municipalités s'intéressent à l'introduction de produits biologiques et locaux dans le menu des repas des cantines afin d'améliorer la qualité nutritionnelle et la santé des enfants (Izumi et al., 2010; Lessirard et al., 2017; Smith et al., 2016). La contrainte économique impose alors de développer un système efficace pour la distribution des repas scolaires afin de garantir une distribution efficace des repas, tant en termes de temps que de qualité (Severson and Schmit, 2015).

La chaîne d'approvisionnement alimentaire locale et en produits issus de l'agriculture biologique peut produire des produits alimentaires plus coûteux que les circuits conventionnels. Il est donc indispensable d'optimiser les coûts de la logistique et de la chaîne d'approvisionnement pour maintenir un coût de repas abordable. C'est pourquoi il est nécessaire d'envisager des décisions logistiques et des solutions de distribution qui visent à réduire la distance entre les producteurs et la cantine scolaire afin de faciliter l'accès aux produits les plus frais et de meilleure qualité. En outre, il est nécessaire d'évaluer ces solutions non seulement en termes de distance et de temps, mais aussi de combiner ces évaluations avec les impacts économiques et environnementaux qui peuvent être générés.

Cependant, pour développer de tels systèmes de distribution alimentaire et les inclure dans une politique alimentaire urbaine, il est important de fournir des outils d'aide à la décision pertinents. Bien que ces outils commencent à être utilisés pour le transport non alimentaire, ils doivent être adaptés à la spécificité du domaine de la distribution alimentaire, et plus précisément à celle de la distribution alimentaire en restauration collective pour laquelle très peu de travaux ont été réalisés et restent préliminaires.

L'objectif de cette thèse est donc de *permettre aux acteurs de la distribution alimentaire d'analyser l'impact de la demande écoresponsable sur les schémas urbains de distribution alimentaire afin de mieux comprendre comment les décisions relatives à la configuration de la distribution des cantines scolaires peuvent avoir des impacts environnementaux et économiques.*

Dans ce but, cette thèse propose un cadre méthodologique pour comparer différentes décisions logistiques susceptibles d'avoir un impact sur l'organisation de la distribution alimentaire en termes d'efficacité, d'évaluation économique et environnementale. Ce cadre vise à aider le décideur à améliorer les systèmes actuels de distribution alimentaire pour les cantines scolaires.

Domaine de recherche : Restauration collective

Compte tenu de l'objet de cette recherche et après discussion avec les acteurs du système alimentaire français, il a été confirmé que dans le but d'améliorer le système, les décideurs ont proposé des politiques visant à encourager des solutions et des stratégies logistiques tenant compte des objectifs durables. Par exemple, l'un des secteurs alimentaires considérés comme l'un des principaux moteurs de l'exécution de ces stratégies est la restauration collective. Les acteurs publics ont ainsi intégré des critères de durabilité à toutes les étapes du processus d'achat, encourageant ainsi davantage de solutions d'approvisionnement et de distribution alimentaire tenant compte des impacts économiques, sociaux et environnementaux (Cerutti et al., 2016; Michelsen and de Boer, 2009).

Le service de traiteur est une activité de détail située à la toute fin de la chaîne d'approvisionne- ment alimentaire (Eriksson et al., 2017). Un service de traiteur peut être classé selon le client et le type de contrat. Les services de restauration peuvent être divisés entre (i) la restauration commerciale et (ii) la restauration collective, selon que les aliments vendus font partie de l'activité commerciale du client ou que le client achète des services de restauration à titre de service secondaire pour nourrir les consommateurs réguliers dans une institution.

La restauration commerciale comprend les livraisons de repas aux cafétérias, restaurants traditionnels, self-service et restauration rapide ; elle représente 51% des repas hors domicile en France. La restauration collective fournit des repas réguliers à une institution dans le cadre d'une convention ou d'un contrat conclu avec une entité privée ou publique; elle représente 49% des repas hors domicile en France (Ademe, 2016). La gestion de la restauration peut être interne (ou directe) et externalisée (ou déléguée), via des contrats de location et de concession. Au total, les services de restauration représentent environ 12% des aliments consommés en France, soit 7.3 milliards de repas par an (Lessirard et al., 2017).

Lessirard et al. (2017) classent la restauration collective en fonction du type de consommateur:

- Restauration scolaire : écoles primaires, écoles secondaires, collèges, lycées et cantines universitaires.

- Restauration d'entreprise ou restauration d'entreprise : restaurants pour entreprises privées et restaurants pour collectivités locales.

- Restauration hospitalière : cantines hospitalières (privées ou publiques) et établissements sociaux, tels que les maisons de retraite.

Selon Lessirard et al. (2017), en moyenne, 70% des acheteurs publics français exigent que les aliments servis dans leurs cantines proviennent du département local (c'est-à-dire de la subdivision administrative utilisée en France) ou des départements voisins. En effet, au cours de l'année 2017, 100% des appels d'offres ont montré que toutes les collectivités locales ont introduit une exigence de circuit-court et de produits locaux dans la restauration collective. Dans la restauration collective à Paris, les produits locaux représentent 20 à 30% de l'offre alimentaire de la restauration collective, mais 80% sont des produits frais locaux et 90 % sont des fruits et légumes locaux (Lessirard et al., 2017).

Pour répondre à ces demandes, certaines stratégies sont mises en oeuvre dans la restauration collective française, en concession institutionnelle. Elles visent à favoriser les chaînes d'approvisionnement alimentaire courtes (en anglais *Short Food Supply Chains (SFSC)*) et à accroître la part des produits locaux, incluant : (i) le développement d'une plate-forme alimentaire régionale (en anglais Food Hub (FH)) pour obtenir les volumes nécessaires pour répondre à la demande, optimiser l'approvisionnement et diminuer les kilomètres parcourus par tonne de produits transportés entre producteurs et clients ; (ii) l'utilisation de cuisines centrales pour combiner et transformer les légumes frais locaux de différents producteurs dans une installation qui sert également de centre de consolidation ; et (iii) la conception de menus composés principalement de produits de saison.

Chapitres

La Figure 1 présente la trame de la recherche qui est développée en plusieurs chapitres dans cette thèse.

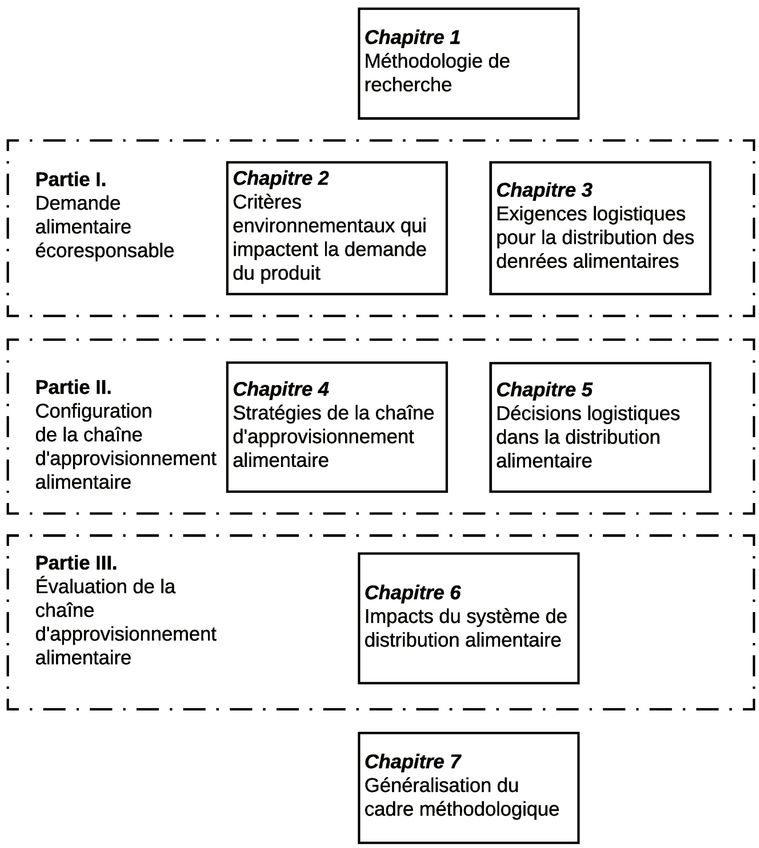


Figure 1: Plan de thèse

Chapitre 1. Méthodologie de recherche

Ce chapitre traite de l'approche méthodologique et des méthodes utilisées pour atteindre l'objectif de la recherche. Le chapitre commence par la description des questions de recherche. Ensuite, nous présentons l'approche de recherche choisie ainsi que le cadreméthodologique mis en place. Cette explication du processus de recherche permet de montrer les relations existant entre les différentes étapes méthodologiques suivies. Ensuite, le plan de recherche est présenté en présentant les données collectées, les méthodes de collecte des données utilisées, suivi d'une discussion sur la qualité de la recherche et la généralisation des résultats obtenus.

Partie I. Définition d'une demande en produits agro-alimentaire écoresponsables

Chapitre 2. Critères environnementaux qui impactent la demande du produit.

Ce chapitre commence définir ce qu'est la qualité environnementale d'un produit afin d'identifier les critères environnementaux susceptibles d'avoir un impact sur la demande de ce produits. Une typologie des critères environnementaux ayant un impact sur la demande du produit est proposée. Un ensemble de critères environnementaux ont été identifiés, sélectionnés et classés dans la typologie proposée. Ensuite, l'identification et la validation des critères les plus importants s'effectuent selon trois méthodes : (i) double codage, (ii) entretiens semi-directifs avec les acteurs du secteur agro-industriel français, (iii) enquête en ligne auprès de 248 entreprises de l'industrie alimentaire en France.

Chapitre 3. Définition des exigences logistiques pour la distribution des denrées alimentaires

Ce chapitre explique comment ces caractéristiques de la demande peuvent être utilisées pour décrire les exigences logistiques de la configuration du système de distribution alimentaire. Dans ce but, le chapitre commence par la représentation des flux alimentaires dans le système de distribution, puis il présente les acteurs de l'approvisionnement et de la distribution alimentaire, les différents types de produits et détaille les différentes configurations des circuits et circuits de distribution. En outre, il explique les exigences logistiques de la distribution alimentaire en fonction des différents acteurs, produits et circuits de distribution qui peuvent être adoptés. Considérant la restauration collective comme un secteur potentiellement à fort enjeu environnemental, les exigences logistiques sont détaillées et comparées aux autres secteurs. Enfin, les besoins logistiques sont comparés sur la base des données primaires et secondaires collectées pour établir les principaux besoins logistiques liés à la demande consciente dans la chaîne d'approvisionnement alimentaire pour la configuration de la distribution alimentaire.

Partie II. Configuration de la chaîne d'approvisionnement alimentaire

Chapitre 4. Stratégies de la chaîne d'approvisionnement alimentaire

Ce chapitre commence par la description des stratégies de la chaîne d'approvisionnement alimentaire visant à améliorer la durabilité de la distribution alimentaire. Pour cette fin, des objectifs de durabilité de la chaîne d'approvisionnement alimentaire sont définis.

Ensuite, les initiatives émergentes de distribution de nourriture en milieu urbain pour améliorer le transport de marchandises sont discutées. Ce chapitre propose d'identifier et de définir le rôle et les caractéristiques des systèmes de distribution basés sur les pôles alimentaires créés pour répondre à la demande du secteur de la restauration en produits bio locaux via une étude de cas dans la région Auvergne-Rhône-Alpes en

France, ainsi que de généraliser une définition globale des systèmes basés sur les pôles alimentaires dans les chaînes logistiques institutionnelles.

Chapitre 5. Décisions logistiques dans la distribution alimentaire
Après avoir analysé les stratégies de la chaîne d'approvisionnement alimentaire qui visent à améliorer la durabilité de la distribution alimentaire, ce chapitre propose une méthodologie pour définir et estimer les impacts des décisions logistiques sur l'organisation de la chaîne d'approvisionnement alimentaire envisagée pour développer les stratégies présentées dans le chapitre précédent. Les résultats suggèrent qu'une organisation logistique efficace des producteurs locaux peut générer des gains logistiques substantiels dans l'objectif d'intégrer les produits locaux dans le menu de la cantine scolaire. Cette organisation logistique intègre des éléments tels qu'un système de distribution coordonné, l'amélioration du nombre d'itinéraires, la distance parcourue et le temps de livraison des produits.

Partie III. Évaluation de la chaîne d'approvisionnement alimentaire

Chapitre 6. Impacts du système de distribution alimentaire
Ce chapitre décrit une analyse de la manière dont la modélisation des systèmes de distribution alimentaire urbaine peut permettre d'estimer les impacts générés par une nouvelle configuration, y compris une estimation des impacts économiques et environnementaux des différentes configuration des différents systèmes de distribution alimentaire envisageables. Enfin, nous proposons une méthodologie qui implique l'identification, le calcul et la validation d'indicateurs environnementaux et économiques pour évaluer différentes configurations de distribution alimentaire.

Chapitre 7. Généralisation du cadre méthodologique Ce chapitre explique le cadre de modélisation des schémas de distribution des aliments en milieu urbain, divisé en quatre étapes: (i) la formalisation des décisions logistiques à prendre en compte, (ii) la caractérisation du système alimentaire, (iii) la construction de scénarios et (iv) l'évaluation des scénarios. Ensuite, ce chapitre présente la discussion sur la généralisation du cadre méthodologique proposé, il inclut les implications techniques et managériales et la transférabilité de la recherche. Enfin, les conclusions générales de la thèse relatives à chaque question de recherche proposée sont présentées, y compris une discussion sur les perspectives de cette recherche.

Conclusion

Ce chapitre présente les conclusions de cette thèse par rapport aux questions de recherche proposées.

L'objectif de ce travail de recherche était de permettre aux acteurs de la distribution alimentaire d'analyser l'impact de la demande en produits agro-alimentaires écoresponsable sur les systèmes de distribution alimentaire en milieu urbain et de les aider à mieux comprendre comment les décisions relatives à la configuration de la distribution des cantines scolaires peuvent avoir des impacts environnementaux et économiques. En conséquence, l'objectif de cette thèse était d'*analyser la relation entre les exigences de la demande de produits et les configurations de distribution alimentaire en tenant compte des impacts environnementaux et économiques.*

Critères environnementaux des produits

Pour explorer l'impact de la demande écoresponsable sur les systèmes de distribution alimentaire en milieu urbain, cette thèse a commencé par identifier les critères environnementaux des produits qui ont un impact sur la demande de produits. Une typologie a été proposée pour classer ces différents critères : ils peuvent être liés aux caractéristiques environnementales du produit, aux stratégies organisationnelles et aux pratiques vertes développées par les entreprises, et au processus de sélection des fournisseurs.

Les résultats des entretiens semi-structurés et du questionnaire d'enquête montrent l'importance de l'introduction de matières premières biologiques labellisées comme l'un des attributs les plus influents pour améliorer la qualité environnementale du produit. En outre, en ce qui concerne les stratégies organisationnelles, les résultats soulignent l'importance de la proximité géographique avec les parties prenantes, qui se reflète dans les décisions relatives à la localisation des installations, telles que (i) la localisation des points de distribution à proximité du marché et (ii) la localisation des installations de production à proximité des fournisseurs.

Ces résultats soulignent l'importance pour les parties prenantes des systèmes alimentaires de considérer les produits biologiques et locaux comme des critères environnementaux qui ont un impact sur la demande et de les considérer comme des critères de sélection importants au moment de choisir un fournisseur.

En ce qui concerne les critères environnementaux des produits qui ont un impact sur la demande, la recherche apporte sa contribution par :

- L'identification et la description de vingt-neuf critères environnementaux de produits associés aux caractéristiques des produits, aux stratégies organisationnelles et à la sélection des fournisseurs.
- Validation des critères environnementaux du produit qui ont un impact sur la demande du secteur alimentaire français pour être pris en compte par les parties prenantes afin d'augmenter la qualité environnementale du produit.

Exigences logistiques pour la distribution des denrées alimentaires

La première partie de cette thèse a permis de comprendre que les acteurs de la chaîne d'approvisionnement alimentaire sont de plus en plus conscients de la nécessité d'améliorer les organisations de logistique alimentaire face à la demande croissante de conscience environnementale et de l'importance de la proximité de la production agroalimentaire. Cette thèse contribue à expliquer la pertinence de l'organisation de la distribution alimentaire en raison de la demande logistique de produits alimentaires passant plus rapidement des producteurs primaires aux consommateurs tout en considérant les externalités de durabilité.

Ces résultats soulignent l'importance pour les parties prenantes qui appartiennent au système alimentaire de comprendre les exigences logistiques liées à la configuration de la distribution alimentaire : (i) localisation des installations (soit à proximité du marché, soit auprès des fournisseurs) ; (ii) sélection du fournisseur (en fonction des caractéristiques du produit et de la localisation du fournisseur liée à une relation de proximité) ; et (iii) optimisation de la distribution grâce au développement des plateformes logistiques et des stratégies de transport (c'est-à-dire réduction de la distance parcourue, augmentation du taux de remplissage des véhicules, réduction des externalités de durabilité).

En ce qui concerne les exigences logistiques pour la distribution des denrées alimentaires, la recherche apporte sa contribution par :

- La caractérisation des configurations de distribution pouvant être développées pour réduire les impacts du transport alimentaire en améliorant l'approvisionnement local et en renforçant la collaboration entre les acteurs locaux de la chaîne alimentaire.

- La compréhension des exigences logistiques pour la configuration de la distribution alimentaire en tenant compte des décisions liées à l'emplacement des installations et à l'optimisation de la distribution.

- L'apport d'informations aux acteurs de la chaîne d'approvisionnement alimentaire lors de la conception des circuits de distribution alimentaire visant à prendre en compte les nouvelles caractéristiques de la demande consciente.

Stratégies de la chaîne d'approvisionnement alimentaire

L'étude des stratégies de la chaîne d'approvisionnement alimentaire qui permettent d'accomplir les exigences logistiques de la distribution alimentaire, en tenant compte des critères environnementaux du produit, a permis à cette thèse d'apporter deux contributions principales. La première contribution consiste à décrire les rôles et les caractéristiques des systèmes de distribution des pôles alimentaires (en anglais Food hubs FH) créés en Auvergne-Rhône-Alpes comme stratégie d'approvisionnement de la demande des cantines scolaires en produits bio locaux. La deuxième contribution consiste à évaluer l'allocation des producteurs aux pôles alimentaires (FH), en tenant compte de la proximité géographique et des stratégies d'allocation des subdivisions administratives.

Ces résultats permettent de conclure que pour renforcer l'approvisionnement alimentaire, il est nécessaire de considérer l'allocation des producteurs en fonction de leur proximité géographique et de l'accessibilité de la plate-forme alimentaire, ce qui affecte l'efficacité de la collecte alimentaire en termes de distances.

Considérant les pôles alimentaires (FH) comme une stratégie de chaîne d'approvisionnement alimentaire pouvant permettre d'accomplir les exigences logistiques de la distribution alimentaire compte tenu des critères environnementaux des produits définis, la recherche apporte sa contribution par :

- La description du rôle de FH pour permettre des chaînes d'approvisionnement courtes et permettre d'envisager une augmentation de la part des produits locaux et biologiques dans la restauration collective.
- L'apport d'informations aux parties prenantes du système alimentaire lors de la conception de chaînes d'approvisionnement courtes avec FH, ainsi qu'aux décideurs politiques qui visent à accroître leur part d'aliments locaux et biologiques dans la restauration collective.

Décisions logistiques qui ont un impact sur l'efficacité du système de distribution alimentaire

Le fait d'avoir compris que l'organisation logistique est un élément important pour réduire les flux de transport et faire face à la demande croissante de produits biologiques et locaux, a permis à cette thèse de proposer un cadre méthodologique qui implique différentes décisions stratégiques et tactiques à considérer pour l'approvisionnement et la distribution alimentaire dans le système de cantine scolaire.

Six cas ont été pris en compte pour cette analyse : sur la base de l'allocation de subdivision administrative (cas 1), sur la base de l'allocation de proximité géographique (cas 2), sur la base de l'allocation de modélisation mathématique selon une capacité fixe de chaque producteur (cas 3), sur la base de l'allocation de modélisation mathématique avec une capacité du producteur potentiellement plus élevée (et flexible) (cas 4), sur la base de l'allocation computationnelle avec le clustering par Affinity propagation (cas 5) et sur la base de l'allocation computationnelle avec le clustering par K-mean (cas 6).

Les résultats basés sur les six cas suggèrent que l'introduction de produits locaux dans le menu de la cantine scolaire nécessite de développer une organisation logistique efficace des producteurs locaux. Il a été observé que l'efficacité de l'organisation logistique dépend fortement des différentes décisions clés considérées.

En ce qui concerne les décisions logistiques qui ont un impact sur l'efficacité du système de distribution alimentaire, la recherche contribue par :

- L'identification et l'analyse des impacts des décisions logistiques sur l'organisation de la chaîne d'approvisionnement alimentaire, en considérant les stratégies d'approvisionnement alimentaire qui permettent une distribution durable.

- L'élaboration d'un cadre méthodologique qui pourrait aider le décideur à établir des collaborations potentielles avec les producteurs locaux et biologiques afin d'améliorer les systèmes actuels de distribution alimentaire pour les cantines scolaires.

Impacts économiques et environnementaux sur l'évaluation de la distribution alimentaire

Concernant les impacts des décisions logistiques sur la configuration de la distribution alimentaire, la modélisation des circuits courts de distribution alimentaire de producteurs indépendants ou groupés et des pôles alimentaires et la définition des schémas de transport adaptés, permet d'estimer les impacts des différentes configurations possibles non seulement en termes d'efficacité du système mais également de performance économique et environnementale.

Pour cette raison, l'étude des impacts des différentes décisions logistiques envisagées pour l'organisation de l'approvisionnement alimentaire, a permis à cette thèse de proposer une méthodologie qui implique l'identification, le calcul et la validation d'indicateurs environnementaux et économiques pour évaluer le système de distribution alimentaire.

En ce qui concerne les impacts économiques et environnementaux sur l'évaluation de la distribution alimentaire, la recherche contribue par :

- L'élaboration d'une méthodologie pour évaluer les impacts économiques et environnementaux des systèmes de logistique alimentaire urbaine

- L'application de la méthodologie aux différents schémas de distribution de l'offre des cantines scolaires pour répondre à ses enjeux d'application, contribuant ainsi au débat sur l'évaluation durable des systèmes alimentaires urbains.

Cadre méthodologique pour la caractérisation et l'évaluation de la distribution alimentaire

Cette thèse a développé un cadre d'évaluation des différentes configurations de distribution alimentaire, qui peut être adapté à différentes applications. Toutefois, les spécificités des données liées au contexte doivent être transférées avec une extrême prudence. Par conséquent, le cadre combine différentes étapes d'une manière intégrée, en utilisant des modèles standard ou unifiés pour estimer les différents éléments nécessaires à l'évaluation des scénarios, mais selon une procédure coordonnée. Ce cadre méthodologique comprend quatre étapes principales : (i) les décisions logistiques à prendre en compte, (ii) la caractérisation du système alimentaire, (iii) la construction de scénarios et (iv) l'évaluation des scénarios.

En particulier, la recherche a eu l'intention d'apporter sa contribution en développant un cadre méthodologique pour comparer les différentes décisions logistiques qui ont un impact sur l'organisation de la distribution alimentaire en termes d'efficacité, d'évaluation économique et environnementale.

En conclusion générale de cette thèse, les résultats du cadre méthodologique proposé pourraient aider le décideur à établir des collaborations potentielles avec les producteurs locaux et biologiques afin d'améliorer les systèmes actuels de distribution alimentaire des cantines scolaires. En fait, en observant la demande écoresponsable et les exigences logistiques, on contribue à analyser l'efficacité (en termes de distance et de temps) de l'impact économique et environnemental sur la distribution alimentaire en tenant compte des décisions logistiques clés telles que l'estimation de la demande et de l'offre, la localisation et la répartition des installations, la construction des routes et l'évaluation du système de distribution.

Enfin, afin d'établir les principales implications du cadre méthodologique proposé pour soutenir les décideurs dans la pratique, certaines conclusions générales peuvent être tirées dans la présente thèse. En suivant ce cadre, les acteurs du système alimentaire pourront : (1) se familiariser avec l'offre locale et biologique ; (2) estimer sa demande logistique potentielle ; (3) évaluer différents cas pour avoir une idée du schéma logistique qui pourrait être développé à l'avenir ; (4) considérer l'efficacité potentielle en termes de distance et de temps, les impacts économiques et environnementaux que la distribution actuelle ou future aura.

Perspectives de cette recherche

Après plus de trois ans de travail dans l'élaboration du cadre méthodologique et dans les cas d'application, plusieurs perspectives de recherche apparaissent dans différents domaines disciplinaires.

Pour de plus amples recherches sur les décisions logistiques qui doivent être prises en considération pour la configuration de la distribution alimentaire, voici deux axes proposés pour des études futures possibles :

- L'analyse plus approfondie de la façon dont les acteurs considèrent les décisions opérationnelles pour mieux configurer la distribution alimentaire afin de mieux comprendre comment les décisions prises à tous les niveaux peuvent avoir un impact sur la configuration de la distribution alimentaire (recherches en sciences de gestion).

- Le développement d'outils d'aide à la décision qui prennent en compte les trois niveaux de décision en matière de logistique alimentaire afin d'aider les décideurs lors de la configuration d'un système de distribution alimentaire considérant des produits écoresponsables (recherche en génie industriel).

Pour de plus amples recherches sur la caractérisation de la distribution des aliments, voici trois axes proposés pour des études futures possibles :

- L'analyse plus approfondie sur la caractérisation d'autres réseaux de distribution alimentaire autres que la restauration collective visant à intégrer cette caractérisation à la généralisation du cadre méthodologique.

- Une étude sur la possibilité d'utiliser les critères environnementaux proposés pour améliorer la qualité environnementale des produits alimentaires dans un autre contexte afin de mieux comprendre l'impact des critères environnementaux sur la demande des produits.

- L'analyse plus approfondie du modèle d'estimation de l'offre et de la demande de produits proposé dans d'autres circuits de distribution alimentaire tels que le commerce de détail alimentaire, HoReCa (Hôtel, Restaurants, Cafés) et d'autres circuits.

Pour des recherches plus approfondies sur la construction de scénarios, il est proposé de se concentrer sur une analyse plus approfondie de la construction de routes en utilisant différents VRP et en cherchant les meilleures routes en considérant d'autres algorithmes pour optimiser la solution.

Pour des recherches plus approfondies sur l'évaluation des scénarios, deux axes proposés pour des études futures possibles sont :

- La prise en compte d'autres estimations d'impacts tels que les impacts sociaux et la mobilité pour l'évaluation du scénario.

- Le développement de l'analyse dans des méthodes multicritères pour donner une robustesse à l'évaluation d'impact visant à soutenir les décideurs considérant ses objectifs de durabilité.

- Le développement d'une méthodologie d'analyse environnementale basée sur l'analyse du cycle de vie pour étudier les impacts potentiels (positifs ou négatifs) du remplacement des véhicules thermiques par d'autres technologies comme les véhicules électriques.

Contents

List of Figures

List of Tables

Table of Abbreviations

Notation	Description
AMAP	Association pour le maintien d'une agriculture paysanne (i.e., English translation: Community-supported agriculture).
CH4	Methane.
CK	Central kitchen.
CO	Carbon monoxide.
CO2	Carbon dioxide.
COPERT	EU standard vehicle emissions calculator.
CVRP	Capacitated vehicle routing problem.
	.
FAO	Food and Agriculture Organization.
FC	Fuel Consumption.
FH	Food hubs.
FNTR	National Federation of Road Transport.
FSC	Food Supply Chain.
FTL	Full truckload.
GAMS	General Algebraic Modelling System.
GIS	Geographic Information System.
H	Hypothesis.
Ho.Re.Ca	Hotels, Restaurants and Cafes.
HR	Human Resources.
	.
LNG	Liquefied natural gas.
LSP	Logistic service provider.
LTL	Less-than-truckload.

Notation	Description
LY	Lyon.
N-LRP	N-echelon Location Routing Problem.
N-VRP	N-echelon Vehicle Routing Problem.
N/A	Not apply.
NOx	Nitrogen oxides.
PEQ	Product's environmental quality.
PM	Particulate matter emissions.
PVC	Point collective de vente (i.e., English translation: Collective sales outlets).
QGIS	Open-source cross-platform for geographic information system.
RQ	Research Question.
RSE	Corporate Social Responsibility.
SC	School Canteen.
SCM	Supply Chain Management.
SFSC	Short Food Supply Chains.
SIRENE	The French Business Register.
ST	Saint-Etienne.
UCC	Urban Consolidation Centre.
VOC	Volatile Organic Compounds.
VRP	Vehicle Routing Problem.

Introduction

The increasing share of the population moving into urban environments has created numerous challenges for city authorities and logistics operators regarding traffic, liveability and land use among others. One of the most important challenges is to feed urban population in an efficient and timely manner, which has several implications in terms of environmental sustainability, social equity and economic development. In consequence, cities require larger amount of food and a better freight transport to deliver it, entailing an emergent need to promote new policies on urban freight transport and food distribution (Morganti, 2011).

The objective of achieving a sustainable society has raised greater interest among consumers, being more aware of the origin of food, how it is produced, processed and distributed, becoming demanding consumers with environmental criteria that must be fulfilled.

Besides, public and private decision-makers have also taken an interest in the sustainability of food supply chains (Nicholson et al., 2011). Indeed, several cities have started to think on how to improve their local supply systems by combining proximity producers' supply with city logistics systems.

An increasing number of municipalities are interested on introducing organic and local products on the students' meals menu as a measure to improve its nutritional and health quality for children (Izumi et al., 2010; Lessirard et al., 2017; Smith et al., 2016).This can be achieved by developing an efficient delivery system for the school canteens as a key factor to ensure the food distribution in an efficient way both time and quality wise (Severson and Schmit, 2015).

Compared to conventional channels, local and organic food supply chain may produce more expensive food products. Therefore, there is a strong challenge to optimize the logistics and supply chain costs to maintain an affordable meal cost. This makes necessary to consider logistic decisions and distribution solutions that seek for food distance travel reduction from the producers to the school canteen having an easier access to freshest and better quality products. Moreover, it is necessary to assess those solutions not only in terms of distance and time, but to combine those assessments with economic and environmental impacts that may be generated.

However, to develop such food distribution systems and include them on a global urban food policy, it is important to provide relevant decision support tools. Although such tools start to be used for non-food transport, they need to be adapted to the specificity of the field of food distribution, and more precisely to that of food distribution in institutional catering for which very few works have been done and remain preliminary.

Therefore, the purpose of this thesis is *to enable food distribution stakeholders to analyse how eco-responsible demand impacts the urban food distribution schemes aiming to understand better how the decisions related to the configuration of school canteen distribution could have environment and economical impacts.*

With that purpose, this thesis proposes a framework for comparing different logistic decisions that impact food distribution organisation considering efficiency, economic and environmental assessment. This framework seeks to support the decision maker to improve the current food distribution systems for school canteens.

Research field

Considering the purpose established for this research and after discussions with stakeholders in the French food system, it has been confirmed that with the aim of improving the system, policy-makers have proposed policies to encourage logistic solutions and strategies considering sustainable goals. For instance, one of the food sectors considered as a main driver for the execution of these strategies is the public institutional catering. In fact, public authorities have been integrating sustainable criteria into all stage of the procurement process (known as green procurement), thus encouraging more food supply and distribution solutions considering economic, social and environmental impacts (Cerutti et al., 2016; Michelsen and de Boer, 2009).

Institutional catering

Catering services is a retail activity located at the very end of food supply chains (Eriksson et al., 2017). A catering service can be classified depending on the customer and type of contract. Catering services can be divided between (i) commercial catering and (ii) institutional catering, depending on whether the food traded is part of the customer's commercial activity, or the customer purchases catering services as a secondary service to feed regular consumers at an institution. Commercial catering includes food deliveries to cafeterias, traditional restaurants, food self-service, and fast-food restaurants; it represents 51% of out-of-home meals in France. Institutional catering provides regular meals to an institution under an agreement or a contract made with a private or public-sector entity; it represents 49% of out-of-home meals in France (Ademe, 2016). Catering management can be either internal (or direct) and outsourced (or delegated), via lease and concession contracts. Overall, catering services represent about 12% of food consumed in France, corresponding to 7.3 billion meals per year (Lessirard et al., 2017).

Lessirard et al. (2017) classify institutional catering based on the type of consumer:

- School catering: primary school, public and private high schools, colleges and university canteens.

- Enterprise or corporate catering: restaurants for private companies and restaurants for local authorities.
- Health catering: hospitals canteens (private or public) and social establishments, such as nursing homes.

Institutional catering represents a stable market for all food chains with a growth of 0.4% to 0.5% per year, this can be explained by the fact of accurate forecasting and the use of annual contracts that establish the number of meals contracted. The direct and delegated management represents 60% and 40%, respectively of the institutional catering sector (Ademe, 2016).

In institutional catering, the customer defines the meal specifications in terms of menu quality and food quantity based on the consumer's health recommendations. The catering company then analyses the customer's food requirements and coordinates with its suppliers, who may be wholesalers or food distributors, food cooperatives, and/or primary producers. Figure 2 explains the flow of information between the stakeholders in delegated institutional catering, and Figure 3 explains in direct institutional catering, which operates in the opposite direction of the flow of food.

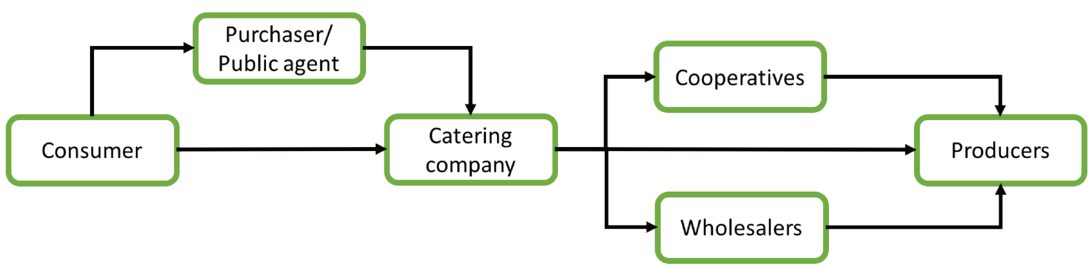


Figure 2: Flow of information between the stakeholders in delegated management institutional catering. Adapted from(Lessirard et al., 2017)

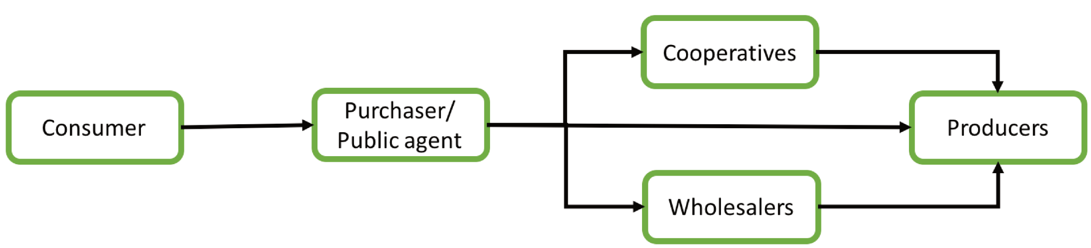


Figure 3: Flow of information between the stakeholders in direct management institutional catering. Adapted from(Lessirard et al., 2017)

*The consumer could be the parent or the student who eats at school canteen; the patient in the hospital; or the employee in the enterprise, among others. *The customer or purchaser could be a territorial authority, public institution, or private enterprise. *The producer could be primary producers and industrial producers.

In institutional-concession catering, local institutions (customer/purchaser) can identify preferred producers types and encourage agreements that prioritize local products. This is achieved by establishing annual quantities to be purchased, negotiating the price directly with producer cooperatives, investing in the development of new products such as organic-local products, and sharing transportation among producers. In the French market, institutional-concession catering is dominated by three international groups, which represent 75% of the turnover of concession catering (Lessirard et al., 2017).

According to Lessirard et al. (2017), on average, 70% of French public purchasers demand that the food served in their canteens comes from the local department (i.e. administrative subdivision used in France) or from neighbouring departments. In fact, during 2017, 100% of the calls for tenders showed that all local authorities introduced a requirement for short circuits and local products in institutional catering. In institutional catering in Paris, local products represent 20-30% of the institutional catering food supply, but 80% are local fresh products and 90% are local fruits and vegetables (Lessirard et al., 2017).

To answer to these demands, strategies implemented in French institutional-concession catering aimed at fostering short food supply chains (SFSC) and increasing the share of local products include: (i) developing regional Food hub (FH) to increase consolidation and decrease kilometres driven per ton of products transported between producers and customers; (ii) using central kitchens to combine and transform local fresh vegetables from different producers in a facility that also serves as a consolidation centre; and (iii) designing menus composed exclusively of seasonal products.

Outline

This chapter has introduced the research topic of the thesis, presented the purpose and described the field study. Figure 4 shows the thesis outline.

Chapter 1. Research methodology

This chapter discusses the methodological approach and the methods used, in order to reach the research purpose. The chapter begins with the research questions description. Then, a discussion of the research approach to explain the methodology strategy is presented, followed by an explanation of the research process showing the relationship between the methodological steps followed. Then, the research design is presented by explaining the data collection, data methods used, followed by a discussion on research quality and generalisability of the results obtained.

Part I. Eco-responsible food demand

Chapter 2. Environmental criteria that impact the product demand

This chapter begins with a review of product's environmental quality definition to

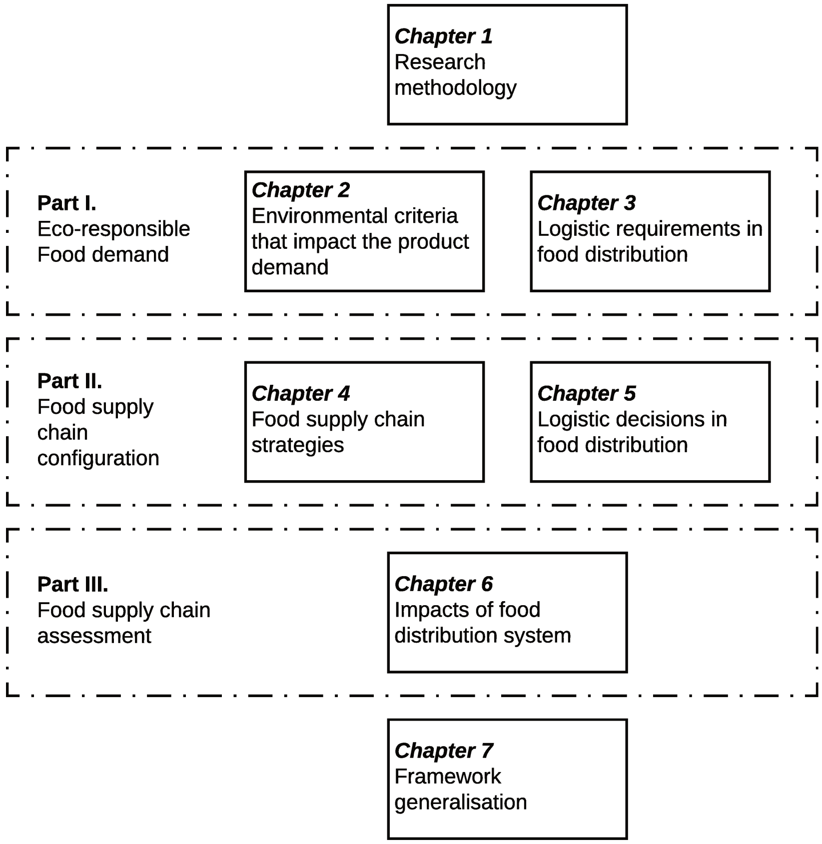


Figure 4: Thesis outline

identify which environmental criteria may impact product demand. A typology of environmental criteria that impact the product demand is proposed. A set of environmental criteria are extracted, selected and classified within the proposed typology. Then, the identification and validation of the most important criteria is performed using three methods: i double coding analysis, ii semi-structured interviews with stakeholders in the French agro-industrial sector, iii a survey of 248 companies from the food industry in France.

Chapter 3. Logistic requirements for food distribution

This chapter explains how these demand characteristics can be used to describe the logistic requirements to configure the food distribution system. With this aim, the chapter begins with the definition of the food flows in the distribution system, then it presents the food supply and distribution actors, the different type of products and details the different configurations of distribution circuits and channels. Furthermore, it explains the logistic requirements for food distribution according to the different actors, products and distribution circuits that may be adopted. Considering the institutional catering as a potentially sector with a strong environmental stakes, the logistic requirements are detailed and compared with other sectors. Finally, the logistic requirements are compared based on the primary and secondary data collected to establish the main logistic requirements linked to the conscious demand in the food supply chain for the food distribution configuration.

Part II. Food supply chain configuration

Chapter 4. Food supply chain strategies
This chapter begins with the description of food supply chain strategies that enable sustainable food distribution. To this end, sustainability objectives of food supply chain are defined. Then, emerging urban food distribution initiatives to improve freight transport are discussed. This chapter proposes to identify and define the role and characteristics of distribution systems based on food hubs created to answer to the catering sector demand for local-organic products via a case study in the Auvergne-Rhône-Alpes region in France, as well as to generalise a global definition of food hubs-based systems in institutional catering supply chains.

Chapter 5. Logistic decisions in food distribution
Having analysed the food supply chain strategies that enable sustainable food distribution, this chapter proposes a framework to define and analyse impacts of logistic decisions on food supply chain organization considered to develop the strategies presented in the previous chapter. The results suggest that an efficient logistical organisation of the local producers may generate substantial logistic gains in the objective to integrate local products in the school canteen's menu. This logistic organisation integrates elements such as a coordinated distribution system, the improvement of the number of routes, driving distance and product delivery time.

Part III. Food supply chain assessment

Chapter 6. Impacts of food distribution system
This chapter describes an analysis of how the modelling of sustainable urban food distribution schemes can estimate the impacts generated, including a review of the estimation of economic and environmental impacts for the configuration of the different food distribution schemes proposed. Finally, a methodology that involves the identification, calculation and validation of environment and economic indicators for assessing the food distribution system is proposed.

Chapter 7. Framework generalisation
This chapter explains the framework for modelling urban food distribution schemes divided into four stages: (i) logistic decisions to consider, (ii) food system characterisation, (iii) scenario construction, and, (iv) scenario assessment. Then, this chapter presents the discussion of the generalisation of the proposed framework, it includes technical and managerial implications and research transferability.

Lastly, the overall conclusions of the thesis related to each research question proposed are offered, including a further research discussion.

Chapter 1

Research methodology

Contents

The purpose of this thesis is to analyse the relationship between product demand requirements and food distribution configurations considering environmental and economic impacts. To address this purpose, there is a need to choose a research approach and to design studies that are suitable as research method.

This chapter discusses the methodological approach and the methods used in order to reach the research purpose. The chapter begins with the research process to explain how the research questions was obtained. Then a discussion of the research approach to explain the methodology strategy is presented, followed by an explanation of the research process showing the relationship between the methodological steps followed. Then, the research design is presented by explaining the data collection and data methods used, followed by a discussion on research quality and generalisability of the results obtained.

1.1 Research process

The research in this thesis has been conducted as part of three research projects with different objectives, depths and length period of time described as follows:

- During 02/2016 - 07/2017, the research was part of the collaborative project ANNONA (Aide à la décision pour le développement de schémas logistiques urbains durables), which is part of the sub-theme "SMART-CITIES" of the call for projects "Cities and Sustainable Buildings" 2013 of the National Agency for Research (ANR). The aim of this project was to develop a modular decision support system for urban logistics tactical planning in a multi-stakeholder and multi-criteria context. During 2017, the research mobility in Sweden for four moths was supported by the Bernard Sutter Grant, from Grands Écoles Paris.
- During 08/2017 - 09/2018, the research was part of another ANR project called CONCLUDE (CONception des Chaînes Logistiques avec une Demande sensible à la performance Environnementale). The aim of this project is to develop and analyse optimization models for supply chain design considering endogenous demand sensitive to environmental performance.
- During 10/2018 - 09/2019, the research is part of the project ELUD (Efficacité Logistique Urbaine alimentaire et Durable). The project's main funder is l'Université de Lyon and the ANR via the labex IMU (Intelligences des Mondes Urbains). The aim of this project is to propose a methodology by providing a scenario simulation framework, as well as a set of indicators and tools for evaluation and analysis of the sustainable performance of new urban food delivery systems.

1.2 Research questions

Research design is an iterative and interactive process (Maxwell, 2012; Yin, 2009). The research development in this thesis has been interactive and progressive, describing research questions that have been proposed according to an iterative process between the literature review, secondary evidence and interviews.

This thesis started by analysing the transportation in cities with the aim of studying different urban logistics solutions to improve transportation systems that can be considered by stakeholders. Nevertheless, the development of these solutions remains a rather complex exercise for decision-makers (Lagorio et al., 2016). Once the solutions are implemented, the complexity increase when the economic viability, social and environmental benefits should be assessed (Behrends, 2016; Gonzalez-Feliu, 2018a; Lindholm, 2010). This thesis contributed to this analysis by focusing on studying the problematic of how to feed a city in a sustainable way. Then, after multiple interviews with public decision-makers in France, it has been confirmed that this problematic was the common interest for public and private stakeholders in the French food system. One of the most important findings was the relationship between the urban transportation and the sustainable goals in food distribution.

Then, this thesis started to study the sustainable food supply chains that are designed and configured to achieve these sustainability goals. The literature (e.g. Colicchia et al. (2013); Kuhmonen (2017); Smith et al. (2016)) proposes three sustainable strategies in food supply chain: (i) Short food supply chain, that integrates the proximity notion in the relationship between producers and consumers aiming to maximize common value added by producers. (ii) Green food chain, that focuses on the environmental impacts of the food supply and distribution, integrating notions such as eco-responsible products, organic and local products, among others. (iii) Fair food chain, that involves analysis of social externalities in the food supply chain, making consumers to be interested in the social conditions of the producers.

After discussions with stakeholders, it has been confirmed that these sustainable strategies have been encouraged by policy-makers through policies that aim to improve food distribution systems. For instance, one of the food sectors that has been a driver to develop these strategies is the public institutional catering, that is characterised by the provision of meals to a community of regular consumers (Lessirard et al., 2017). In fact, public authorities have been integrating sustainable criteria into all stage of the procurement process, thus encouraging more food supply and distribution solutions considering economic, social and environmental impacts (Cerutti et al., 2016; Michelsen and de Boer, 2009).

Then, to analyse these sustainable criteria that are integrated into the procurement process, this thesis proposed as the main research question:

How eco-responsible demand requirements impact the food supply and distribution configuration?

To address this main question, three phases of this research has been proposed to answer six specific research questions that have been formulated.

Phase 1: Eco-responsible demand

With the aim to identify eco-responsible product demand characteristics that can be used to analyse its influence on the configuration of the food distribution system, a review of the definition of product environmental quality firstly has been done. The objective was to find the product's environmental criteria that influence the product demand by proposing the following research question:

RQ1a: Which environmental criteria related to a product have an influence on its demand?

Then, once the product's environmental criteria have been identified, a second question is proposed:

RQ1b: What eco-responsible product demand characteristics can be used as request *variables to configure an urban food supply system?*

These research questions are addressed in the manuscript. RQ1a is studied in Chapter 2 and RQ1b is studied in Chapter 3.

Phase 2: Food supply chain configuration

When considering new requirements on the food supply chain, it is important to be familiarized with the main solutions proposed in the literature review and evaluate its pertinence regarding the customer demand. To address this issue, a third research question is proposed as follows:

RQ2a: What are the food supply chain strategies that accomplish the eco-responsible product demand characteristics?

Once these strategies are identified, it is important to study the logistic decisions to be considered for the development of these solutions. With this aim, a fourth research question is proposed as follows:

RQ2b: Which are the logistic decisions impacts on food supply chain organization when considering food supply chain strategies that enable sustainable food distribution?

These research questions are addressed in the manuscript. RQ2a is studied in Chapter 4 and RQ2b is studied in Chapter 5.

Phase 3: Food supply chain assessment

Once the impact generated of the logistic decisions in the food distribution system are considered, it is necessary to understand how these solutions can be assessed in terms of efficiency (time and distance that food travels), but also it is important to consider which are the environmental and economic impacts that can be generated. To answer to this issue, the fifth research question is proposed as follows:

RQ3a: Which indicators can be used to assess the economic and environmental impacts of a food distribution system?

Once the system is analysed in terms of efficiency and impacts generated, it is important to assess the change of the current distribution system compared to the strategies developed. With this aim, the last research question is proposed as follows:

RQ3b: How the changes of a current food distribution system (in a logic of before-after scenario assessment) can be identified and quantified?

These research questions are addressed in the manuscript. RQ3a and RQ3b are studied in Chapter 6 and Chapter 7.

1.3 Research design

The research design is a logical plan for how to answer to the research questions proposed. The research undertaken in this thesis adopted an abductive approach, characterised by considering practices and theories. In general, there are two main research approaches to take into account, qualitative and quantitative research: (i) Qualitative research is linked to induction (theory building) collecting data to develop a theory as a result of the data analysis. (ii) Quantitative research involves deduction (theory testing), designing research strategies to test hypotheses that have been developed based on theory. The fact of combining them is called abductive approach.

Considering research design, this thesis applies a dialogical process of integrating findings in the literature and the empirical material as shows Figure 1.2 by adopting an abductive research approach.

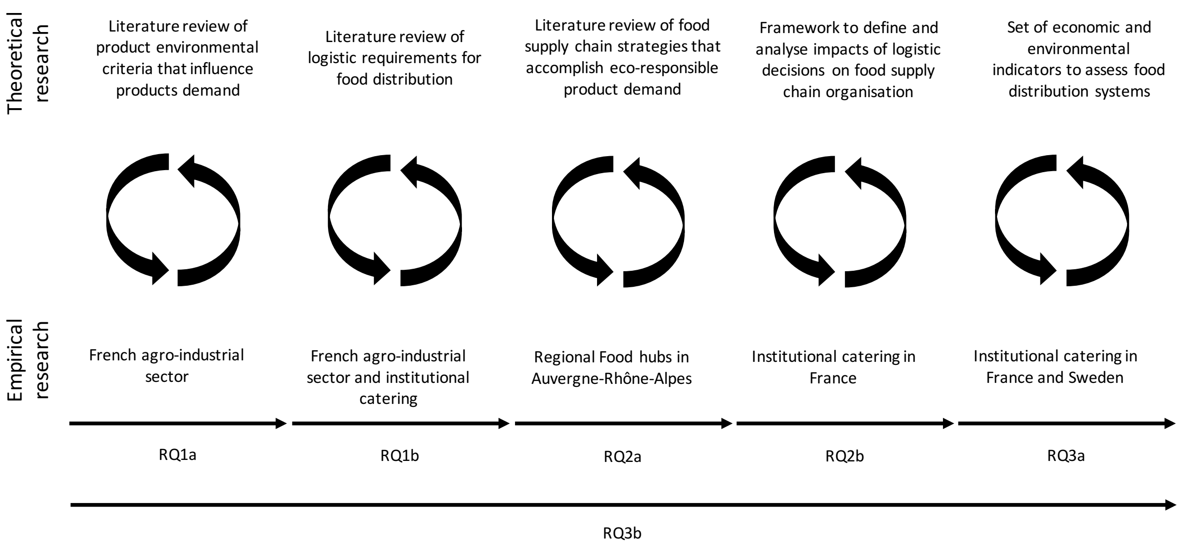


Figure 1.1: Thesis research abductive approach

For instance, all research questions are addressed by conducting literature reviews and by using empirical material. All integrates searches of the literature to gain understanding of state of the art and to propose research frameworks and methodologies.

1.4 Research approach

The research approach describes the methods used to answer the research questions. According to Marshall and Rossman (2014); Yin (2009), the first step is to identify the research question typology, in order to select the suitable method. They propose three types: (i) explorative questions aim to explore, identify and discover a phenomenon; (ii) explanatory questions seek to explain, identify and interpret relationships that shape a phenomenon; (iii) descriptive questions aim to document and describe the phenomenon. Depending on the type of research questions and on where the research study is developed, this thesis has elements of explanation, exploration and/or description.

Although, the main purpose of this thesis research is explanatory, explorative and descriptive. RQ1a aims to identify which are the product environmental criteria that influence the product demand. With a starting point of identifying product environmental criteria, the question is explorative; however, those criteria should be described, meaning that the question is also descriptive. Considering this fact, the research approaches used are a literature review and a case study (French agro-industrial sector). To be able to identify and validate product environmental criteria in different companies, a multiple-case study is chosen. RQ1a is studied in Chapter 2.

Then, RQ1b seeks to identify what eco-responsible product demand characteristics can be used as request variables to configure an urban food supply system. As RQ1a, this research question is also explorative and descriptive. By using the same method used before, a literature review about the logistic requirements for food distribution is performed to then validated through a multiple-case study in the French agro-industrial sector. RQ1b is studied in Chapter 3.

Moreover, RQ2a aims to identify what are the food supply chain strategies that accomplish the eco-responsible product demand characteristics. As RQ1, this research question is both exploratory and descriptive. In fact, to identify the current food supply strategies, a literature review is performed. Then, to analyse how these strategies work, a multiple-case study in regional Food hubs is performed. RQ2a is studied in Chapter 4.

Afterwards, RQ2b attempts to find which are the impacts of logistic decisions on food supply organization when the food supply strategies are considered. Since the literature provides a set of logistic decisions to consider for food supply organization, this thesis focused on understanding the impacts generated when considering one strategy over another one. This means that this question can be typified as an explanatory research question, and the recommended method used in case study. Multiple-case study and modelisation of supply chains are chosen in order to study the impacts between the different logistic decisions considered. RQ2b is studied in Chapter 5.

Furthermore, RQ3a intends to identify which indicators can be used to assess the economic and environmental impacts of a food distribution system. This research question is both exploratory and explanatory. From the literature review, a set of indicators can be identified and extracted to assess a distribution system. Nevertheless, this thesis focuses on analysing which of those indicators from the literature review are currently used by the stakeholders to assess the food distribution system. Then, a literature review is performed to extract the set of indicators and multiple-case study is chosen to validated its pertinence in the current food system. RQ3a is studied in Chapter 6 and Chapter 7.

Finally, RQ3b inquiries how the changes of a current food distribution system (in a logic of before-after scenario assessment) can be identified and quantified. This research question is explanatory. This thesis focuses on proposing a framework to characterize and assess a food distribution system considering eco-responsible demand. Nevertheless, to understand how a change can be assessed, it is necessary to apply the framework to multiple-case study. Then, multiple-case study in institutional catering sector is chosen to apply and validated the proposed framework. RQ3b is studied in Chapter 6 and Chapter 7.

The research approach of this thesis can thus be summarised as exploration and description in range and explanation in depth. By contrast, all research questions address a well-covered field of literature that then it is validated by applying it to multiple-case study. Table 1.1 details the research approach process followed in this thesis.

Table 1.1: Research approach process followed in this thesis

RQ	Type of RQ	Type of study	Phenomenon	Context
1a	Explorative and descriptive	Multiple-case study	Product environmental criteria	French agro-industrial sector
1b	Explorative and descriptive	Multiple-case study	Logistic requirements for food distribution	French agro-industrial sector and institutional catering
2a	Explorative and descriptive	Multiple-case study	Food supply chain strategies that accomplish the eco-responsible product demand	Regional Food hubs in Auvergne Rhone Alpes region
2b	Explanatory	Multiple-case study	Impacts of logistic decisions on food supply chain organisation	Institutional catering in France
3a	Explorative and explanatory	Multiple-case study	Economic and environmental indicators for food distribution systems assessment	Institutional catering
3b	Explanatory	Multiple-case study	Food distribution assessment	Institutional catering in France an Sweden

1.5 Research methods

Literature review

Literature reviews are performed to answer all research questions, combining different strings in different databases. The literature review is used to increase the knowledge about the research themes and allows to build theoretical frameworks (e.g. Chapter 2 and 5 show), to develop new analysis (e.g. Chapter 3 shows), to map earlier findings (e.g. Chapter 4 shows), to provide input to the assessment (e.g. Chapter 6 and 7 show), etc.

The search terms used for the literature searches are defined as key words related to the topic and then discussed with other researchers in the food logistics, food distribution and eco-responsible demand field. Further, snowballing was used to find relevant literature. The searches were conducted using search tools (e.g. Google scholar) and specific databases (e.g. Science direct and Web of science). The literature review process and screening process were replied (e.g. Chapter 2, 3 and 6) by following the same flowchart for data collection, evaluation and analysis detailed in Figure 1.2. The literature review includes conference proceedings, journal articles, book chapters and grey literature (e.g. technical reports and work in progress) as long as they are mentioned by the search tools considered.

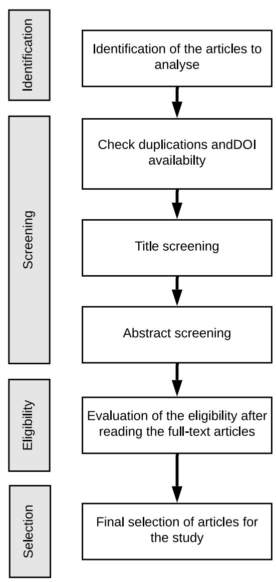


Figure 1.2: Flowchart of literature review and screening process

Case studies

The case definition and selection process were different according to the research question. To answer the RQ1a, stakeholders from the institutional catering sector were chosen, because it is believed that it is a field that is already conscientious of the product environmental criteria that impact the product demand, considering the school meals as an important societal topic. Besides, to validate the environmental criteria extracted from the literature, a set of French companies from agro-industrial sector are chosen. For RQ1b, the same cases were selected in order to compare the logistic requirements for food distribution with the previous product environmental criteria stated.

Moreover, RQ2a focuses on regional food hubs in Auvergne-Rhone-Alpes region to analyse how they supply the institutional catering considering the current organic producers in the region for fruits and vegetables. RQ2b integrates stakeholders involved in the institutional catering for two different school canteen systems in France aiming to analyse the impacts of the logistic decisions considered at strategic and tactical levels and how it impacts on the food distribution efficiency in terms of time and distance travelled.

Then, RQ3a considers the same stakeholders involved in the institutional catering for two different school canteen systems in France aiming to validate the environmental and economic indicators extracted from the literature review to assess the food distribution. Finally, for RQ3b it is considered two different contexts linked to two different countries, France and Sweden with the aim of proposing and generalising a framework for characterisation and assessment of food distribution considering environmental and economic impacts.

Finally, it is necessary to clarify that the sampling of cases is suitable. The relevance of the cases becomes apparent during the research. Finding and choosing relevant factors from the context have been taken place at the same time as the interviews were being arranged. Several stakeholders were contacted by recommendation of the actors interviewed.

By following the sample strategies explained by Flick (2018), the main sampling strategy conducted to answer the research questions proposed in this thesis is the maximal variation strategy explained as follows:

- RQ1a and RQ1b aim to analyse varied companies from agro-industrial sector to validate the product environmental criteria that influence the demand of product, regardless the intrinsic characteristics of the product.
- RQ2a and RQ2b seek to study diverse stakeholders at different stages of the food distribution system that connect the organic and local producers with the consumers. Besides, these research questions pursue to analyse the impacts on the system efficiency of diverse logistic decisions considered at strategic and tactical level.
- RQ3a and RQ3b target to modelise different food canteen system from different contextual factors to validate a framework to characterise and assess food distribution systems.

The criteria for case selection are described in Table 1.2.

Data collection

For data collection, this thesis collects qualitative and quantitative data. For the qualitative data, semi-structured interviews, documentation, survey and direct observation were considered. For quantitative data, data for the literature review and historical demand datasets were considered. Table 1.3 summarises the data collection methods used.

RQ1a: Products environmental criteria

Table 1.2: Overview of case selection

RQ	Case	Sampling	Selection criteria
1a - 1b	French agro-industrial companies	Variation	*Qualifier*: Companies that offer agro-industrial products. *Variation*: Type of product, size of company.
1a - 1b	Stakeholders of institutional catering	Variation	*Qualifier*: Stakeholders involved in the food supply and distribution for institutional catering. *Variation*: Different stage of the food supply chain.
2a	Regional Food hubs and organic producers in Auvergne Rhone Alpes	Variation	*Qualifier*: Stakeholders involved in the offer and demand of local and organic vegetables and fruits for the school canteen system. *Variation*: Type of offer, producer location, food hub function.
2b	Stakeholders of institutional catering in France	Variation	*Qualifier*: School canteen systems in France. *Variation*: Contextual dimensions.
3a	Decision makers in institutional catering in France	Variation	*Qualifier*: Stakeholders involved in the food distribution assessment for the school canteen system in France. *Variation*: Performing actions to assess the food distribution.
3b	Other school canteen system	Variation	*Qualifier*: School canteen system in other country that uses a different food distribution system for institutional catering. *Variation*: Cultural dimensions.

To answer RQ1a, the first step of data collected was based on a literature review, the research terms were considered linked to provide a detailed list or mention environmental characteristics and attributes of products, and to explain green practices and green strategies to improve the product's environmental quality. The total number of documents related to these terms found is 3037. Then, after analysing the titles and abstracts, only 415 papers deal with the product's environmental quality. From this list, 18 explain the characteristics of environmental quality that a product should have; 252 study green practices and strategies to obtain the product's environmental quality; 86 explain the perception of the product's environmental quality. Only two papers link the three concepts. Finally, after a discussion among the researchers, 75 papers were selected according to their content.

The second step aims to represent the product environmental criteria's perception from the practitioners. With this aim, five semi-structured interviews were developed to collect data from the interviewees in terms of explicit and implicit assumptions captured with open questions and theory driven questions. In fact, the environmental criteria extracted from the literature review, in combination with the aim of the research, led to different topics that guided the formulation of the interview questions.

The third step is to contrast and validate the criteria extracted and perceived from the practitioners. For this end, a questionnaire survey for companies in the food

Table 1.3: Data collection description

RQ	Method of collection and data collected	Additional data collection
1a (i.e., literature review)	75 papers	N/A
1a (i.e., criteria perception)	5 semi-structured interviews	Visits and documents
1a (i.e., criteria validation)	248 complete survey answers	Company information
1b (i.e., literature review)	22 papers	N/A
1b (i.e., logistic requirements)	6 semi-structured interviews	Visits and documents
1b (i.e., requirements validation)	248 complete questionnaire survey answers	Company information
2a (i.e., literature review)	57 papers	N/A
2a (i.e., FH for institutional catering)	9 semi-structured interviews	Visits and documents
2a (i.e., organic and local offer)	153 producers information about product offer and location	Documents from Regional Organic Agriculture Observatory
2b (i.e., literature review)	75 papers	N/A
2b (i.e., demand estimation)	School meal demand statistics	Location of school canteens and CK
2b (i.e., organic and local offer)	Product offer statistics	Documents from Regional Organic Agriculture Observatory
2b (i.e., organic and local producers)	10 structured telephone interviews with producers	Producers information
3a (i.e., literature review)	43 papers	N/A
3a (i.e., Env indicators)	Emission database of COPERT V	N/A
3a (i.e., Eco indicators)	Transportation cost database of French National Road Committee (CNR).	N/A
3a (i.e., indicators assessment validation)	4 semi-structured interviews	Visits and documents
3b (i.e. school system description)	3 semi-structured interviews	Visits and documents
3b (i.e. demand estimation)	School meal historical demand statistics	N/A
3b (i.e., Env indicators)	Emission database of COPERT V	N/A
3b (i.e., Eco indicators)	Transportation cost database of Swedish Transport Administration	N/A
3b (i.e. system framework validation)	Group discussion	Documents

industry in France was developed. It is composed of four main sections: (i) respondent information, (ii) product's environmental criteria linked to the raw material and packaging characteristics, (iii) organizational strategies and green practices that the firm performed to increase the product's environmental quality of the product and, (iv) the environmental criteria that the company considers in the supplier selection process. The survey was administrated through a self-completed questionnaire via internet on a survey platform called Limesurvey. The survey was conducted from April to August, 2018. A first pilot survey was carried out face to face among few professionals to validate the understanding of the questions. RQ1a is studied in Chapter 2.

RQ1b: Logistic requirement for food distribution

To answer RQ1b, the first step of data collected was based on a literature review. Research terms linked to logistic requirement for food distribution considering the environmental characteristics defined in RQ1a were considered. 167 documents were found, then after analysing the titles and abstracts, only 74 documents were really dealing with the logistic requirements for food supply and distribution. After a discussion among the researchers, 22 documents were selected according to their content.

The second step is to contrast and validate the logistic requirements from the practitioners. With this aim, six semi-structured interviews were developed. The interview guide is based mainly on the theory driven from the literature review. With the aim of answering to this research questions linked to the first one, in some cases, the same stakeholder was contacted again to better understand the logistic requirements specific to the institutional catering system.

Besides, from the questionnaire survey developed in the previous data collection for RQ1a, the third step considers data collection only from those respondents who affirmed that purchases and distribution practices increase product demand. RQ1b is studied in Chapter 3.

RQ2a: Food supply chain strategies

To answer RQ2a, the first step of data collected was based on a literature review, the research terms are considered linked to food supply chain strategies found in the literature that aim to achieve the environmental criteria of product demand and logistic requirements defined before. This literature review is based on the Food hub strategy that is developed in Palacios-Argüello and Gonzalez-Feliu (2016b); Palacios-Argüello et al. (2017) and considers after a discussion among the researchers, 57 documents that are selected according to their content.

The second step is to explore and describe the Food hubs role in the food supply and distribution. For this end, nine semi-structured interviews were done with different stakeholders at different stages of the school canteen system that work with Food hubs. The interview guide was based on the theory driven questions captured from the literature review and open questions captured from empirical assumptions of the practitioners.

The third step of data collection was to access to producers' information through a dataset collected from the regional organic agriculture observatory (Cor). In this dataset, the information about the producers' location and offer characteristics is detailed. RQ2a is studied in Chapter 4.

RQ2b: Logistic decisions that impact the food distribution system efficiency

To answer RQ2b, the first step of data collected was based on a literature review, the research terms were considered linked to logistic decisions that impact the food distribution system efficiency. Based on decisions at strategic, tactical and operational level, 75 papers were considered after discussion among the researchers.

Aiming to propose a model for demand estimation, the second step considers that it is necessary to have a dataset of school meal's demand statistics that integrates the number of students registered at school and yearly statistics of the students who actually eat at the school canteen. Besides, the local nutritional program was consulted to have an estimation of grams per meal that are suitable for a specific school canteen type.

To estimate the product's offer, a third step of data collection integrated the product's offer statistics in terms of number of producers and type of products offered (i.e., vegetables, fruits, organic and local).

Finally, a fourth step is considered to analyse the food distribution decisions considered by the producer to supply the school canteen system. With this aim, 10 structured telephone interviews were done with producers from the Auvergne-Rhône-Alpes region. The aim of these interviews were to the characterise and analyse the producers' distribution schemes adopted, the producers' production capacities and the logistic requirements specified for the institutional catering system. RQ2b is studied in Chapter 5.

RQ3a: Economic and environmental impacts on food distribution assessment

To answer RQ3a, the first step for data collection was based on a literature review, the research terms were considered linked to indicators to assess the food distribution system impacts. The total number of documents found is 568. Therefore, the list of selected papers are refined by reading the full text and searching for references using citation-tracking databases. After a discussion among the researchers, 43 papers are finally selected according to their content.

The second step for data collection was the environmental coefficient database. They were extracted from the emission database of COPERT V (Computer Programme to calculate Emissions from Road Transport Methodology and emission factors) (Gkatzoflias et al., 2007). The database used for function definition is from 2017 and includes the different euro norms (from 3 to 6).

The third step for data collection is the economic indicators database. The costs linked to the taxes, insurance, maintenance and tires cost have been retrieved from the website of National Road Committee (CNR). Besides, to calculate the diesel cost, an official French website supported by the Ministry of Economy and Finance is consulted, where the French government provides the data of fuel price in France.

Finally, to validate the indicators assessment, four semi-structured interviews were developed. Once the set of indicators is extracted from the literature review and the available official secondary sources, the indicators were validated by the institutional catering stakeholders. During the interviews, data sheets of internal economic assessment used by the stakeholders were provided. RQ3a is studied in Chapter 6 and Chapter 7.

RQ3b: Framework for food distribution characterisation and assessment
To answer RQ3b, aiming to generalise the proposed framework, another food distribution system for school canteen was selected. The first exploratory data collection was made through a visit of the Municipality facility in Sweden. Three semi-structured interviews were done with the stakeholders of the school canteen system. During the semi-structured interviews, the school meal historical demand statistics was obtained as a data input for demand estimation. Then, the environmental coefficients were also extracted from COPERT V and the economic indicators database was extracted from the annual report of the Swedish Transport Administration (Tra). Besides, the diesel cost and liquefied natural gas (LNG) cost were consulted on a website that provides the data of historical fuel price on Sweden (Dis). Finally, a discussion with experts was developed to validate the findings of the framework application on the Swedish case and to collect data for generalisation issues analysis. RQ3b is studied in Chapter 6 and Chapter 7.

Data analysis

In this thesis, a data analysis is performed regarding qualitative and quantitative data collected. The data analysis performed follows the serpentine model proposed by Creswell (2014) that invites to perform an iterative analyses process.

The first step of the data analysis was made during the data collection preparation (i.e., theoretical background to mobilize, topics to include in the interview guide, etc.). Then, the second step of data analysis was made during the data collection, regarding the data collection flexibility (i.e., adapt question from the interview guide during the interview development). The third step integrated a data management analysis where is defined how the data is structured. The fourth step took into account the reading and reflection process based on the data collected. For this step, periodic discussions with the advisers are performed. The fifth step involved description, categorisation and connection of the data collected (detailed in the following subsection regarding qualitative data analysis). Finally, the last step of data analysis was how the data can be visualised and represented to provide the results of the data analysis.

Qualitative data analysis

With regards to qualitative data analysis, for the literature review, semi-structured interviews and survey questionnaire, the analysis proposed by Maxwell (2012) was followed. It involves description, categorisation and connection of the data collected. Table 1.4 describes the data analysis applied for qualitative data.

Besides of the qualitative analyses described, for answering RQ1a, aiming to categorize the environmental criteria extracted from the literature review, a double coding analysis was developed and divided into two steps: intra-coding and inter-coding (Miles and Huberman, 1984). The first one aims to ensure the consistency of the individual coding work, whereas the second one aims to compare each contribution to reach a common data analysis.

Furthermore, for all semi-structured interviews developed, a pattern matching method proposed by Yin (2009) comparing empirical data with predicted patterns was applied. By matching empirical data with the developed frameworks and conceptual models proposed the data was analysed. This data analysis was performed within-case and cross-case analysis aiming to compare findings that differ from context or stakeholders positions.

Quantitative data analysis

With regards to quantitative data analysis, statistical analysis, calculations and modelling methods are used.

- *Statistical analysis*: To analyse the survey questionnaire results, descriptive statistical analysis were performed as well as statistical tests were applied. Chi-square, p-value and cramer-value tests were used to identify the relationships between the variables. These analysis were made with SPAD 5.0 a reference software in data analysis (Coh). Then, considering the historical data from demand at the school canteen, statistical analysis were performed to propose a demand model estimation and using the product offer statistics to estimate the offer' capacity by producer.

- *Calculations*: Those are performed by using the data regarding the transportation cost database of National Road Committee (CNR) (CNR) for the French context and database of the Swedish Transport Administration (Tra).

- *Modelling methods*:
  - Facilities location: Two different methods were compared:
    - Empirical location using the current facilities described in the primary data collected.
    - Computational, using clusters to integrate logistic networks for producers by proposing new facilities' location. For this, two algorithms were used: the Affinity Propagation and K-means.
  - Demand/offer allocation to facilities: Two methods were used:
    - Analytical: allocation based on geographic proximity and based on administrative subdivision.

Table 1.4: Qualitative data analysis

RQ	Describe	Categorise	Connect
1a	Product environmental criteria	Extracted criteria according to: (i) product characteristics, (ii) organisational practices and (iii) supplier selection process.	Product environmental criteria extracted from literature review with criteria perceived by the stakeholders with the criteria validated by practitioners.
1b	Logistic requirements for food distribution	Logistic requirements by: (i) actors in the food supply chain, (ii) product type, (iii) distribution system, (iv) institutional catering system.	Logistic requirements extracted from the literature review with the current requirements from stakeholders with requirements of purchasing and distribution practices developed by practitioners.
2a	Food supply chain strategies that considers product environmental criteria and logistic requirements	Food hubs as suitable strategy for food supply and distribution considering: (i) Stakeholders involved, (ii) FH structure, (iii) FH commercial and logistical functions.	FH characteristics extracted from the literature review with real function of regional FH with current producers that are suitable to use FH.
2b	Logistic decisions that impact food supply chain strategies organisation	Logistic decisions according to: (i) distribution network design (S), (ii) distribution network planning (T), and (iii) transportation planning (O).	Logistic decisions at strategic, tactical and operational level extracted in the literature with distribution decisions to consider for demand and offer estimation, facilities location and allocation, routes construction and efficiency assessment.
3a	Economic and environmental impacts on food distribution	Economic and environmental impacts considering : (i) indicators quality, (ii) validation process and (iii) data production for indicators selection and calculation.	Indicators extracted from the literature review with relevance analysis, context applicability, and, calculation methods adopted by the stakeholders.
3b	Framework to assess food distribution considering efficiency, economic and environmental impacts	Frameworks related to: (i) food supply chain characterisation, (ii) food supply chain modelling and (iii) food supply chain assessment.	Logistic decisions, food system characterisation, demand and offer estimation, location and allocation problems, routes construction, efficiency and impacts assessment.

  * Mathematical modelling, proposing a linear programming model that allows assigning the freight to each echelon considering the distance and demand quantities of each echelon aiming to minimize the total logistic cost. GAMS software with simplex algorithm was used for this data analysis.

- Route construction was performed by using vehicle routing problem (VRP) algorithms. To propose a coherent set of routes, close to those in practice, it is proposed to use the VRP Spreadsheet solver developed by Erdoğan (2017).

1.6 Research quality

Since this thesis research uses qualitative and quantitative methods, it is important to consider research quality criteria that are suitable to this type of research. To that end, Bell et al. (2018) propose four criteria to be considered: credibility or validity, transferability or generalisability, dependability or reliability and confirmability or objectivity.

In this thesis, to ensure credibility, the triangulation approach was applied. In all cases, respondent validation continued through analysis of the data collected. Therefore, the credibility was reinforced by proposing results discussion with key food distribution stakeholders, which enabled the triangulation of sources by combining quantitative and qualitative data, such as interview guide emerged from literature review, results discussion and validation to the theory.

Moreover, to ensure transferability, the generalisability of the results has been discussed aiming to put forward the context in which the results are valid. To generalise the framework proposed to other contexts and taking into account that no one-size-fits-all solution exists, this thesis ensures transferability by applying two approaches proposed by Bell et al. (2018); Eisenhardt (1989): (i) to describe the thesis findings in a set of conference papers and journal articles already published to enable the framework's transfer to other context; (ii) to use case study to help readers to understand whether the framework findings could be transferred. Chapter 7 describes the generalisability issues of the framework proposed. In addition, the general application of the findings is reached by the fact of having applied interviews with multiple respondents, multiple round of interviews and the richness of detail during the interviews.

Besides, to ensure dependability and by following the reliability aspects proposed by Bell et al. (2018), this thesis ensures reliability with a documentation of the research process and review of findings by peers. To answer to all research questions, method descriptions referred to sampling, data collection and data analysis are explained. In fact, for RQ1a to RQ3b interviews guides were used and interviews were audio-recorded with the permission of the interviewed. For the efficiency and impact assessment, all the VRP excel files as well as the COPERT extraction in excel files were saved.

Finally, to ensure confirmability or objectivity of the thesis results, it was established collaboration discussions with the project leaders and other researchers and practitioners. Besides, during the process of conference papers and journal papers redaction, the results were discussed and determined by consensus with both academic and industry representatives. At last, to gather input from other academics, the thesis results were presented at different conferences and workshops and received feedback from attendees. A research exchange in a Swedish university was also performed during the thesis development as another mean to confirm the thesis results. The details of such papers have been presented in conference and submitted to journals are presented at the beginning of each chapter. Additionally, to receive input from the practitioners, a workshop was organised to present the thesis results during the spring of 2019. This presentation afforded useful feedback about the findings presented and possible collaborations in the future based on the framework proposed.

Part I

Eco-responsible food demand

Chapter 2

Environmental criteria that impact the product demand

Contents

The work described in this chapter has been presented in the 2018 International Conference on Information Systems, Logistics and Supply Chain (ILS) (Palacios-Argüello et al., 2018a) and submitted for publication in the Journal of Cleaner Production. This work was mainly conducted during the CONCLUDE project that was financed by the French National Agency for Research (ANR). The statistical work described in this chapter had been performed with the collaboration of M. Girard from Ecole de Mines de Saint-Etienne. The selection of environmental criteria had been made in collaboration with I. Nouira from Rennes Business School. The double-codage work described in this chapter had been performed with the collaboration of S. Hajboune from École de Mines de Saint-Etienne.

To answer the first research questions (RQ1a), this chapter presents a review of the definition of product environmental quality to identify which environmental criteria may impact product demand. These criteria are related to the product's environmental characteristics, to the organisational strategies and green practices developed by the companies, and to the supplier selection process. Then, a set of environmental criteria that impacts the product demand are extracted, selected and validated.

2.1 Introduction

Nowadays, firms offer more products with high environmental quality by improving the environmental performance of their products (Mantovani et al., 2016). However, the concept of product's environmental quality is very broad and covers very different aspects, which generates confusion about the concept and does not give clear directions to companies willing to offer products with a high environmental quality. Clarifying this concept may prevent the company and consumer from misinterpreting the "technical" environmental performance of a product and the green image that can be associated with its consumption.

Nonetheless, several terms may refer to what is called "product's environmental quality" by Nouira (2013). These terms refer more generally to the environmental attributes of the product. These attributes are divided according to consumer perception by Deltas et al. (2004) in vertical and horizontal. The "vertical" attributes are related to decisions that influence the technical characteristics of the product (such as design decisions that influence the environmental impact through the product lifecycle) and the "horizontal" attributes are related to decisions that influence the environmental image of the product (Brécard, 2014; Gupta and Palsule-Desai, 2011; Mantovani and Vergari, 2017; Nouira, 2013).

Nonetheless, different definitions of these environmental attributes can be found in the literature dealing with concepts such as eco-efficient product, eco-friendly product, sustainable product, and green product's issues. The first two concepts are more related to the results of the assessment process rather than the product itself:

- Eco-efficient and eco-friendly products refer to reduction of the environmental impact through the product lifecycle. They are defined by addressing ecological and economic issues.

- Sustainable products can bring environmental, social and economic benefits. This concept does not refer exclusively to environmental impacts. "Green" products are supposed to generate fewer environmental impacts than conventional products.

These definitions highlight the importance of the environmental assessment through the product lifecycle and underline the importance of a real environmental approach.

In the literature review, different tools to assess the product's greenness were found, while the most common is the Products Life Cycle Analysis (PLCA). The European

Commission proposed in 2012 to build the "Single Market for Green Products" to provide better information on the environmental performance of products. It defines green products as those that use resources more efficiently and cause fewer environmental damage to similar products in the same category, through their lifecycle, from raw material extraction, production, distribution, use, to the end of their useful life (including reuse, recycling and recovery). "Green products" exist in any product category, regardless of being eco-labelled or marketed as green; in fact, it is their environmental performance that defines them as "green" (European Commission, 2012). The European Commission proposed the Product environmental footprint (PEF) as a multi-criteria measure of the environmental performance of a product or service throughout its lifecycle. Its objective is to reduce the environmental impacts of products considering supply chain activities based on the Life-cycle assessment approach. Nevertheless, the European Commission recognises that "there is no widely accepted scientific definition of what a green product and a green organisation actually are" (European Commission, 2013).

Numerous standards are proposed for assessing the environmental performance of products. These standards can be obtained from a number of sources: (i) models (such as internal and external organisational models), (ii) product standards (including government legislation and voluntary practices such as green strategies and green practices), (iii) industry guidelines (corporate goals), and (iv) environmental sustainability requirements (such as eco-labels). Similarly, industries integrate environmental issues into their strategic decisions (Handfield et al., 2002). Not only because they must follow governmental legislation, but also because, end-users are becoming more aware and have been attracted by green industries offering eco-responsible products (Ghadimi et al., 2016).

In this context, the business customers, stakeholder, and end-consumers can act as drivers of environmental performance: (1) large customers (business customers) encourage suppliers to improve their environmental performance by selecting suppliers on the basis of green criteria. They also act as a driver by promoting environmentally friendly practices (Ghadimi et al., 2016). (2) Stakeholders realize that green purchasing could positively affect cost, operational and corporate performance along environmental dimensions (Handfield et al., 2002). (3) End-consumers demand green products and components, favouring companies that offer them (Ghadimi et al., 2016).

Several studies focus on the B to C product's environmental quality based on end-customer perception (Dagiliūtė et al., 2018; Portnov et al., 2018; Tan et al., 2016; Yang et al., 2015; Zhang et al., 2018) . However, few papers focus on B to B context based on large customer and stakeholders' criteria selection (Li et al., 2018; Wang et al., 2018). This can be explained by the fact that firms are reluctant to share information, which makes data collection difficult.

Both practitioners and researchers consider the existence of a correlation between the product demand and its environmental quality (see for example (Garg, 2015)). However, none of the existing papers gives a clear idea of the environmental criteria that actually impact the demand. This is reflected in the fact that various industrial sectors are considering different environmental criteria to show the environmental quality of their products. Indeed, several companies use eco-labels, some consider the carbon footprint as an environmental criterion, and others describe their social or environmental actions on the packaging of their products trying to attract customers sensitive to sustainability issues. Obviously, this non-uniformity on environmental criteria can derive from a misunderstanding on the environmental criteria that really impact the customers and consequently the product demand. This is why, it is necessary to understand which environmental criteria impact the product demand for industrials and managers.

Nevertheless, many researchers tried to assess the impact of product environmental quality on the product demand, and consequently, on their supply chain decisions (Anderson et al., 2005; Dong et al., 2016; Du et al., 2016; Jiang and Chen, 2016; Nouira, 2013; Nouira et al., 2016; Xiong et al., 2016; Xu et al., 2017; Yalabik and Fairchild, 2011; Yenipazarli, 2016; Zheng et al., 2016). These works attempt to model demand as an endogenous function depending on the product's environmental quality. They consider different criteria for describing environmental quality and most of them stress the need for conceptual works that evaluate the relation between the product's environmental quality and its demand, to understand which environmental criteria are really impacting the customer sensitivity and, consequently, on the product demand.

Within this scope in mind, the aim of this chapter is to answer to the following research question: *Which environmental criteria related to a product have an influence on its demand?*.

Furthermore, the motivation of this research is to provide insights to contribute on the understanding of the eco-responsible product demand forecasting. It is assumed that the environmental criteria differ from one industrial sector to another. Therefore, this study focuses on the French food sector.

In section 2.2, concepts related to eco-responsible product will be defined through the revision of the literature review. Then the main concepts will be explained related to: (i) the product's environmental characteristics, (ii) the organisational strategies and green practices developed by companies, and (iii) the supplier selection process. Three hypotheses will then be proposed regarding the link between the three main concepts and product demand. To conclude the section, the conceptual approach proposed will be described.

In section 2.3, it is explained how the environmental criteria extracted from the literature review are validated through three methods: (i) double coding analysis performed by two different coders(ii) semi-structured interviews with stakeholders in the French agro-industrial sector, (iii) on-line survey of 248 companies from the food industry in France. Data collection, assessment and analysis are explained.

Section 2.4 describes the main results of the methods proposed and explains the descriptive statistic and test carried out with the on-line survey results. In section 2.5, there is a discussion of the results regarding the validation of the hypotheses proposed. Finally, section 2.6 presents the main conclusions related to the research question proposed.

2.2 Literature review: Eco-responsible product demand

A rigorous, systematic and reproducible literature review is proposed to consolidate existing literature, and identify the gaps and barriers.

Literature review methodological approach

The collection of material was mainly based on a documentary gathering. The scopus database was used to identify and quantify the published articles, considering that Scopus shows a broad view of global and interdisciplinary scientific work on a specific research topic. Databases from major publishers and library services, such as Science direct, Emerald and Springer were then selected to compare and complete the list of articles compared to the results obtained from Scopus and Web of science.

Regarding the inclusion criteria, firstly, the main keywords of the research problem were defined so that the search would be as focused as possible. To select the search terms, it was necessary to choose those that are closely related to the research topic (including alternative words and abbreviations). The keyword equation was considered to define the use of Boolean operators and get the right information. After that, the time period was defined. Finally, regarding the field codes, the research was based on the abstracts, titles and keywords of published papers.

The first selection included conference proceedings and grey literature (i.e. technical reports and work in progress). Then to more accurately answer the first research question, a second round of keyword inclusion was conducted. Finally, a third round was performed to select only those documents that : (i) provide a detailed list or mention environmental characteristics and attributes of products, and (ii) explain green practices and green strategies to improve the product's environmental quality. Table 2.1 shows the main inclusion criteria considered.

The total number of documents found is 3037. Therefore, only 2333 papers with DOI have been selected to ensure their publication and electronic availability. After having selected only the publications of the last ten years, 2154 papers were considered.

Then, after analysing the titles and abstracts, only 415 papers deal with the product's environmental quality. From this list, 18 explain the characteristics of environmental quality that a product should have; 252 study green practices and strategies to obtain the product's environmental quality; 86 explain the perception of the product's environmental quality. Only two papers link the three concepts (Brécard, 2014; Dangelico and Pontrandolfo, 2010). Figure 2.1 shows the number of papers found by topic and covering various topics.

Finally, the list of selected papers was refined by reading the full text and searching for references using citation-tracking databases. After a discussion among the researchers, 75 papers were selected according to their content.

Table 2.1: Inclusion criteria

	First round	Second round	Third round
Keywords	Green Supply Chain, Environment, Eco-product, Supply Chain, Purchase decisions	Green product, eco-responsible product, sustainable product, eco-efficiency product.	Product's environmental quality, product's environmental attributes
Document type	Paper, book chapter, conference paper, article in press	Paper, book chapter, conference paper, article in press	Paper, book chapter, conference paper, article in press, technical reports
Time interval	2007 – 2017	2007 – 2017	1987 – 2017
Language	English	English	English

Driving concepts and hypotheses

Different criteria that influence the environmental quality of a product were extracted from the literature review. About 300 criteria were found. These criteria can be classified into three groups. The first group represents the criteria related to the product characteristics that are indicated in the following sections by "intrinsic characteristics". The second group is related to the supply chain practices that impact the environmental quality of a product. Finally, a third group is proposed that represents the criteria related to the selection of suppliers according to their environmental performance. This subsection presents the environmental criteria cited and studied in the existing literature. Then, a comprehensive framework is presented to structure the different environmental quality criteria.

The meta-narrative analyses applied by Gonzalez-Feliu (2011); Greenhalgh et al. (2005) were used to define a general framework for structuring the different environmental quality criteria. A meta-narrative comprises "a shared set of concepts, theories and preferred methods" and "is cited within a particular scientific discipline and should be regarded not as the unified voice of a community of scholars but as the unfolding of what they are currently discussing about" (Greenhalgh et al., 2005). This means that meta-narrative analyses are related not to words but to concepts. Indeed, researchers and scholars from different or similar research communities may explain and describe product's environmental criteria in different words but may refer to the same concept.

Definition of the intrinsic environmental characteristic of the products

This subsection aims to establish the environmental criteria related to the product's characteristics and environmental attributes that define the "environmental quality" of

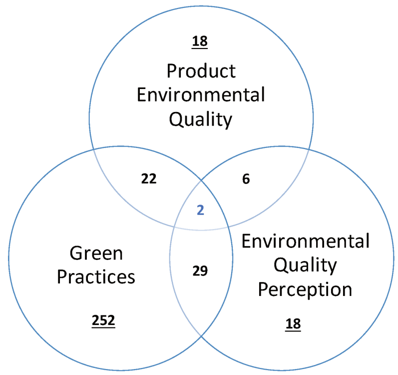


Figure 2.1: Number of papers found

a product.

Nouira (2013) affirms that the product's environmental quality (PEQ) is linked to the rate of green components used. Besides, Brécard (2014) suggests that the product's environmental quality may differ depending on the stringency of eco-labelling standards. Deltas et al. (2004) suggest that product's environmental criteria could represent the energy efficiency of the product and the degree to which the product can be recycled. This last notion of product recyclability is defined as product's environmental criterion by (Alwitt and Pitts, 1996; Giancarlo, 2005; Yenipazarli and Vakharia, 2017). Similarly, Chen (1994) defined as product's environmental quality criteria: product durability, reparability, and material usage. Chen (2001) states as important environmental criteria of the product: recycled content, energy- and fuel-efficiency, and non-toxicity (Yenipazarli and Vakharia, 2017).

Soylu and Dumville (2011) define product's environmental quality (PEQ) criteria that include attributes such as: (1) be free from toxic substances, (2) be biodegradable, (3) be recyclable, (4) be upgradeable, (5) have low energy conversion.

Villanueva-Ponce et al. (2015) define the rate of disassembly, recycling, and green raw materials as product's environmental criteria. D'Souza et al. (2006) state that an important product's environmental criterion that is perceived by the customer is the product's environmental label. These labels can be: environment-friendly, ozone-friendly, earth-friendly, degradable, recycled, recyclable, renewable, reusable and biodegradable.

Besides, Dangelico and Pontrandolfo (2010) affirm that the product's environmental criteria are related to products that conserve energy and/or resources and reduce or eliminate the use of toxic agents, pollution, and waste.

Yang et al. (2003) define a product with environmental quality as the product that offers:

1. Excellent environmental performance: The product can minimize the impact on the environment.

2. Full use of material resources: It reduces the quantity of material, especially rare or expensive material and poisonous or harmful material.

3. Efficient use of energy resources: It maximizes the use of resources and reduces the consumption of the energy resources in its life cycle.

According to Lindgreen et al. (2009), the key environmental characteristic of the products are: reducing energy consumption, packaging materials, hazardous substances and product weight, increasing recycling levels and safety measures during product disposal.

In summary, the environmental criteria extracted from the literature review that relate to product characteristics and the environmental attributes that define the "environmental quality" of a product are as follows:

- Raw materials: this category includes the characteristics of raw materials that improve the product's environmental quality, such as environmentally certified raw materials, less polluting or non-polluting/toxic materials, capacity to recycle various materials among others.

- Packaging: this category includes the characteristics of the product packaging such as recyclable, biodegradable, reduced size and weight packaging, and environmental information on the product packaging, among others.

The first hypothesis is therefore proposed as follows:

Hypothesis 1. The intrinsic environmental characteristics of the product contributes to the product environmental quality and may impact the product demand (remains stable, decreases or increases).

Organisational strategies and green practices

This subsection establishes the environmental criteria related to green practices and organisational strategies that may improve the environmental quality of a product.

Gupta and Palsule-Desai (2011); Mantovani and Vergari (2017) define practices that improve the product's environmental quality as the practices that aim to reduce emissions, amount of waste generated or disposed, and the increase of the energy efficiency. Besides, Nouira (2013) states that product's environmental quality is linked to carbon emissions from transport activities; as well as to the emission rates generated by selected production process. Similarly, Feng et al. (2017) consider as environmental attributes the carbon emissions and energy efficiency associated with the manufacture of the product.

Brécard (2014) affirms that the product's environmental quality may differ according to the phase of the product's life cycle. Deltas et al. (2004) state that the product's environmental criteria could represent the reduction in pollutants generated during the product's manufacture or during the use of the product. Dunk (2004) supports the fact that the product's environmental quality (PEQ) is largely fixed at the design stage.

Chen (1994) explains that the fact of having environmental policies during product development is an important purchasing practices to improve product's environmental quality. These environmental policies can be defined as the best combination of material usage, choice of material, waste emission and cost-effectiveness without compromising product quality. This is confronted by (Ottman et al., 2006), which states that the greenness of a product depends largely on the characteristics of its manufacturing process (Dangelico and Pontrandolfo, 2010). These characteristics can be the prevention of air, water or noise pollution through production and distribution processes (Yang et al., 2003).

Likewise, manufacturing and transport decisions, such as the selection of clean technologies, may have environmental impacts (e.g. reduced carbon emission and energy consumption during production) and potentially impact the company's environmental image (Nouira et al., 2014).

In a Business-to-business (b-to-b) context, "greening" the supply chain should include the dissemination of the best environmental practices. Such practices can be intra- and inter-firm. These practices can be: environmental technology transfer, cooperation and partnership practices, and environmental performance measurement. Likewise, another internal practice adopted by organisational buyers is to privilege formal partnerships and collaboration agreements between stakeholders in the supply chain (Fraj et al., 2013). Similarly, (Fraj et al., 2013; Garg, 2015; Sharma et al., 2010) propose that the integration of such environmental practices should be communicated through the use of marketing.

Regarding the use of marketing, Fraj et al. (2013) define Green marketing strategy (GMS) as an approach that incorporates: (1) practices that b-to-b customers carry out on products and processes to satisfy the environmental demands of their customers; (2) Decisions of b-to-b customers to communicate "an environmentally responsible behaviour" to stakeholders. Consequently, green marketing is a vast subject that includes information on a wide range of activities such as product design, manufacturing process, service delivery processes, packaging, recycling, among others (Vaccaro, 2009).

In summary, the environmental criteria extracted from the literature review relate to supply chain practices that improve the product's environmental quality are:

- Purchasing: this category includes criteria related to the location of the supplier, the environmental impact of purchased materials, the environmental practices performed by the supplier, green purchasing guideline, and environmental partnership or environmental cooperation agreements with suppliers.
- Manufacturing: this category includes criteria related to decision on location of manufacturing facilities and warehouse, as well as practices aiming to the energy efficiency and eco-efficiency during the manufacturing process.
- Distribution: this category includes criteria related to decision on location of distribution points, energy efficiency of distribution, eco-efficiency of distribution (related to the reduction of transport emissions and pollution control).
- Reverse logistics: this category includes criteria related to the formal policy on reverse logistics of the product and packaging.

- Collaboration between supply chain stakeholders: this category includes criteria related to customer management practices, efficiency of green network, assessment of the product's environmental performance throughout the supply chain and the implementation of the environmental management system (EMS).

The second hypothesis is proposed as follows:
Hypothesis 2. The organisational strategies and green practices within the supply chain contribute to the product's environmental quality and impact product demand (remains stable, decreases or increases).

Supplier selection based on environmental criteria influencing the product demand

This subsection aims to identify the environmental criteria related to the supplier selection processes that are considered to improve the product's environmental quality. This is an important issue because sometimes the customer may not be aware of the product's environmental quality due to suppliers who did not communicate their strategies and green practices. This is as (Lacoste, 2016; Simula et al., 2009) called "missed opportunity" to gain a competitive advantage and, consequently increase the product demand.

On one hand, regarding the final customer behaviour (in a B-to-C context), Garg (2015) affirms that there is a positive influence of green marketing strategies on the customers purchasing patterns. Their perception of the product's environmental quality is influenced by the use of eco-labelling, recyclable packaging, and product claims such as "eco-friendly", "recyclable", "biodegradable" and "ozone-friendly".

On the other hand, the business customers (in a B-to-B context), are more concerned about the real product's environmental quality, which can be assessed through a standard reference model developed by each company for the selection of its suppliers (Sharma et al., 2010). They also consider the communication of green practices and strategies related to environmental certifications, eco-labelling or eco-design. Fraj et al. (2013) explain that large companies could gain credibility by emphasizing their environmental activities to their business customers. Likewise, business customers could be more reliable by emphasizing environmentally-friendly policies in their transactions with other companies, as they put pressure on organisations to be environmentally-conscious.

Purchasing managers may request their suppliers or subcontractors to be certified (e.g. ISO 14001) because they are responsible not only for the procurement of raw materials but also their disposal at the end-life of the product, with extended producer responsibility (Handfield et al., 2002). Sarkis (2003) states that a green product depends on its supplier's components. This means that a supplier can be considered as a green supplier if it offers green components and/or has environmental certifications such as ISO14001. This is reflected in the requirement made by commercial customer to their suppliers to have the environmental management system certification (Fraj et al., 2013).

Nouira et al. (2014) affirm that the supply chain decisions, such as the selection of components used to manufacture a product have a direct impact on the product greenness.

Likewise, Villanueva-Ponce et al. (2015) define as product's environmental criteria related to supplier selection: green product design practices, environmental regulations certification and environmental audit process, the supplier's green image, the supplier's environmental competencies.

Besides, many environmental criteria can be used to select suppliers. Nevertheless, according to Jabbour and Jabbour (2009), the criteria used are proportional to the environmental demand of final consumers. Besides, most of the criteria selected are used to estimate environmental impacts (Igarashi et al., 2013). However, the classification of criteria varies among studies.

Indeed, the product's environmental criteria in a B-to-B context may be perceived in different ways. (i) How customers perceive the products' environmental quality must be distinguished from how the manager assess the environmental attributes (Garg, 2015). In fact, (Fraj et al., 2013) affirm that the background of the decision makers is reflected in their choices and sometimes determines the perception of environmental quality. (ii) The supply chain position of the customer and the power balance between buyers and supplier may influence the environmental criteria for the supplier selection (Igarashi et al., 2013).

Furthermore, considering environmental criteria for suppliers' evaluation might not increase the products demand but rather select the right suppliers. It can eventually be a driver for widening a company's profit margin, reduce purchasing cost, improve competitiveness and enhance end-user satisfaction among others (Ghadimi et al., 2016).

In summary, the environmental criteria, extracted from the literature review, which are related to supplier selection process with the aim of improving the product's environmental quality, are:

- Product's environmental quality offered by the supplier: This involves product labelling, environmental information about the product, raw materials origin.

- Supplier practices: It involves criteria related to supplier's internal practices such as eco-conception (e.g. innovation capacity), supply management, production and quality (e.g. supplier's reputation), distribution (delivery conditions), collaborative practices and marketing strategies (e.g., environmental management systems, environmental certifications and green image).

Then, the third hypothesis is proposed as follows:

Hypothesis 3. The environmental criteria used in supplier's selection process contribute to the product's environmental quality and may impact the product demand (remains stable, decreases or increases).

Conceptual model

A conceptual model is proposed from the results of the literature review presented above. Figure 2.2 presents an overview of the proposed constructs and their relationships. In a context Business to Business (BtoB), on one hand, there are green strategies and practices that aim to improve the environmental quality performance of the product. On the other hand, the product's environmental quality (PEQ) is perceived by business customers when they select green supplier, influenced by the supplier's green marketing strategy and based on its own competitive advantage.

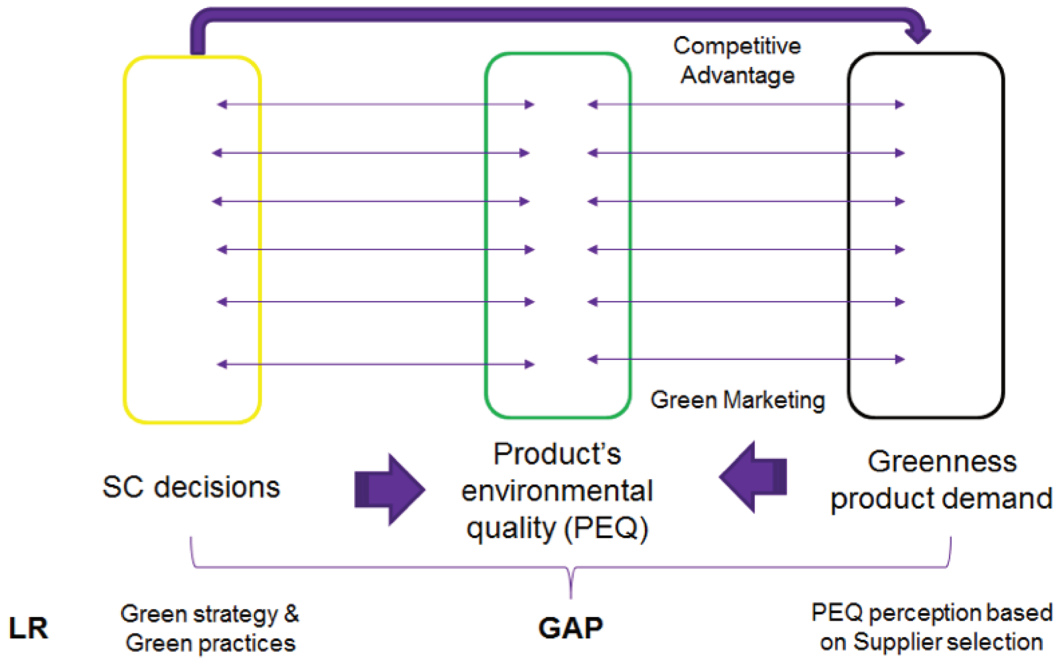


Figure 2.2: Conceptual approach proposed

2.3 Material and method: Product's environmental criteria validation

Figure 2.3 shows how the criteria are extracted and validated through three methods: (i) double coding analysis performed by two different coders(ii) semi-structured interviews with stakeholders in the French agro-industrial sector, (iii) on-line survey of 248 companies in the food industry in France.

Data collection

Data collection includes primary and secondary data. Secondary data are used for a documentary analysis of the environmental criteria extracted from the literature review. The classification of the categories is then validated by double coding analysis. These data are complemented by primary data collected through semi-structured interviews and the development of an on-line survey.

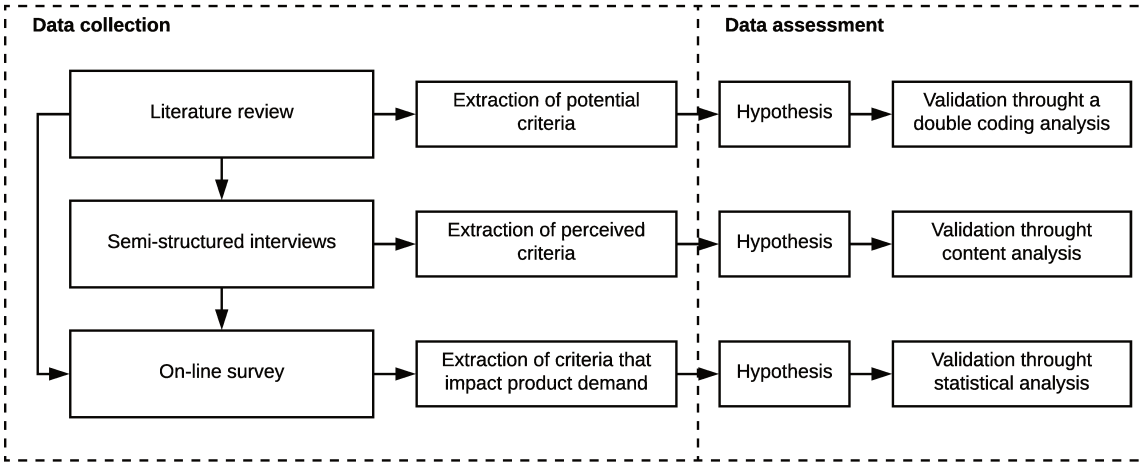


Figure 2.3: Methodology for extracting and validating product environmental criteria

Double coding analysis

To categorize the environmental criteria preselected from the literature review and extracted from the bibliographical research, a double coding analysis is developed. The double-coding can be divided into two steps: intra-coding and inter-coding (Miles and Huberman, 1984). The first treatment performed by the coder is to ensure the consistency of his own work by reviewing his results regularly. As for the second treatment, the results obtained by the two coders are compared to ideally arrive at a common resolution of each contribution. The disagreements and dissonance results allow researchers to reach a common vision of data categorization. This method not only helps to have a clear idea on the research issue, but also provides a good reliability on the criteria selected. As a result, the typology of product's environmental criteria are presented in Appendix .1 and Appendix .2.

The main categories used by the two coders (first level of typology in Appendix .1and Appendix .2) are the same, however, the subcategories (such as O1.1) are different. The results show a similar proportion for each category and its range with slight differences. Qualitatively, each coder developed her own classification in terms of subcategories, the first coder established 18 subcategories and the second coder established 20 subcategories. However, there are similarities in some cases, but with a different formulation, other subcategories are either split or grouped. Regarding the double-coding results, the product's characteristics are the same criteria for both coders but criteria related to practices present differences between coders that are described in Table 2.2.

Finally, it can be concluded that the overall results are very similar. This categorization of the criteria is used as the basis for the design of the on-line survey, which attempt to identify the relative weight of each type of criterion on the impact of product demand.

Table 2.2: Criteria categorisation results from double coding analysis

Categories	**Coder 1**	**Coder 2**	**Gap between coders**
Product characteristics	12%	12%	0%
Purchasing	15%	10%	5%
Manufacturing	12%	11%	1%
Distribution	17.7%	21%	3.3%
Use	5.7%	6%	0.3%
Reverse logistics	10.6%	12%	1.4%
Collaboration	27%	28%	1%

Semi-structured interviews

The semi-structured interviews are based on open-end questions to stakeholders that belong to the food industry in France. The sample was designed following the snowball sampling method (Bell et al., 2018), starting with the contacts of the organic-local food distribution system.

To conduct semi-structured interviews, two documents were created: an interview protocol, and an interview guide. The protocol was used to explain the interview development: the aim of the study, the time, the type of questions, the issues to be addressed, the feedback, and the use of the information. The interview guide was developed following the IDPA model (in French : Identification, Diagnostic, Prospective, Amélioration) developed by Ollagnon (1987). This model establishes four phases: (1) identification of the situation, (2) diagnosis, (3) foresight and (4) improvement. This guide was used to make the questions as effective and efficient as possible without forgetting any important issue to collect and document all impressions and experiences from each interview. The interview guide is showed in Appendix .3.

The research focused on stakeholders related to the organic-local food distribution system. In total, five semi-structured interviews were conducted (see Table 2.3). They lasted between 30 and 90 minutes and were conducted in French.

Regarding the qualitative data analysis, to verify the research quality approach (Bell et al., 2018), additional discussions were held with researchers to ensure that a sufficient number of stakeholders were interviewed and that the perspective would be to extract environmental criteria perceived by stakeholders as criteria that impact product demand. The results of the interview analysis were discussed by the authors and with the help of secondary data, a synthesis of the analysed interviews was made. To increase trust-worthiness, secondary data were read prior to the meetings. This was done to reduce the possible misunderstanding between interviewers and interviewees.

Table 2.3: Information about interviewees

Stakeholder	Position of the interviewee(s)	Date of the first interview
Organic producer platform	Manager of organic-local offer for institutional catering in Rhône and Loire departments.	20/10/2017
An expert on organic food distribution in the catering sector	Regional manager of organic-local offer for institutional catering in Auvergne-Rhône-Alpes	23/11/2017
Fresh food distributor	Logistic Regional Manager	05/12/2017
Expert on organic food supplies	Regional manager	26/01/2018
Meal contractor	Manager of the meals distribution for school canteens at Saint-Etienne	16/02/2018

On-line survey

The on-line survey was based on the environmental criteria extracted from the literature review. It is composed of four main sections. The first section covers the objective of the research, the description of the survey and the academic purpose from the data collected. It also includes questions about the characteristics of the company, the position of the company in the supply chain, the experience of the respondent, the current area and job title. Depending on the area where the respondent works, three other sections are proposed. The second section focuses on questions about the product's environmental criteria regarding the raw material and packaging characteristics. The third section focuses on organisational strategies and green practices that the firm performed to increase the product's environmental quality of the product. The fourth section focuses on the environmental criteria that the company considers in the supplier selection process. Finally, at the end of the section, the quantification of the impact of this criterion on product demand is requested.

The survey was administrated through a self-completed questionnaire by internet on a on-line survey platform called Limesurvey. The survey was conducted from April to August, 2018. First, a pilot survey was carried out among few professionals to validate the understanding of the questions.

Regarding the sample, the respondents' database was obtained from three different sources: (i) 6150 e-mails addresses of agro-industrial managers from companies in France, obtained through the company Kompass, which is a global on-line directory of companies. (ii) 850 emails from producers, transformers and distributors from the agro-industrial sector, obtained through the Auvergne-Rhône-Alpes Observatory. (iii) 450 e-mails addresses of agro-industrial companies managers in Bretagne Region, obtained through the Rennes Business School. The invitation to answer to the questionnaire was sent to 7450 professionals and, after e-mails addresses validation, the final size of the population obtained was 5820.

In total, 555 anonymous questionnaires were received, 307 questionnaires were excluded due to incomplete information, leaving 248 valid questionnaires. Following the sample size formula suggested by Krejcie and Morgan (1970) considering that the population size is 5820, a sample with 95% of confidence level should be 359 valid questionnaires; this means that the number of stakeholders surveyed was not sufficient. Nevertheless, the length of the survey (57 questions), as well as the answer time (between 19 and 90 minutes) should be taken into account. Besides, contrary to most studies that can be found in the literature, this study is placed in B-to-B and not B-to-C context. Therefore, this study is an original contribution to understand the influence of product's environmental quality on the product demand in the French food sector.

The composition of the sample of respondents is shown in Table 2.4. The majority of the respondents work in small and medium companies. However, 43% of the total companies surveyed are part of a group. Industry types were grouped according to their main activity based on the typology of the National Institute of Statistics and Economic Studies (Insee). Despite some biases due to sampling and clustering of industries, the distribution among the study industries is fairly representative. The profile of the respondents is over 90% of high qualified profiles, including executive officers and engineers. This fact is confirmed by the years of experience that respondents have in that job, the majority has over 6 years of experience in that job, and more than 50% of the respondents has over 10 years. Finally, each area involved is between 10% and 20% of the total answers, which means that each area is fairly representative in the study.

Data assessment

The data assessment and the statistical analyses are based on the 248 complete answers received.

Conception of the on-line survey

The questions in the three parts of the questionnaire on the demand impact were created in reference to the environmental criteria of products characteristics, organisational strategies/practices, and suppliers' selection, which are mentioned in the literature review above. The questionnaire reproduced in Appendix.4, was designed as a compromise between the information needed to validate the hypotheses presented above and the limited amount of time the target respondents had available. In total, the survey has 57 questions. The first twelve questions are mandatory and, according to the respondent's area of work, the other questions are asked. The type of question for the on-line survey is described as following:

- 28 Multiple choice questions representing 49.1% of the survey.
- 3 Dichotomous questions (Yes/No) representing 5.3% of the survey.

Table 2.4: Respondents' demographics

		N	%
Company size			
	Micro: 5 employees or less	13	5.2%
	Small: Between 6 and 50 employees	111	44.8%
	Medium: Between 51 and 250 employees	84	33.9%
	Large: Over 250 employees	40	16.1%
Group			
	Part of a group	107	43.1%
Industry type			
	Fruit and vegetables industry	19	7.7%
	Meats industry	43	17.3%
	Fish industry	13	5.2%
	Grain industry	16	6.5%
	Dairy industry	29	11.7%
	Beverage industry	10	4.0%
	Pasta and Bakery industry	34	13.7%
	Animal feed industry	17	6.9%
Job position			
	Executive officer	170	68.5%
	Engineer	55	22.2%
	Technician	20	8.1%
	External consultant	3	1.2%
Experience			
	Less than 2 years	19	7.7%
	Between 2 and 5 years	41	16.5%
	Between 6 and 10 years	42	16.9%
	Over 10 years	143	57.7%
Area			
	CSR - Quality	139	19.8%
	Purchasing - Supplies	104	14.8%
	Production	101	14.4%
	Logistics	72	10.3%
	Marketing - Distribution	100	14.2%
	Communication / Marketing	84	12.0%
	Direction - HR	102	14.5%

- 11 Closed-ended questions using Likert scale based on semantic differential scale method, which represents 19.3% of the survey.
- 15 Open-ended questions representing 26.3% of the survey (e.g. detailed comments and opinions on the development of the survey).

Data analysis: Common method variance

Chi-square was used to test differences and links between variables. The p-value was used for statistical hypotheses testing; a small p-value (typically ≤ 0.05) indicates strong evidence against the null hypothesis (H0) and consequently the null hypothesis is rejected. In fact, the null hypothesis states the non-existent of association or difference between variables. A large p-value (>0.05) indicates weak evidence against the null hypothesis, which means that the null hypothesis cannot be rejected. Then Cramer's V is used to measure association between two variables (Cramer, 1946). Table 2.5 shows the values, giving a value between 0 and +1 (inclusive).

Table 2.5: Cramer's V : Strength of the statistical association

Cramer's V	Nature of association
0.00 - 0.04	Lack of rapport
0.05 - 0.10	Very weak
0.10 - 0.20	Weak
0.20 - 0.40	Moderate
0.40 - 0.80	Strong
0.80 - 1.00	Very strong

2.4 Findings: Link between the product's environmental quality and product demand

Semi-structured interviews' results

This subsection explains the results of the first validation of the product's environmental criteria by a group of actors in the food industry. Table 2.6 shows the categorization of the criteria validated by each actor.

Based on the feedback from the development of the semi-structured interviews, 78% of the environmental criteria related to the product's characteristics were mentioned directly or indirectly during the interviews. Besides, 100% of the environmental criteria related to organisation strategies and green practices were mentioned directly or indirectly during the interviews. Extractions from the interviews are presented in Table 2.7, 2.8, 2.9, 2.10, 2.11.

Table 2.6: Criteria according to the semi-structured interviews

Stakeholder	**Product's characteristics**	**Organisational strategies and green practices**	**Supplier selection**
Expert on organic food supplies	2/9	10/17	7/10
Meal contractor	5/9	14/17	9/10
Organic producer platform	2/9	8/17	10/10
An expert on organic food distribution in the catering sector	2/9	10/17	7/10
Fresh food distributor	3/9	10/17	10/10

Table 2.7: Extract from the semi-structured interview with an expert on organic food supply

"One of the most important environmental characteristic of the product demand is the fact of propose a product with organic label".. Expert on organic food supply

Table 2.8: Extract from the semi-structured interview with a Fresh food distributor

"Demand for local products, means geographical proximity, products coming from the same department or from bordering departments".. Fresh food distributor

Table 2.9: Extract from the semi-structured interview with an expert on organic food distribution in the catering sector

"The institutional catering demands specific characteristics of the product with regard to the packaging of the product, the cutting of pieces and specific grammage of the product that are not requested by the commercial restauration".. Expert on organic food distribution in the catering sector

Table 2.10: Extract from the semi-structured interview with a meal contractor

"As the municipality request organic and local products for the schools canteen menu, we insure the local demand by consulting suppliers located near to our facility aiming to reduce food travel distance".. Meal contractor

Table 2.11: Extract from the semi-structured interview with an organic producer platform

"For us, it is very important the quality and environmental performance of the products we offer, in fact we only work with producers who have the organic label or those who are in the second year of conversion to organic agriculture".. Organic producer platform

On-line survey results: Descriptive statistic

This subsection shows the description of the quantitative survey results according to the three hypotheses presented above.

H1. The environmental characteristics of the product contribute to the product's environmental quality and may impact the product demand (remains stable, decreases or increases).

Regarding the question about what happens if there is an improvement of the intrinsic environmental quality of the product, 55.6% of the respondent answered that there could be an increase of the product's demand, 0.9% a decrease of the demand, 24.8% a maintenance of the demand, 23.4% a change of customers, 21.5% no change in the product's demand. In fact, 26.2% considered more than one reason of those above presented.

Regarding those who answered that there could be an increase of the product's demand because of the improvement of the intrinsic environmental quality of the product, the magnitude of that increase is shown in Table 2.12.

Table 2.12: Demand increase according to the product's environmental quality improvement

Magnitude of the increase	
Less than 5%	27.7%
Between 5 to 10%	33.6%
Between 10 to 25%	21.0%
Between 25 to 50%	4.2%
More than 50%	10.9%
Does not know or no answer	2.6%

The main cause identified for the decrease of the demand is due to the increase in price. From those who answered that it could be a maintenance of the demand, 17% estimate that it is because customers have become less volatile, 28.3% because new customers replaced those who left, 5.7% for other reasons, and 49% do not know the reason for maintaining demand. Nevertheless, 62.3% of the respondents affirmed that they did not perceive a change in demand, but they would have lost orders if they had not done anything.

Thus it can be concluded that the first hypothesis (H1) can be validated by these results. Indeed, for more than half of the companies in the sample, the environmental characteristics of the product that improve the product's environmental quality increase the product's demand. Nearly a third of the respondents reckon on the increase of more than 5% of the demand. However, the increase of the product demand is not linear and appears limited to 25%.

H2. The organisational strategies and green practices contribute to the product's environmental quality and it may impact the product demand (remains stable, decreases or increases).

Figure 2.4 describes the practices that are already developed and have the most influence on the demand (0: no influence - 3: maximum influence).

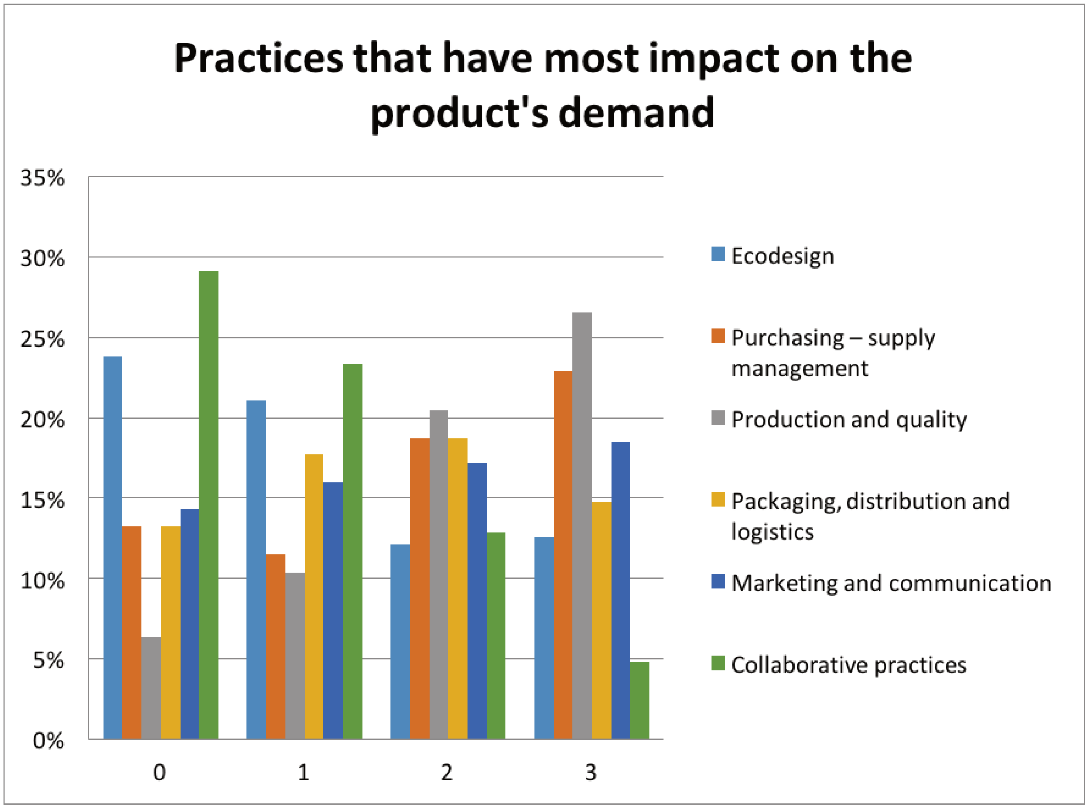


Figure 2.4: Practices that have an impact on the product's demand (0: no influence - 3: maximum influence)

Production and quality practices appear to have the greatest impact on the product demand, followed by purchasing and supply management practices. In the third place, there are marketing and communication practices. However, it is interesting to note that the point of view on these last practices is rather mitigated: the same number of respondents that think that there is no impact and those who think that there is a strong impact. Packaging, distribution and logistics practices are also mitigated. Finally, eco-design and collaborative practices are assessed as practices with least impact on product demand.

However, the second hypothesis is not fully validated. In fact, only 23.8% of the respondents affirmed that the implementation of these practices actually increase demand positively. 27.7% do not believe that there is an increase in the product demand and the other 48.5% do not know.

H3. The environmental criteria used on supplier selection process contribute to the product's environmental quality and it impacts the product demand (remains stable, decreases or increases).

Figure 2.5 shows the results of the question about the product's environmental performance on the supplier's assessment, the importance allocated to the supplier's practices according to (0: no influence - 3: maximum influence).

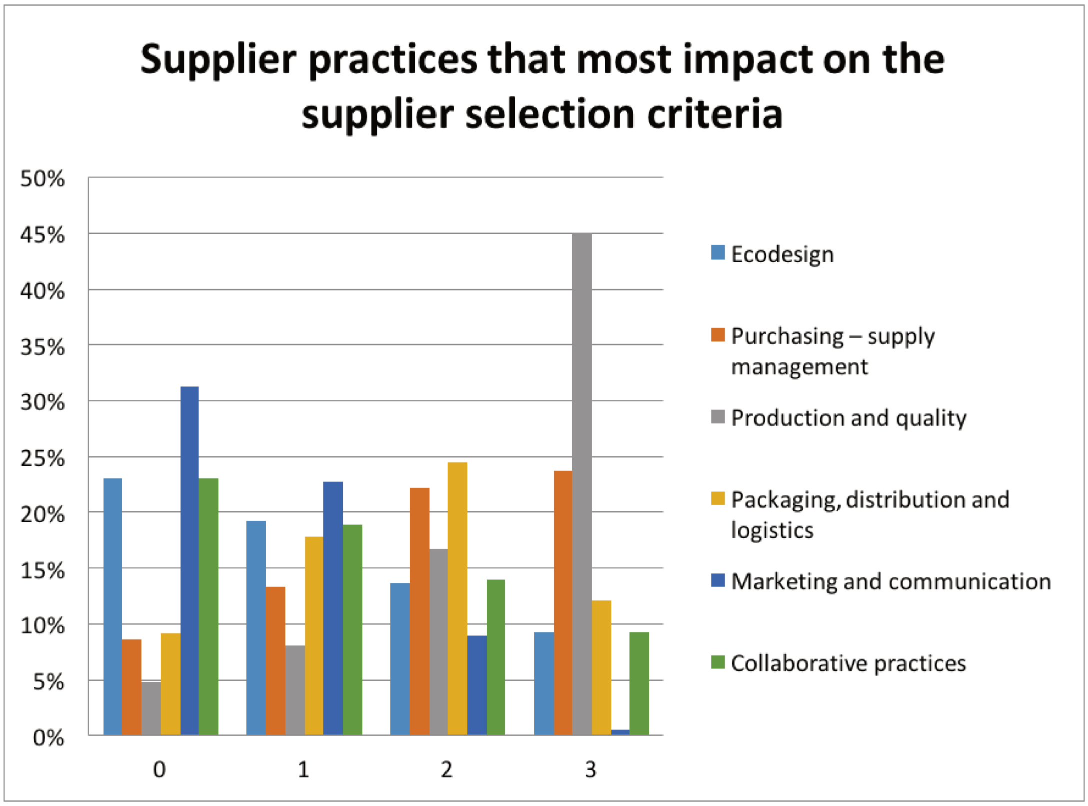


Figure 2.5: Supplier practices that are considered to assess the environmental performance of the supplier (0: no influence - 3: maximum influence)

To assess the environmental performance of their suppliers, the respondents stated that they focus mainly on their production and quality practices, followed by purchasing and supply management practices. To a lesser extent, they consider packaging, distribution and logistics practices. Collaborative and eco-design practices appear to have fewer impact on demand, while respondents claim that marketing and communication practices have the least impact on supplier selection.

As Figure 2.6 shows, when asking which criteria are most important when selecting suppliers, the first criterion that emerges is quality and technical specifications, slightly ahead of price and delivery conditions. The quality and environmental performance of components appear only in the background.

Thus, it can be concluded that quality and environmental performance appear as a

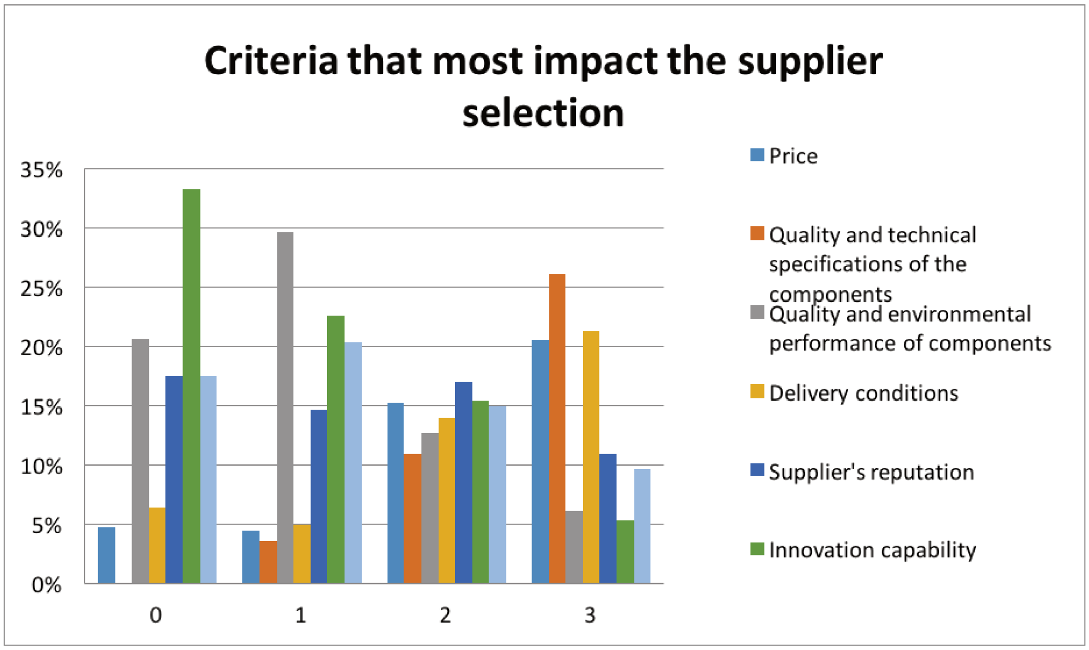


Figure 2.6: Criteria that most impact the supplier selection (0: no influence - 3: maximum influence)

distinguishing factor, but only if the company already provides a product with good quality and specifications, at a competitive price and guarantees good delivery conditions.

However, almost 65% of the respondents would be willing to pay more to the supplier to improve the environmental quality of their products. 80% would be willing to pay until 5% more of the current price, 14% would be willing to pay until 15% more of the current price and, 6% would be willing to pay over 15% more of the current price.

On-line survey results: Statistical test

This subsection shows results of Chi-square, p-value and cramer-value test to identify the relationships between the variables. For the following analysis, only dependent variables were analysed, with a p-value <0.05. Regarding the strength of the statistical link between the variables, only moderate and strong were considered.

H1. Improving the product's environmental quality increases the product's demand.

Table 2.13. shows that there is a strong statistical relationship between the increase of product demand ($QEP - D>$) and the fact of having a labelled product. 83.6% of the respondents who have products with label ($LabelPRO$) affirm that this increases the product demand. Besides, 87.5% of the respondents who have products with organic label ($LabelPRO - Bio$) affirm that this increases the product demand.

Table 2.13: Statistical test results regarding the H1

Var 1	Var 2	Khi-2	P-value	Cramer value	Strength of the statistical link
QEP-D >	MP-Eq	12.7	0.00	0.2	Moderate
QEP-D >	MP-Eq (Yates)	11.3	0.00	0.2	Moderate
QEP-D >	MP-Bio	23.8	0.00	0.3	Moderate
QEP-D >	MP-Bio (Yates)	22.4	0.00	0.3	Moderate
QEP-D >	LabelPRO	38.4	0.00	0.4	Strong
QEP-D >	LabelPRO-Bio	5.9	0.02	0.3	Moderate
QEP-D >	LabelPRO-Aut	6.8	0.01	0.3	Moderate
QEP-D >	LabelPRO-Aut(Yates)	5.2	0.02	0.3	Moderate

There are two moderate statistical relationships between the raw material characteristics and the fact of having an increase in the product demand. 86.2% of the respondents who have fair trade raw material ($MP - Eq$) affirm that this increases the product demand. 74% of those respondents who have organic raw materials ($MP - Bio$) affirm that this increases the product demand.

Table 2.14: Statistical test results regarding the H1 focusing on the increase's amplitude of the product's demand

Var 1	Var 2	Khi-2	P-value	Cramer value	Strength of the statistical link
QEP-D >AMP plus de 10%	MP-Bio	15.1	0.00	0.3	Moderate
QEP-D >AMP plus de 10%	MP-Bio (Yates)	13.6	0.00	0.3	Moderate

Table 2.14 shows that there is a moderate relationship between the increase over 10% of the product demand ($QEP-D>AMPplusde10\%$) when the raw material of the product is organic ($MP - Bio$). 75.8% of the respondents who think that the product demand could increase over 10% also stated that their product contains ingredients labelled AB (organic farming).

H2. The organisational strategies and green practices may improve the product's environmental quality and increase the product demand.

Table 2.15 shows eleven moderate statistical links between the variables related to the increase of product demand ($IPCL - D$) due to the practices developed to increase the environmental quality of the company.

There are two moderate statistical links between the perception in the increase of the product demand and the current position of the respondent. 35.4% of respondents

Table 2.15: Statistical test results regarding the H2

Var 1	Var 2	Khi-2	P-value	Cramer value	Strength of the statistical link
IPCL-D	Resp-QSE	9.9	0.01	0.2	Moderate
IPCL-D	Resp-PRO	8.8	0.01	0.2	Moderate
IPCL-D	IPD-Aap	19.1	0.00	0.2	Moderate
IPCL-D	Rec-A-50k-200k	19.0	0.00	0.2	Moderate
IPCL-D	Rec-D-<50k	21.1	0.00	0.2	Moderate
IPCL-D	Rec-D-50k-200k	17.1	0.00	0.2	Moderate
IPCL-D	D-ProxD	6.9	0.03	0.2	Moderate
IPCL-D	D-ProxF	8.8	0.01	0.2	Moderate
IPCL-D	MK-bio	15.3	0.00	0.3	Moderate
IPCL-D	Rec-SCQE-ColVeilInno	16.5	0.00	0.2	Moderate

who think that practices developed to increase the product's environmental quality will actually increase the product demand work in the area of QSE quality ($Resp - QSE$)), and 25% work in the area of production ($Resp - PRO$).

Two moderate statistical links appear between the perception of the increase of the products demand and the importance given to purchasing and supply practices ($IPD - Aap$) to improve the product's environmental quality. Indeed, 79.2% of respondents, who think that the practices developed to increase the product's environmental quality may increase the product's demand, identified purchasing and supply practices as important practices that influence the product's demand (Question 47 in the questionnaire in Appendix .4).

There is a moderate statistical link between the increase of products demand and favouring the purchase of regional products ($Rec - A - 50k - 200k$). 39.6% of respondents who think that the practices developed to increase the product's environmental quality may increase the product demand, privileging the fact of purchasing over the 20% of regional origin products.

Respondents working in companies with local customers are prone to think more than the others that the company's practices may impact the demand. Indeed, there are two moderate statistical links between the increase of products demand and the companies who have local customers ($Rec - D - <50k$) and regional customers ($Rec - D - 50k - 200k$). This may be explained by the fact that when a company and its customer are geographically close, they have a close relationship due to the proximity that promotes the knowledge by the customer, of the process and supplier's facility organisation (e.g. more frequent site visits for example).

There are also two moderate statistical links between the increase of products demand and the company's distribution practices that have been developed to improve product's environmental performance, such as the location of distribution points close to the market ($D - ProxD$) and the location of production facilities close to suppliers ($D - ProxF$).

Among the respondents who think that the distribution practices developed to increase the product's environmental quality could increase the product's demand, 35.7% privilege the location of distribution points close to the market (while this percentage is 18.8% of the total population surveyed) and 28.6% favour the location of production facilities close to suppliers (while this percentage is only 13.6% of the total population surveyed).

There is a moderate statistical link between the increase of products demand and the company's green marketing and communication practices, such as organic labelled products marketing ($MK - bio$). Among the respondents who think that some practices of the company may increase the product demand, 75.6% privilege the marketing of organic label on the product as the most influential practice (while this percentage is only 33.3% of the total population surveyed).

There is a moderate statistical link between the increase of products' demand and the company's collaborative practices with supply chain stakeholders, such as collaboration on monitoring, strategic information gathering to anticipate change, regulation and innovation ($Rec - SCQE - ColVeilInno$). This is confirmed by 75% of respondents who believe that collaborative practices developed to increase the product's environmental quality could increase the product's demand.

H3. The environmental criteria used in supplier selection process may improve the product's environmental quality and it impacts the product demand.

Table 2.16 shows the results of the statistical link between the function of respondents and the willingness to pay more for "greener" products ($AccepPrix - QPE$). There is a strong and four moderate statistical link between these variables.

Table 2.16: Statistical test results regarding the H3

Var 1	Var 2	Khi-2	P-value	Cramer value	Strength of the statistical link
AccepPrix-QPE	Resp-DRH	9.0	0.01	0.2	Moderate
AccepPrix-QPE	AD-AttQEAP	20.9	0.00	0.4	Moderate
AccepPrix-QPE	ASF-QPE	30.6	0.00	0.4	Strong
AccepPrix-QPE	ASF-CondComm	19.7	0.00	0.4	Moderate
AccepPrix-QPE	Rec-AF-Sensib	12.6	0.00	0.3	Moderate

The strongest statistical link is between the willingness to pay more and the selection of the quality and environmental performance of components offered considered as the most important criterion ($ASF - QPE$) when choosing a supplier. 100% of the respondents who assessed the quality and environmental performance of components offered during the supplier selection process as very important criterion, are willing to pay more, with the aim of increasing the product's environmental quality.

100% of respondents who think that their company is attentive to the environmental qualities and performance of supplies ($AD - AttQEAP$), are willing to pay more to increase the product's environmental quality. This is confirmed by the moderate statistical link between these variables.

There is a moderate statistical link between the willingness to pay more aiming to increase the product's environmental quality and the respondents who assessed as an important criterion the commercial conditions established ($ASF - CondComm$) when choosing a supplier. 62.1% of respondents, who assessed as important criterion the commercial conditions established during the supplier selection process, are willing to pay more to increase the product's environmental quality.

There is also a moderate statistical link between the willingness to pay more and importance given to the environmental quality generally demonstrated by their suppliers ($Rec - AF - Sensib$). 80% of respondents, who assessed over 60% the sensitivity to environmental quality demonstrated on average by their suppliers, are willing to pay more to increase the product's environmental quality.

Finally, and more surprisingly, there is a moderate statistical link with respondents working in the area of human resource ($Resp - DRH$) and willingness to pay more. 80% of respondents that accepted an increase of more than 5% of the initial price work in the area of human resources (while the human resources managers represent half of the sample of the respondents to this question).

2.5 Discussion

The results are based on an on-line survey completed by 248 professionals from the food-processing sector. The first hypothesis is validated: Improving the product's environmental quality may increase the product's demand. Indeed, for more than half of those surveyed, improving the product's environmental quality may increase the product's demand. Nearly a third of those surveyed consider an increase of more than 5% of the demand. The most influential attribute is the introduction of labelled organic raw materials.

However, the second hypothesis is not fully validated. Indeed, only 23.8% of respondents affirmed that the implementation of organisational strategies or green practices increases the demand positively. 27.7% do not think that there is an increase in the product's demand and the other 48.5% do not know. The respondent's position impacts the perception about the role of "green practices" on the demand: respondents dealing with health, safety, security, environmental or production issues are more likely to think that the environmental practices of the company may impact the product demand.

Besides, the practices identified as having the greatest influential on the demand are, on one hand, the location of distribution points close to the market and the location of production facilities close to suppliers and, on the other hand, the company's green marketing and communication practices (in particular, organic label).

Moreover, the interest in implementing organisational strategies or green practices, for the companies, is not only within a potential increase of demand. In fact, one respondent reminded that improving the environmental practices of the companies has other advantages than increasing the demand. These environmental practices can enhance the material and energy efficiency of the company; help maintain its activity, etc. In this way, it can be concluded that the environmental performance of a product appears as a distinguishing factor, but only if the company already provides a product with good quality and specifications, at a competitive price and insures good delivery conditions.

Finally, concerning the third hypothesis, almost the 65% of the respondents affirm that they would be willing to pay more to their suppliers to improve the environmental quality of the purchased products. This willingness to pay more is related to: (i) the importance given to the quality and environmental performance of components purchased as the most important selection criterion when choosing a supplier. (ii) the importance given to commercial conditions and (iii) the attention given to environmental qualities and performance of the suppliers.

2.6 Conclusion

To conclude, it is necessary to notice that the sample is not representative of the entire food sector. However, the fact of having 248 complete answers allows to have a confidence level close to 90% within the conclusions. Besides, intrinsic to any on-line survey, some biases may be identified within the sample: those who responded to the survey and spent time on a questionnaire on this topic are probably the most interested in environmental issues, and the proportion of environmentally conscious respondents may be higher than in the population as a whole. However, there is no doubt that some of the respondents were not particularly environmentally conscious.

Therefore, it can be considered that although the results in terms of percent of the survey may not be applicable to the entire French food sector, the qualitative conclusions of this survey are reliable:

- The most influential attribute to improve the product's environmental quality that increases the product's demand is the introduction of organic labelled raw materials.
- The practices that influence mostly the product demand are related to the geographical proximity with the stakeholders. This impacts decisions related to the facilities location such as (i) the location of distribution points close to the market and (ii) the location of production facilities close to suppliers.
- The most important selection criterion when choosing a supplier is the importance given to the quality and environmental performance of components offered.

These findings allowed to conclude that the consumers are becoming more and more exigent by privileging organic labelled and local products and making that the companies analyse the geographical proximity with the stakeholders as a key factor during the selection process. Lastly, from those conclusions, it is necessary to understand which of these environmental criteria extracted and validated can be used to describe the logistic requirements to configure food distribution system that could fulfil the demand requirements.

Chapter 3

Logistic requirements for food distribution

Contents

The work described in this chapter has been presented in the Prolog 2019 Conference (Palacios-Argüello et al., 2018a). This work was mainly conducted during the CONCLUDE project that was financed by the French National Agency for Research (ANR), and during the ELUD project that was financed by l'Université de Lyon with

the labex IMU (Intelligences des Mondes Urbains).

Having extracted and validated the environmental criteria that influence product demand, such as the fact of privileging organic labelled and local products for example, or the fact of considering geographical proximity with the stakeholders as an organisational practice; this chapter aims to answer to the second research question: *What eco-responsible demand characteristics can be used as request variables to configure an urban food supply system?*

With this aim, this chapter explains how these demand characteristics can be used to describe the logistic requirements for food distribution configuration.

3.1 Introduction

To feed the world, food logistic organization is a crucial factor (Fredriksson and Liljestrand, 2015). The goal of the urban food supply system is to satisfy the food city requirements considering the quality and quantity specifications demanded (Morganti, 2011). Nowadays there is an increasing need for developing food distribution strategies on a social, economic, and environmental sound basis that have been encouraging a research effort in the fields of food system sustainability. This is reinforced by increased product quality demands (Fredriksson and Liljestrand, 2015) and the increasing environmentally consciousness of consumers (Oglethorpe and Heron, 2010).

(Oglethorpe and Heron, 2010) listed emerging solutions that encourage the large distribution networks reduction. It involves less processed food, packaging reduction, more organic products and local products consumption making the food distribution process less environmentally damaging. This is one of the reasons why these changes in food quality and consumptions patterns influence changes in how the food is supplied and distributed, and consequently, the way the food distribution circuits are designed. This makes possible to configure different food distribution schemas and a variety of distribution channels by which food is supplied to final consumers (Morganti, 2018).

Consequently, the food distribution systems become extremely divers and complexes, including different distribution organizations, increasing the complexity of the food supply and distribution networks (Skilton and Robinson, 2009). This complexity can be reflected in the number of food actors involved, the logistic requirements according to the food type and the distribution configuration adopted (Morganti, 2018).

With the aim of decreasing this network's complexity and to satisfy consumers who demands greater quality and traceability in the food supply chains, alternative forms of consumption in conventional food systems have emerged (Bosona and Gebresenbet, 2011; Fredriksson and Liljestrand, 2015; Nsamzinshuti et al., 2018). One of those is the consumption of local products restringing a distribution configuration with a maximum one (or ideally none) intermediary between the producer and the consumer, reducing externalities caused by conventional long distribution circuits (Nsamzinshuti et al., 2018).

As described above, the demand characteristics may influence the food distribution configuration. This chapter explains how these demand characteristics can be used to describe the logistic requirements for food distribution configuration. With this aim, the chapter begins with the definition of the food flows in the distribution system, then explains the food supply and distribution actors, type of products and detail the different configuration of distribution circuits, channels, and networks. Furthermore, it explains the logistic requirements for food distribution according to the different actors, products and distribution circuits adopted. Considering the institutional catering as a sector with a stronger environmental consciousness demand, the logistic requirements are detailed compared with other sectors. Finally, the logistic requirements are compared based on the primary and secondary data collected to establish the main logistic requirements linked to the conscious demand in the food supply chain for the food distribution configuration.

Background: Logistic requirements for food distribution in the school canteen system linked to eco-responsible demand characteristics

Regarding the food supply configuration, Morganti (2018) mentions three great challenges that the city planners are faced to today: complexity; distribution nodes and markets; and lastly, the challenge of achieving higher levels of sustainability. Considering the third challenge, it will be explained the main logistic requirements found in the literature for food distribution in the school canteen system linked to eco-responsible demand characteristics.

In Europe for the call tenders in food sector, the European Union (e.g. European Parliament Directives 2004/17/EC and 2004/18/EC) considers criteria based on the sustainability of practices, such as the products' seasonality, harvesting practices, waste and packaging minimisation practices, among others (Union, 2011). In practice, Cerutti et al. (2016) cite three specific policies that have been embraced for the institutional catering sector: geographical origin of the products, protocol of production and type of vehicles used for food distribution.

Geographical origin of the products

Compared to conventional channels, local and organic food supply chain may produce more expensive food products. Therefore, there is a strong stake to optimize the logistics and supply chain costs to maintain an affordable meal cost. This makes necessary to reduce the distance travelled and distribution cost to reach the school canteen (Severson and Schmit, 2015), favouring an easier access to freshest and better quality foods (Cretella and Buenger, 2016).

Protocol of the product's production

Apaiah et al. (2006) classify the food supply chain into two main types : supply chain for fresh agricultural products and supply chain for processed food products. In the first one, the characteristics of the product do not change, and in the second one the characteristics changes to add value to the product.

To deal with the food supply requirements, control entities and supply chain stakeholders have promoted local food production and consumption (Stroink and Nelson, 2013). This is the case of the food distribution system for school canteen. Nowadays, the municipalities' food policies are interested on introducing organic and local products on the students' meals menu as a measure to improve its nutritional quality and reduce the environmental impacts. In this way, they ensure a market and encourage the development of local food supply chains, thus supporting local employment.

Type of vehicles used for food distribution

There are different types of food chains that are considered in the food school canteen distribution system such as: (1) supply chain of fresh foods (product's with short product life cycles and fast transportation and lower levels of stock) and (2) supply chain of frozen foods (product's with long product life cycles and slower transportation) (Zanoni and Zavanella, 2012). Besides, because of environmental regulations on air quality, aiming to reduce the emissions of particulate matter for population's health reasons, the urban distribution fleet seeks to replace diesel vehicles by vehicles fuelled by natural gas or electricity.

3.2 Material and methods: Methodology to extract logistic requirements from eco-responsible demand characteristics

This section explains how the logistic requirements for food distribution have been collected through primary and secondary data and how the data collected has been analysed through content and statistical analysis. Figure 3.1 shows the methodology proposed.

- *Data collection*: To collect secondary data, a literature review has been conducted to identify the logistic requirements for food distribution configuration. Then, to collect primary data a set of semi-structured interviews with stakeholders in the institutional catering have been conducted and a on-line survey of 248 companies in the food industry in France has been performed.

- *Data analysis*: To analyse the data collected, two methods are proposed. For the qualitative data collected, a content analysis is used and, for quantitative data collected, a statistical analysis is proposed.

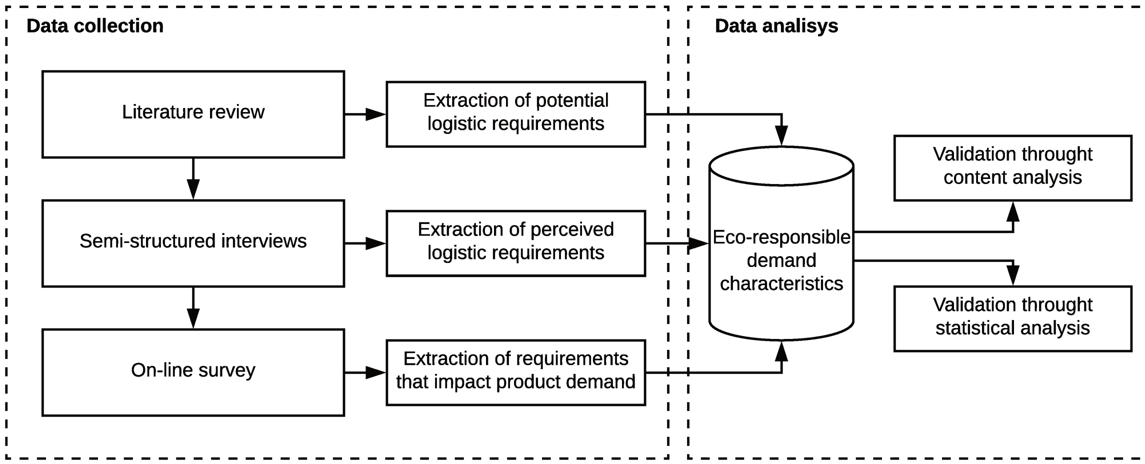


Figure 3.1: Methodology to extract logistic requirements from eco-responsible demand characteristics

Literature review

The collection of material was mainly based on a documentary gathering. The scopus database was used to identify and quantify the published articles. Scopus presents a broad view of global and interdisciplinary scientific work on a specific research topic. Databases from major publishers and library services, such as Science direct, Emerald and Springer were then selected to compare and complete the list of articles compared to the results obtained from Scopus and Web of science.

Regarding the inclusion criteria Table 3.1 shows the main criteria that have been considered.

Table 3.1: Inclusion criteria considered for the literature review

	Criterias
Keywords	Logistic requirements, food supply chains, food distribution, food supply, institutional catering, distribution network.
Document type	Paper, book chapter, conference paper, article in press with DOI, PhD thesis
Time interval	2008 - 2019
Language	English, French

167 documents were found, then after analysing the titles and abstracts, only 74 documents deal with the logistic requirements for food supply and distribution. Finally, the list of selected papers was refined by reading the full text and searching for references using citation-tracking databases. After a discussion among the researchers,

22 documents were selected according to their content.

Table 3.2: Information about interviewees face to face

Stakeholder	Position of the interviewee(s)	Date of the interview
Producer	Vegetables and fruits producer	16/02/2018
Carrier	Logistic Manager	10/04/2018
Wholesaler	Logistic Regional Manager	30/04/2018
Producer cooperative	Manager of organic-local offer for institutional catering	11/05/2018
Public agent	Manager of the meals distribution for school canteens at Saint-Etienne	31/05/2018
Receiver	Manager of the central kitchen for school canteens at Saint-Etienne	06/06/2018

Semi-structured interviews

The semi-structured interviews are based on open-end questions to stakeholders that belong to the food industry in France. The sample design method and research quality approach used is adopted from Bell et al. (2018). The development of the interview guide has been done by following the IDPA model developed by Ollagnon (1987). The interview guide is available in Appendix .5.

Table 3.3: Information about interviewees by telephone

Stakeholder	Position of the interviewee(s)	Date of the interview
Producer	Vegetables producer	31/08/2018
Producer	Vegetables and fruits producer	24/10/2018
Producer	Vegetables producer	24/10/2018
Producer	Vegetables and fruits producer	24/10/2018
Producer	Vegetables and fruits producer	24/10/2018
Producer	Vegetables producer	24/10/2018
Industrial producer	Milk transformer	25/10/2018
Producer	Vegetables and fruits producer	25/10/2018
Industrial producer	Fruits transformer	25/10/2018
Producer	Vegetables and fruits producer	31/10/2018

The research is focused on stakeholders related to the organic-local food distribution system. In total, five semi-structured interviews face to face and ten interviews by telephone were conducted. They lasted between 30 and 90 minutes and were conducted in French. Table 3.2 shows the information about the people interviewed during the face to face interviews and, Table 3.3 provides information about the people interviewed during the interviews performed by telephone.

On-line survey

To perform the on-line survey, it was used the same survey applied in the previous chapter. The methodological approach considered in this chapter is explained in Section 2.3.

The questions about the characteristics of food product, organisational strategies and supplier selection linked to logistic requirements for food supply and distribution were considered. These questions were validated by a pilot survey that was carried out with professionals in the food sector. Table 3.4 shows the questions from the on-line survey considered.

Table 3.4: Questions considered from the on-line suvey linked to logistic requirements

Demand characteristics	**Questions considered**
Product characteristics	15 - 23
Organisational practices	29 - 50
Supplier selection	51 - 57

From the valid questionnaires obtained, 119 were considered for product characteristics, 94 were considered for organisational practices and 73 for supplier selection. Such questionnaires corresponds to those respondents who affirmed that products characteristics, practices and/or supplier selection environmental criteria considered that increase product demand.

3.3 Findings: Logistic requirements for food distribution

Literature review: Potential logistic requirements

This subsection deals with the main logistic requirements found in the literature according the actor involved, the type of product distributed and the distribution schema adopted. Figure 3.2 shows the methodology proposed to extract the potential logistic requirements.

Before describing the logistic requirements for food distribution, it is necessary to describe and identify the food flows within the city. Morganti (2011) proposes two flows:

- Food supply to cities subsystem: It includes all activities involved from the food production until to the food supply to the city. Those activities can be food production, imports, processing, storage, packaging, and transport.

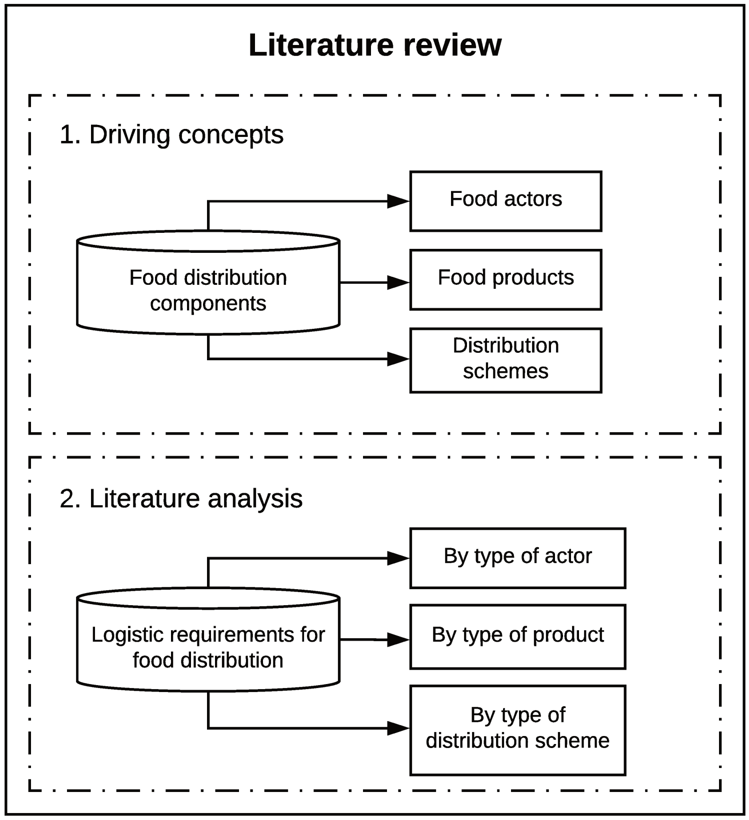


Figure 3.2: Methodology to extract logistic requirements from eco-responsible demand characteristics

- Urban food distribution subsystem: It includes all activities involved in the food distribution within an urban area. Those activities can be food wholesale, intra-urban transport and retailing.

Logistic requirements by actors

Actors involved in food supply and distribution

The food supply and distribution involve a complex system of activities, functions, and relations between the actors. In the literature there are different categories proposed for classifying the actors involved in food distribution.

Blanquart et al. (2010) describe two main actors' typology : (1) upstream actors (producers/suppliers) and (2) downstream actors (receivers). Moreover, Fredriksson and Liljestrand (2015) describe deeper those upstream and downstream actors by proposing the following typology: (1) Primary producers: They grow or breed the raw materials. (2) Industrial producers: They transform the raw material, adding value to the food product. (3) Wholesalers: They distribute, store and convey the products between primary producers and industrial producers. (4) Retailers: They sell the products to the consumers.

Besides, Morganti (2011) describe three other types of actors linked to the stakeholder nature: (1) Economic agents such as producers, wholesalers, retailers. (2) Public institutions: such as city and local governments, public food marketing boards, Ministry of Agriculture, Ministry of Transport. (3) Private associations: such as traders, transporters, shop owners and consumers.

Likewise, Nsamzinshuti et al. (2018) propose another actors' category: (1) Organization of producers (producers and producer cooperatives). (2) Sales intermediaries (food wholesalers and distributors). (3) Receiver (private customers, community- supported agriculture groups (CSA), grocery stores, conventional supermarkets, restaurants, and institutional catering restaurants). Nonetheless, some actors can play different functions at different stages of the food supply chain (Morganti, 2011).

Furthermore, considering the variety of the actors involved in the institutional catering, Le Velly et al. (2010) propose the following typology: (1) Producer or producer cooperative: produce the food product. (2) Collector or shipper: Collects the raw products at the farm and perform a control quality of the product considering specific demand requirements. (3) Processor: Peels, washes and trims the food. (4) Distributor: Manages orders and delivers them to the central kitchen. (5) Receiver: It could be a caterer company (external management) or a community central kitchen (internal management) who cooks and provides the final meals.

It is shown that local products that arrive at the central kitchen are often the result of a heterogeneous combination of intermediaries. Nevertheless, there are some initiatives to shorten the food supply chain by mixing some functions and making the producer or producer cooperatives may be at the same time: producer, collector, processor and distributor for the institutional catering.

Lastly, another actor involved in the institutional catering that is not frequently considered by the literature is the territorial authority (known in French as *"donneur d'ordre"*), who act as a purchaser that defines the food requirements specifications for the canteens through a public tender.

Logistic requirements

According to Blanquart et al. (2015); Fredriksson and Liljestrand (2015); Morganti (2018) the logistic requirements by actors in the food supply chain are shown in Table 3.5.

Logistic requirements by type of products

The food should be considered very different from other commodities regarding the logistics organization to guaranteeing product quality requirements. This is why, it is important to define the different type of products considered in food distribution.

Table 3.5: Logistic requirements by actor adapted from Blanquart et al. (2015); Fredriksson and Liljestrand (2015); Morganti (2018)

Actors	Logistic characteristics and requirments
Primary producers	- They need to ensure food traceability and quality during the distribution process. - They implement collective organisation to transport the food
Industrial producers	- They are interested in delivery speed and geographical location, considering the perishability of products that require specific physical distribution solutions and in consequence that are sensitive to distribution costs - They prefer not to postpone production steps to suppliers, because these companies think that the logistics companies have limited knowledge of food quality or lack flexibility. - They need manufacturing flexibility because of their relatively high product and volume variety.
Retailers	- They are interested in distribution issues because a substantial part of the operations cost of food retailers is the logistics costs. - They depend on high availability on the store s shelves. - They are looking for well developed distribution strategies that provide them with a competitive advantage. - They promote vertical integration within retailers networks, focuses on logistics management aiming to improve their logistics systems continuously.
Corporate retailers	- They invest heavily in distribution networks to take control of deliveries and increase overall supply chain efficiency. - They are interested in consolidating supplies upstream of stores at centralized distribution centres. - They are interested in achieving economies of scale through centralized, more consolidated and less frequent deliveries.
Independent retail and the HoReCa	- They often do not control deliveries, with wholesalers or suppliers being responsible for goods transport. - They usually do not pay for the transport directly and have no contact with the carrier except for the receipt of the delivery. - They are supplied frequently, because they have diverse suppliers, with a predominant use of own vehicles and low vehicle fill rates.
Wholesalers	- They are interested in improving the distribution aiming to have gains in transport costs, which is an important issue when sourcing fresh food products.

Type of products considered in food distribution

Morganti (2011) proposes two classifications for food products according to the expiry dates and the specific preservation conditions: (1) Dry grocery: Foodstuffs at middle or long expiry dates, not bound to specific preservation conditions. (2) Fresh food products, refrigerated grocery, and frozen foods: Fresh foodstuffs with close expiry date and bound by special preservation conditions.

In addition, Fredriksson and Liljestrand (2015) consider the product's temperature regime, they propose three groups: (1) Ambient products: Those products should be kept at room temperature. (2) Chilled products: Those products should be kept within a temperature range from just above the freezing point to a maximum of +8C (meat and milk) or +15C (vegetables). (3) Frozen products: Those products should be kept at -18C or lower.

Logistic requirements

The logistic requirements according to the food product type impose constraints that do not apply to non-food supply chains, especially for goods that require cold chain technology. These requirements according to Fredriksson and Liljestrand (2015) are linked to their perishability, sensitivity to the surrounding environment, seasonality in demand and supply, the dependency on natural conditions for production and the demands on quality and traceability.

Morganti (2018); Morganti and Gonzalez-Feliu (2015a) describe the following logistic requirements that are for all type of food products: (1) Short lead times and just-in-time deliveries. (2) Specific handling procedures. (3) Regulatory issues (related to temperature requirements) : thermal integrity of the shipments. Fredriksson and Liljestrand (2015) propose the following logistic requirements according to the food type:

- Fresh products: The importance of (i) food quality regarding the sensory properties (taste, odour, appearance, colour, size, and image), and (ii) food traceability regarding the product safety issues.

- Chilled products: Demands on the duration and conditions of storage, processing, and transportation, which limits the possibilities of distribution.

- Frozen products: The importance of warehouse location, either close to the harvest/production or close to the market

Compared with other non-highly perishable food and non-food supply chains, these logistic requirements result in higher consumption of energy, lower levels of consolidation and lower efficiency, leading to additional costs for transport operations (Fredriksson and Liljestrand, 2015). Morganti (2018) affirm that the logistics solutions developed for other product groups are not directly applicable to the food industry. In conclusion, compared to other types of products, handling foods is far more complex and includes much higher risks (Thron et al., 2007).

Logistic requirements by type of food distribution considered

A literature review has been conducted to identify distribution schemes configuration used in food supply chains. According with Blanquart et al. (2010), there is not only one food distribution schema or one type of logistic organization. It can vary according to the supply mode, the final product destination and the food distribution purpose (to consuming at home or out of home). Nevertheless, a different classification has been proposed by Gonçalves (2013), where the distribution system has two independent components:

- Distribution circuit: it refers to the schema that a product follows from its production until its consumption.
- Distribution channel: it refers to the different forms of product distribution and sales. Then one type of distribution circuits could serve more than one distribution channel.

Type of distribution circuits considered in food distribution

Gonçalves (2013) studied three different circuits:

- Direct distribution: There is no intermediary or middlemen between the producer (P) and the customer (C) as Figure 3.3 shows.

Figure 3.3: Direct distribution circuit

- Short distribution: There is only one intermediary (INT) between the producer (P) and the customer (C). Frequently the intermediary is a retailer, as Figure 3.4 shows.

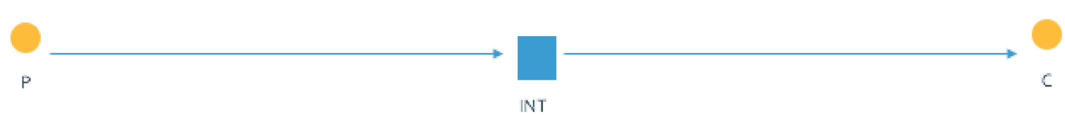
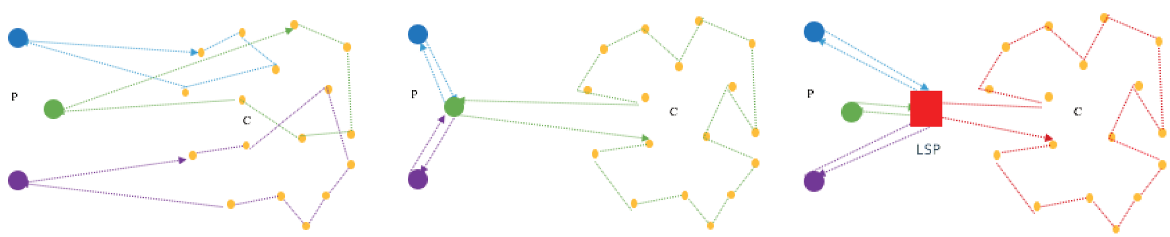


Figure 3.4: Short distribution circuit

- Long distribution: There are at least two intermediaries (INT) between the producer (P) and the customer (C). Frequently the intermediary is a wholesaler and a retailer,as Figure 3.5 shows.

Figure 3.5: Long distribution circuit

The intermediaries act as middlemen between different members of the distribution chain. Those who are considered as intermediaries are traders, central purchasing departments of large-scale retailers and/or logistics service providers (Blanquart et al., 2010). However, Fredriksson and Liljestrand (2015); Gonçalves (2013) consider that logistics service providers are not considered to be intermediaries, only those who perform a sales function for the products are considered. Considering the direct distribution circuits, Nsamzinshuti et al. (2018) propose three different types: (1) direct distribution, (2) horizontal collaboration and (3) distribution through a logistics service provider (LSP), as Figure 3.6 shows:



(a) Direct distribution (b) Horizontal distribution (c) LSP distribution

Figure 3.6: Typology of direct distribution circuits

- Direct distribution Figure 3.6 (a): It is the most basic form of logistical organization with no intermediaries, where producers transport directly to the receivers using their own vehicles. This is also known as self-distribution. It is characterized by the great flexibility that it provides.

- Horizontal collaboration Figure 3.6 (b): With the aim of optimizing the distribution activities, it refers to a collaboration between several producers. This is a popular initiative in direct and short distribution circuits.

- Direct Distribution through a Logistics Service Provider (LSP) Figure 3.6 (c) : Aiming to reach new customers and not only for distribution optimization of existing customers, producers perform the food distribution through LSP, who provide logistics services to stakeholders of supply chains. These services include:
  - Logistic platforms: The use of logistics platforms (called in the food sector Food Hubs) is an emerging solution used for the management and optimization

of distribution networks to reduce the number of vehicle trips and vehicle kilometres ensuring the respect for the cold chain.

– Transport services: It allows to enhance logistics performance (cost, reliability, responsiveness) especially in urban areas.

Besides, regarding the food distribution short circuits, Gonçalves (2013) and Torre and Wallet (2014) define the following types:

- Food short circuit: It is characterized by a reduced distance between the producer, the intermediary, and the customer.
- Short circuit for large distribution: It is characterized by one intermediary who frequently is a national or inter-regional distribution network distributing all or part of the producer's offer on all or the great majority of its network.
- Proximity circuit: It is characterized by linking actors located in the same region.

Moreover, Blanquart et al. (2010) identified four logistics schemes used by the producers in short distribution circuits:

- A basic logistic organization with small or medium-sized producers (1 or 2, rarely more) and with commercialization in community-supported agriculture (AMAP) (i.e., AMAP means association pour le maintien d'une agriculture paysanne. English translation: Community-supported agriculture).
- A basic logistic organization with bigger producers and with commercialization in AMAP.
- A basic logistic organization with producers with commercial links without AMAP (other distribution channels such as producers' markets, farm sells among others)
- A complex and subcontracted logistic organization with commercialization outside the AMAP system. There is a commercial intermediary who collects the producers' products and delivered them using drop-off points.

Logistic requirements according to the distribution circuit adopted

Blanquart et al. (2010); Fredriksson and Liljestrand (2015) describe the main logistic requirements according to the distribution circuit adopted as Table 3.6 shows.

Type of distribution channels considered in food distribution

Other authors have provided typologies of distribution channels according to the food distribution circuits based on the number of intermediaries and the individual or

Table 3.6: Logistic requirements according to the distribution circuit adopted. Adapted from Blanquart et al. (2010); Fredriksson and Liljestrand (2015)

Distribution circuit	**Logistic characteristics and requirements**
Direct distribution	- Shippers transport for their own account. - They perform fewer deliveries per delivery round than professional transport operators. - They lead to lower load factors of vehicles. - They face higher costs and environmental impacts.
Horizontal collaboration	- To collaborate with other producers to increase the trust between stakeholders. - To avoid the fear of the loss of their independence, singularity of their distribution network, lack of tools and cost sharing methods. - To increase the vehicle's fill rates and thus reducing transport costs. - To reduce kilometres travelled compared to individual transport is observed.
Distribution through a LSP	- Logistics platforms as a key to the optimization of bulking and un-bulking without storage. - Specialized transportation companies.

collective character of the chain.

Chaffotte and Chiffoleau (2007); Gonçalves (2013); Nsamzinshuti et al. (2018); Raton et al. (2015) propose: (1) With or without sales intermediaries between producer and consumer, and the corresponding direct and indirect distribution; and (2) an individual or collective dimension of the distribution. Table 3.7 shows the food distribution channels configuration by defining the number of intermediaries.

According to Morganti and Gonzalez-Feliu (2015a); Morganti (2011) there are two types of food distribution channels regarding the place of food consumption described in Table 3.8.

Logistic requirements according to the distribution channel adopted

Table 3.9 shows the logistic requirements according to the food distribution channels related to the place of food consumption, defined by Morganti and Gonzalez-Feliu (2015a); Morganti (2011).

Table 3.7: Food distribution channels configuration. Adapted from Chaffotte and Chiffoleau (2007); Gonçalves (2013); Nsamzinshuti et al. (2018); Raton et al. (2015).

	Direct	**Indirect**
Individual	- Outdoor and local markets (0) - Direct sale on the farm (0) - Box Schemes Distribution Systems (0)	- Internet sales (1) - Commercial restaurants - Caterers: Institutional catering external management (More 2) Specialized retailers (1) - Wholesalers (More 2)
Collective	- Producers' markets managed by an association (0) - Collective sales outlets (i.e., French traduction: Point de Vente Collective) managed by a collective structure of producers (0) - AMAP system	- Shops selling local produce on consignment. - Institutional catering internal management (1) - Sell through cooperatives and associations of consumers or producers (2)

Table 3.8: Food distribution channels regarding the place of food consumption. Adapted from Morganti and Gonzalez-Feliu (2015a); Morganti (2011)

	Channel	**Type**
At home consumption	Corporate retail	Hypermarkets, Supermarkets, Discounts
	Independent retail	Grocery stores, Specialised stores
	Alternative channels	On-farm retail, Farmers' markets, Community supported agriculture initiatives
Out of home consumption	Hotels, restautants and cafes (Ho.Re.Ca.)	-Organized: Hotel and restaurant chains. -Non-Organized: Small bars, restaurants and hotels.
	Institutional food services	Canteens in schools, hospitals and prisons
	Corporate cafeteria	Private restaurants in enterprise

Logistic requirements for the Institutional Catering

The logistic requirements for the institutional catering are similar to the wholesalers. It is noticed that institutional catering requires large volumes while the available supply

Table 3.9: Logistic requirements according to the food distribution channels regarding the place of food consumption. Adapted from Morganti and Gonzalez-Feliu (2015a); Morganti (2011).

Distribution system	**Distribution channel**	**Logistic characteristics and requirements**
At home consumption	Corporate retail	- It is necessary to have a centralized supply chain management system with the aim of managing stocks efficiently, monitoring the flow of goods and coordinating inbound and internal logistics. - It is necessary an accurate logistics management of perishable products procurement, especially regarding timely order fulfilment and economies of scale savings. - The distribution strategy adopted is essentially cost effective and mostly optimized through centralization measures.
	Independent retail	- It has usually limited stock management and logistics activities. - It reflects a fragmented supply chain that usually makes transport and logistic activities inefficient (e.g. empty runs, old vehicles with high fuel consumption and routes non optimized.
	Alternative channels	- It requires that both producers and consumers travel to distribute and purchase the products.
Out of home consumption	Ho.Re.Ca	- It requests small and frequent deliveries of perishable products in congested urban areas. Similar logistic requirements to independent retail.
	Institutional food services and corporate cafeterias	- As the prepared meal is highly perishable it requires to be handled properly and fast during the delivery activities. - The delivery schedules must be coordinated because its demand for food occurs at peak times (around breakfast, lunch, and dinner). - It adopts a centralized system (central food production facility) where the meal is prepared and transported to external locations (satellites or receiving kitchens).

from local producers is generally fragmented (Morganti and Gonzalez-Feliu, 2015a). They usually buy a great volume of food from local producers or international producers, then, it is stocked to ensure a regular food supply for consumers (local restaurants, school, hospital canteens, etc). The latter allows to describe the logistic activities like a long distribution chain which usually performs centralized and dedicated logistics services, ensuring high consolidation levels (Morganti and Gonzalez-Feliu, 2015a).

Nevertheless, this is changing with emerging demands for local and organic products, requesting a new distribution configuration similar to the direct and short distribution circuits (Raton et al., 2015). However, in the literature, direct or short distribution circuits adopted in the institutional catering have been little studied (Praly et al., 2009). This local demand can be considered as a short distribution circuit integrating a set of intermediaries, reinforcing the proximity notion among the producers, making the logistics requirement a central question in the distribution configuration research.

Le Velly et al. (2010); Praly et al. (2009); Raton et al. (2015) highlight the main logistic requirements of the institutional catering when local demand is crucial:

- It is necessary to adopt short food circuits for local products rather than use long circuits.
- The high requirements concerning product quality, traceability and security ensuring the availability of right quantities, respecting the delivery times.
- Producers flexibility and reactivity in terms of food conditioning and quantities (right rations) that usually need a previous food transformation.
- Regulatory constraints such as the fair trade including call tenders without the limitation of local producers.

Accomplish such logistics requirements is difficult (Blanquart et al., 2010; Raton et al., 2015). Producers prefer to sell directly the products in the farmer's markets rather than in the institutional catering (Praly et al., 2009). Some of the reasons are: lower sale price, increased risk of delivery problems and the extra work for the food conditioning requirements from the institutional catering (Le Velly et al., 2010). Likewise, Raton et al. (2015) provided two additional reasons: the legal and administrative limits (e.g. call for tenders for purchases over 25,000 euros) and logistical limits (e.g. do not have the vehicle for food transport, do not have the capacity to deliver large volumes, etc..).

Semi-structured interviews: Perceived logistic requirements

Table 3.10 explains perceived logistic requirements for food distribution by a group of actors in the food industry focusing on institutional catering.

Based on the feedback from the development of the semi-structured interviews, it was possible to constant that the consumer's consciousness is growing and in consequence, there is a strong demand for sustainable food supply. This enforces the need for adapting the food distribution to improve its environmental performance but remaining food supply chains economically competitive.

One of the most common logistic requirement mention by all the actors interviewed was the need for a stronger involvement of local actors in the food supply. This logistic

Table 3.10: Logistic requirements perceived

Actors	**Logistic requirments**
Public agents	- They need to ensure food traceability and quality for the institutional catering. - They demand 50% of organic products with an increment of 10% every year since 2014. Currently they demand 80%. - They demand 70% of local products and make regular controls for ensuring the food origin.
Primary producers	- They have between 50% and 100% of customers located in the department and which are interested in local products. - They collaborate with other producer to propose an offer more robust, ensuring the great volume demanded by the institutional catering. - They must ensure the strong product delivery schedule demanded by the institutional catering. - They should have a high reactivity to answer the constraints in terms of product quality, time and amount delivery demanded by the institutional catering. - They should offer a product variety to accomplish the institutional catering expectations. - 10% of the producers offer the product delivery by working with a carrier and 90% do it by themselves.
Industrial producers	- They must accomplish the product quality specificities linked to size, weight and calibration of the product demanded by the institutional catering. - They must ensure the strong product delivery schedule demanded by the institutional catering. - They should have a high reactivity to answer the constraints imposed by the institutional catering.
Carriers	- They must ensure the respect of the cold chain to gather the product quality requested. - They must ensure the strong product delivery schedule demanded by the institutional catering. - They must develop distribution strategies to optimize the distance and accomplish the service quality demanded by the institutional catering.
Wholesalers	- They develop strategies for optimizing food collection and distribution by working in collaboration with producers and institutional catering actors.
Receiver	- They often perform control deliveries to verify the product size, weight and calibration. - They select privilege local and organic cooperative of producers that are available to provide the volume and quality of the product demanded. - They work in collaboration with the producers to develop new product range specific for the institutional catering.

requirement can be explained as a crucial question of spatial distances; perceived as proximity circuit, a term used to characterize the length in local food approaches (Kebir and Torre, 2012; Torre and Wallet, 2014), which means a short distance between producers and consumers. Another logistic requirement that was raised is the importance of the collaboration between the actors to improve the distribution system activities in the entire supply chain. This vertical and horizontal collaboration involved:

- Development of information system to share information about the demand quantities, improving the demand forecasting.
- The mutualisation of transportation among the actors involved.
- The food consolidation strategies that have been developed between the producers to have a robust offer and to have a centralized distribution. These allow them to take control of deliveries and increase overall upstream distribution efficiency.

Regarding the sustainability issues of the distribution system, another logistic requirement evoked was the request of using clean technologies during the food distribution. The retailers and the wholesalers use clean vehicles (gas powered freight vehicles) as a call-tender requirement from the public agent.

Finally, another logistic requirement mentioned by all the interviewed is the need for a distribution network flexibility. This flexibility is requested in terms of food conditioning and quantities, but also in terms of delivery time and frequency.

On-line survey: Logistic requirements that impact the product demand

This subsection shows the description of the descriptive statistics from the survey results according to logistic requirements for food distribution. This subsection only considered those respondents who affirmed that purchases and distribution practices increase product demand, representing 119 for product characteristics, 94 for organisational practices and 73 for supplier selection.

Purchasing practices

It appears that the main purchasing practices developed to increase the environmental quality of the products and, which are linked to logistic requirements for food distribution are:

- The selection of local suppliers that represents the 67.4% of the respondents.
- Cooperation on storage and transport nodes that represents 17.4% of the respondents.

Figure 3.7 shows other criteria considered that are not liked directly with the logistic requirements.

Figure 3.7: Purchasing practices

Distribution practices

It appears that the main distribution practices developed to increase the environmental quality of the products are:

- The optimization of kilometres travelled for transportation and logistics mutualisation were the most voted (60.7%) followed by logistics mutualisation (53.6%). Then the location decisions (near to the market (35.7%) and suppliers (28.6%)) is mentioned.

- The less voted was the use of less emitting technologies for road transport (e.g. electric trucks, LNG trucks, Euro 6) (7.1%) followed by the use of alternative modes to road transport (e.g. rail or river freight) (10.7%), as Figure 3.8 shows .

.

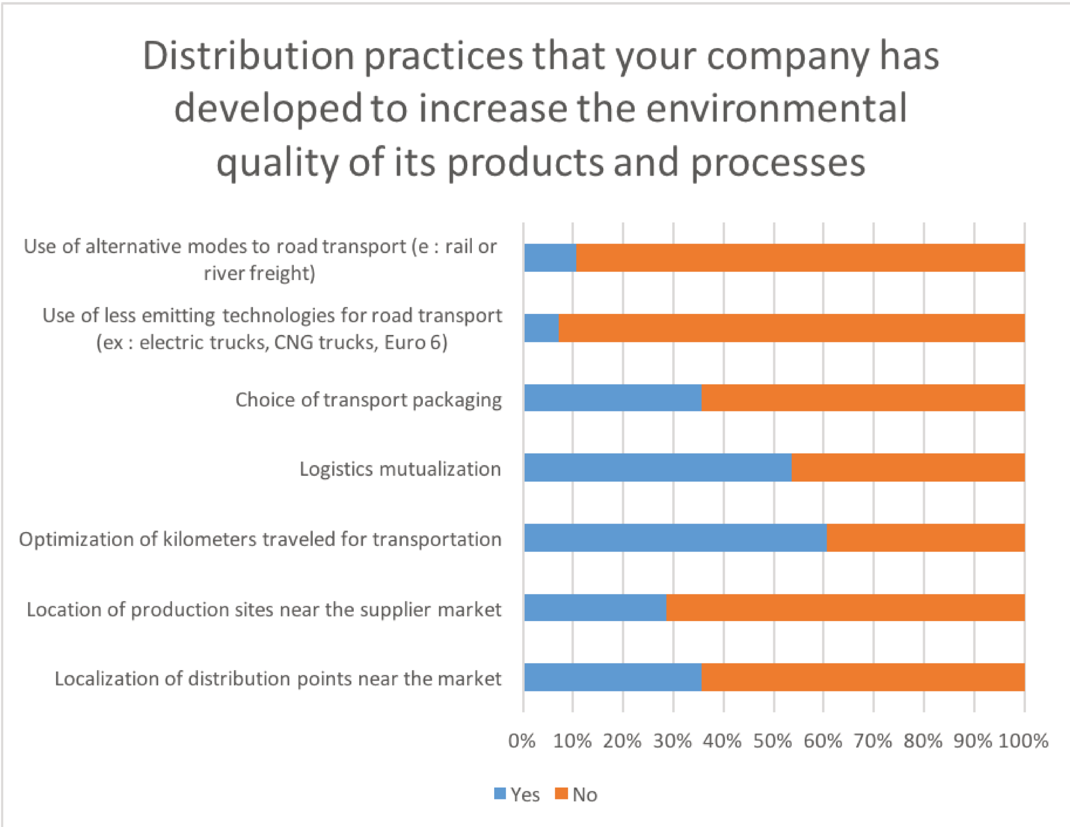


Figure 3.8: Distribution practices

3.4 Discussion

Logistic requirements related to product characteristics

From the data collected, it can be inferred that the logistic requirements related to product characteristics that are one of the most important for the stakeholders is the notion of local offer. Local products mean that they should come from the same department or neighbouring departments. This is reflected by the distance between the producer and the canteen, assessed in food travel distance.

Logistic requirements related to organisational practices

From the data collected, it can be inferred that the logistic requirements related to organisational practices developed by the stakeholders is the common collaboration with other stakeholders aiming to have access to the market or to propose a better offer, such one of producer affirmed.

Other practice evoked during the interviews is the importance of the distribution practices. The stakeholders privilege logistic mutualisation or work with a carrier to

Extract from the semi-structured interview with a producer.

"We partner with other producers to have a more robust, secure and perineal offer.".. Producer

optimise their products' distribution.

Extract from the semi-structured interview with a carrier.

"The logistical cost is quite significant for producers, which is why some prefer to use a platform or pass through a carrier to not guarantee the delivery of products and therefore not increase the logistical cost".. Carrier

Another logistic requirement related to the distribution is the short times between the product request from the institutional catering and the product delivery that sometimes must be the same day.

Extract from the semi-structured interview with a wholesaler.

"The time of reception of the order and the delivery is very short, it corresponds to the fact of being able to have a great reactivity to the demands of the institutional catering".. Wholesaler

Other logistic requirement privileged in purchasing and distribution practices is the fact of having suppliers that use clean technologies such gas or electric vehicles or to pay attention to the technology used (EURO 5 or 6).

Logistic requirements related to supplier selection

From the data collected, it can be inferred that one of the most common logistic requirement is the availability of the requested volume of the product demanded by the institutional catering. This is one of the key criterion to select a supplier.

Extract from the semi-structured interview with a public agent

"It is hard to select and work directly with organic and local producers. There are organic producers who do not want to work with institutional catering because they either do not have the necessary volume or because the negotiation price is very low.".. Public agent

Another aspect is the selection of local and organic producers. Nowadays, during the call tenders, the public agents and the receivers contacted ensure the local requirement by asking for product transformation performed the same day that they are delivered for example, because they can not specify that they only select local producers because of the fair trade. Nevertheless, they can ask for organic label to ensure the part of organic products that should be considered in the canteen menu.

3.5 Conclusions

The actors in the food supply chain are becoming more aware of the need for the food logistic organizations improvement regarding the increasing environmental conscious demand. Distribution is then a relevant topic of research nowadays with the logistic request of food products passing more quickly from primary producers to consumers while they consider sustainability externalities.

However, because of the different logistic requirements, different distribution configurations are needed that reduce the external impacts of food transportation by improving local supply and strengthening the collaboration among the actors of the food supply chain.

From the data collected (literature review, semi-structured interviews and on-line survey), it is possible to affirm that there are three kinds of logistic requirements that actually influence the food distribution configuration:

- Distribution circuit design regarding the facility location that could be near to the market or near to the suppliers.
- Suppliers choice regarding the product characteristics requested and the proximity relationship considering the supplier location.
- Distribution optimization considering logistic platforms and transportation strategies (i.e. distance travelled reduction, increasing vehicle's fill rates, decreasing environmental impacts)

Nowadays, to satisfy the local demand, it is considered as a strategy to relocate or maintain regional agricultural activities. Local is perceived as food miles' reduction which at the same time is linked to shorter transport routes and proximity supply confirming what was affirmed by Oglethorpe and Heron (2010). Nevertheless, the local food demand must consider other dimensions more than just food miles' reduction, such as vehicles technology used, vehicle filling rate among others, confirming what was established by Blanquart et al. (2010).

In terms of research limitations, the logistic requirements for food distribution discussed in this chapter are only based on the methodological approach adopted to collect information from the literature review, the interviews of stakeholders involved in the food system and the results from a survey to the French industrial sector. However, it is possible that there are some logistic requirements imposed by the final consumers that are not considered. The results of this research provide information to food supply chain actors when designing the food distribution circuits aiming to answer to conscious demand characteristics that are emerging.

Part II

Food supply chain configuration

Chapter 4

Food Supply Chain strategies

Contents

The work described in this chapter has been presented in the RIODD 2016 Conference (Palacios-Argüello and Gonzalez-Feliu, 2016b) and was published in a Spanish version on the journal *Revista Transporte y Territorio* (Palacios-Argüello et al., 2017). Moreover, the results of promoting a logistics system based on flows centralization in a food hub on institutional catering study has been submitted to Food Supply Chains in Cities as a book chapter. This work was mainly conducted during the ELUD project that was financed by l'Université de Lyon with the labex IMU (Intelligences des Mondes Urbains).The maps in QGIS presented in this chapter had been designed with the collaboration of S. Rauf from École de Mines de Saint-Etienne.

In this chapter, it will be presented the definitions about food supply chain strategies that aim to achieve the environmental criteria of product demand (RQ2a). Next, a case of study on logistics system based on flows centralization in a food hub on institutional catering will be presented.

4.1 Introduction

Food supply chains face multiple challenges related to traceability, transparency, sustainability, trust and flexible legislation (De Fazio, 2016). These challenges have increased consumer mistrust in globalized agri-food systems, and have led to a growing interest in, and calls for, more environmentally sustainable, local and organic food (Aubry and Kebir, 2013). Politicians and public authorities have noticed these concerns, and have responded by requesting food industries to re-examine the sustainability of their supply chains, and by increasing policies and strategies aimed at increasing the competitiveness of local and organic food (De Fazio, 2016; Nicholson et al., 2011).

Such initiatives as direct sales from producers to consumers, producers' shops, urban farmers' markets and e-commerce for local quality products, continue to emerge in this context (Bosona and Gebresenbet, 2011; Holguín-Veras et al., 2016; Sánchez-Díaz, 2018). While these producer-focused initiatives are attractive to consumers because of the sustainability of the products offered, they face common challenges related to physical distribution costs. The main strategies to reduce costs are to decrease the number of intermediaries who do not add value to the final product, and design distribution systems that allow local rural products to reach consumers in a cost-efficient manner. Distribution systems with these characteristics are referred to in the literature as Short Food Supply Chains (SFSC) (De Fazio, 2016). In addition to the obvious benefits for local producers, SFSC can also benefit society by reducing overall negative environmental externalities (De Fazio, 2016; Migliore et al., 2015).

In 2009, the French Ministry of Agriculture adopted an official national definition of SFSC: *"the supply chain is short when it has at most one intermediary between the agricultural producer and the consumer"* (Aubry and Kebir, 2013). SFSC stimulate food relocation by reducing intermediaries and distance, and by creating proximity between producers and consumers (Aubry and Kebir, 2013). It also provides better incomes and economic security to the producers. In fact, The Food and Agriculture Organization (FAO) consider that the SFSC are an invaluable contribution to the fight against hunger and malnutrition, and helpful in alleviating social, economic, and environmental sustainability issues (Rodríguez-Reyes, 2009). Besides, this type of initiatives encourage the horizontal cooperation among the stakeholders that are at the same level in the supply chain. Indeed, the introduction of horizontal cooperation in the supply chain is with the aim of pooling specialised logistics systems and networks (Pan, 2010).

Policymakers have identified the market segment of institutional catering serving public entities as one with great potential to increase the share of local and organic food because public authorities can establish strict specifications for products and suppliers. However, they also recognise the need to redesign the physical distribution system to make SFSC more competitive and sustainable. As Fredriksson and Liljestrand (2015); Nordmark et al. (2012) mention, this requires an analysis and redesign of current logistics systems to identify issues and potential solutions. One key strategy to enable a successful implementation of short, sustainable and efficient food supply chains is the introduction of Food Hubs (FH). FH are specialized logistics platforms where supplies from multiple local vendors are gathered and consolidated before being distributed either to local kitchens for further preparation (i.e., cooking), or directly to consumers locations (Morganti, 2011), which correspond to canteens in the case of institutional catering (Morganti and Gonzalez-Feliu, 2013).

With this scope in mind, the aim of this chapter is to answer to the following research question: What are the food supply chain strategies that accomplish the eco-responsible product demand characteristics?

To this end, the purpose of this chapter is to identify the functions and characteristics of FH used for institutional catering, particularly school canteens, and analyse how these FH should be designed to support the objective of increasing local and organic products for the distribution of meals in these settings.

4.2 Background of FSC strategies

Sustainability strategies in food supply chain

The concept of "sustainability" and "sustainable development" has become increasingly influential in policy considerations in recent years. The most widely accepted definition of sustainable development has been defined by the World Commission on Environment and Development in 1987 and it refers to "how the needs of the present human generation can be met without compromising the ability of future generations to meet their needs" (Akkerman et al., 2010; Moldan et al., 2012; Pope et al., 2004). According to Abbasi and Nilsson (2016), sustainable development of logistics refers to "activities that lead to the highest economic and social gains while reducing the negative environmental losses". Elkington (2013) define as the triple bottom line, the three sustainability's goals important to the society: environmental quality, social equity and economic prosperity.

Regarding the sustainability strategies in food supply chain, Li et al. (2014) examined the options and solutions for food sustainability from three perspectives: improve efficiency, demand restraint, and improve governance. According to Ilbery and Maye (2005), the sustainable food supply chains achieve "mutually reinforcing benefits" for:

- Economy, in terms of efficient producers, enhanced incomes and fewer burdens on the taxpayer.
- Environment, in terms of conserving natural resources and maintaining biodiversity.
- Society, in terms of better health, high animal welfare standards and stronger rural communities.

The most important indicators of sustainability in the food supply chain are : energy consumption, land use, employment possibilities, revenue, waste production, production costs and percentage of food loss, among others (Bouchery et al., 2010; Čuček et al., 2012; Sgarbossa and Russo, 2017). Given these indicators, an evident way to improve sustainability is to influence food distribution system to reduce transport energy consumption, inventory cost, reduction of environmental costs without harming employ or any other economic aspect for private firms (Manzini and Accorsi, 2013).

In this context, Colicchia et al. (2013); McKinnon (2000) have identified a set of efficient initiatives to increase the sustainability of the food supply chain: fleet technological innovation to reduce GHG (Green House Gases) and CO2 emissions, such as cleaner vehicles and the use of alternative fuels or vehicles (e.g. electric, hybrid); shifting traffic to more fuel efficient modes, freight consolidation, reducing vehicle idling time; food hubs consolidation and localized food supply chains relate to the concept food-miles (distance a food product has travelled to get to the consumer) and to proximate, originating from the closest practicable source or the minimization of energy use; community supported or shared agriculture, consumers' purchasing groups or organizations, community gardening, certification and labelling programs, food box schemes among others.

Besides, Kuhmonen (2017) propose three strategies for economic, environmental and social sustainability explained in Table 4.1.

Table 4.1: Sustainability strategies in food supply chain

Strategy	**Sustainability impact**	**Description**
Short Food Chain	Economic	The short value chain is transparent. The producers guarantee the quality and safety of their products. The closer link between production and consumption reduces waste. The short chain maximizes the common value added by producers and consumers within the food chain.
Green Food Chain	Environmental	The environmental impacts of food are transparent through the geographical proximity of production and consumption. Maintenance of soil productivity, reduction of long-distance transportation and cutting of environmental damage. Inputs are mainly local. It maximizes the local environmental capital stock and its productivity in food production.
Fair Food Chain	Social	The social impacts of food are transparent through certification. The terms of the certificate provide full-cost pricing of local food, including the costs of animal welfare, hired labor and farmer's inputs. The certificate is widely required in the public procurement of food and allows the consumer knows the economic and social effects of her/his choices.

Those measures enable policy-makers and practitioners make an important contribution to delivering more sustainable food systems and better public health nutrition (Smith et al., 2016).

According to Cerutti et al. (2016); Michelsen and de Boer (2009); Smith et al. (2016) analyze the public procurement as a tool for the development of economic, social and environmental issues. Sustainable or Green procurement is a process whereby organizations meet their needs for goods, services, works, and utilities in a way that generates benefits not only for the organization but also for society and the economy while minimizing damage to the environment. Green Public Procurement (GPP) is the approach by which public authorities integrate sustainable criteria into all stages of their procurement process, thus encouraging the spread of environmental technologies and the development of environmentally sound products, by seeking and choosing outcomes and solutions that have the least possible impact on the environment throughout their whole life cycle.

Considering both direct and indirect environmental pressures, Cerutti et al. (2016) have estimated that more than 50% of the environmental impact of the public sector comes from the supply chains of products. This means that in the public sector in general, the percentage is most likely greater in the supply chains of public catering because of the large material and energy intensity of food products in comparison to other products and services. Furthermore, public services related to the food sector are numerous and they support a large number of meals every day throughout a country, including schools, hospitals, universities, prisons and others.

To answer to these demands from local institutional catering, there are some logistical solutions related to fair, short and green supply chains. This includes, food collection and consolidation strategies that link the producers with the consumer to shorten the supply chain and add value to the local producers. The deployment of Food hubs (FH), specialized logistics platforms for food product's collection and distribution is one of these strategies that are currently emerging.

4.3 Material and method: FH Research design

The aim of this research is to identify the functions and characteristics of Food hubs (FH) used for institutional catering, and analyse how these FH should be designed to support the objective of increasing local and organic products. In so doing, a mixed approach that combines quantitative and qualitative data production is proposed. The method designed is based on the principles of case study research (Bell et al., 2018; Eisenhardt, 1989; Maxwell, 2012; Yin, 2009).

The Auvergne-Rhône-Alpes region in France was selected as the case study given: (i) its goal of using exclusively local and organic food in the public-school canteens system; and (ii) the canteens' suppliers have successfully implemented FH to enable short supply chains.

The method is developed in three phases, the first two seek to understand the role of FH in short supply chains, and the last one seeks to assess quantitatively different designs of a FH-based distribution system. Figure 4.1 explains the FH research design proposed.

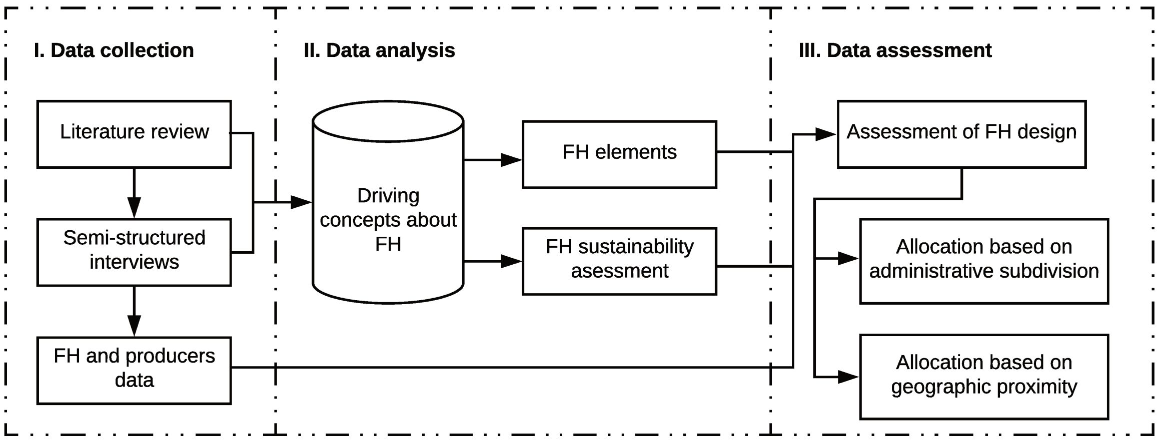


Figure 4.1: FH Research design

Data collection

The data is collected via literature analysis and semi-structured interviews with key private and public-sector stakeholders involved in the food distribution system.

The data collection includes primary and secondary data. The secondary data uses a documentary analysis of scientific and technical/legislation documents to describe cases and context. The data is complemented with primary data collected through semi-structured interviews based on open-ended and theory-driven questions. These interviews were performed with stakeholders of the institutional catering supply chains in the Auvergne-Rhône-Alpes region in France.

The sample was designed following the snowball sampling method (Bell et al., 2018). The first interview was held with the head of the school meals program at Saint-Etienne, who referred us to the regional manager of organic-local offer for institutional catering in Auvergne-Rhône-Alpes. At the end of the interviews the regional managers pointed identified other regional managers who could be contacted to ensure a complete overview of the system.

To perform the semi-structured interviews and ensure high-quality research, two documents were created: an interview protocol and an interview guide. The protocol was used to explain the purpose of the interview: the study aim, time, type of questions, main topics to consider, feedback, and use of information. The interview guide was used to make the questions asked as effective and efficient as possible, without forgetting any important topic, and to document all impressions and experiences from each interview. The interview guide is available in Appendix .6.

Each potential stakeholder was contacted via e-mail. The e-mails included the purpose of the study, a description of the research area, and an invitation to be interviewed.

Potential respondents were informed of the study aims and the structure of the case studies. In total, nine semi-structured interviews were conducted. The duration of each interview was between 30 and 90 minutes. All interviews were conducted in French. Table 4.2 shows the position of the stakeholder interviewee, and the date of the first interview. These interviews were followed up with a validation process, and secondary interviews were performed from 2017 to 2018.

Table 4.2: Information about interviewees

Stakeholder	**Position of the interviewee(s)**	**Date of the first interview**
Public authority	Head of the school meals program at Saint-Etienne	25/05/2016
Meal contractor	Manager of the meal distribution for school canteens at Saint-Etienne	18/11/2016
Public authority	Manager of organic-local offer for institutional catering in Rhône and Loire departments.	22/11/2017
Public authority	Regional manager of organic-local offer for institutional catering in Auvergne-Rhône-Alpes	23/10/2017
FH1	Marketing manager, in charge of the local producers, transformers and institutional catering customers' communication.	11/06/2018
FH2	Supply manager, in charge of the local producers and transformers	15/06/2018
FH3	Sales Manager, in charge of central kitchens, corporate restaurants and institutional catering	11/11/2017
FH4	Supply manager, in charge of the local producers and transformers	18/06/2018
FH5	Sales manager, in charge of central kitchens, corporate restaurants and institutional catering	17/07/2018

Additional discussions were held with researchers to verify the quality of the research approach, and to ensure that a sufficient number of stakeholders were interviewed. The interviews were analysed using secondary data for comparison. To increase trustworthiness, the secondary data of each FH and school canteen system were read in advance of meetings. This was done to reduce any possible misunderstandings between interviewers and interviewees.

Finally, the data linked to FH and producers were collected aiming to analyse FH design. The data collected was obtained by the Regional Organic Agriculture Observatory that encompasses data from 153 producers that offer organic products (e.g. vegetables and fruits).

Data analysis

A descriptive and interpretive approach is used to analyse these data and to understand the role of FH in short supply chains by comparing the literature with the reality. To do this, a set of driving concepts are defined to characterise the FH. Then a based on the data collected, a FH typology is proposed. Lastly, considering the sustainable impacts found in the literature, an analysis of the data collected from the semi-structured interviews allows to perform an analysis on the current economic, social and environmental impacts addressed by the FH studied.

Data assessment

This phase seeks to assess quantitatively different designs of a Food Hub-based distribution system. To this effect, secondary-data provided by the stakeholders interviewed was analysed using a Vehicle Routing Problem Spreadsheet Solver (VRP) developed by (Erdoğan, 2017).

The VRP Spreadsheet Solver is an open-source unified platform for representing, solving, and visualizing the results of vehicle routing problem. It unifies excel, public geographic information system (GIS) and metaheuristics (which refers to find a heuristic that provide an improved solution to an optimization problem). Three functions of the public GIS were used: *geocoding*, which converts addresses into the latitude / longitude values; *direction*, which is the function that returns the distance and driving time between two points; and *static maps*, which return image files defined by their centre point, zoom level, and size. In the VRP Spreadsheet Solver the optimization algorithm is of the same nature and relevance as those of route construction and fleet management software tools, and thus can be used as a reference for obtaining realistic food transport routes (Erdoğan, 2017).

Different designs of a Food Hub-based distribution system are assessed based on the distance travelled. The alternative designs of a Food Hub-based distribution system can be:

1. Allocation of producers to FH for organic-local products according to geographical proximity.

2. Allocation of producers to FH for organic-local products according to the administrative subdivision (i.e., the Department, which is the political division in France).

4.4 Findings

From the primary and secondary data collected, it is possible to affirm that the Auvergne-Rhône-Alpes has the second highest number of organic farms among regions of France, with about 5380 organic farms by the end of 2017 (AURA, 2018). Sixty percent of organic farms in this region sell at least part of their production directly through short circuits, or through only one intermediary between producers and consumers. There are FH that have been created specifically to have a robust offer for the institutional catering market as an alternative to solve dysfunctions in the aggregation and distribution of locally grown food.

Those FH have been supported by the Regional Federation of Organic Agriculture of Auvergne-Rhône-Alpes (FRAB AuRA),entity adhered to the FNAB (National Federation of Organic Agriculture), which protects the interests of organic producers at the national level. FRAB AuRA represents the collective interests of organic farmers in Auvergne-Rhône-Alpes, with regional organizations and communities. It promotes different actions for the development of organic agriculture in the region. This entity is one of the most important interlocutors of farmers and stakeholders in the agriculture sector, representing them with public authorities.

FH for organic and local products as a sustainable strategy

FH definition

From the literature review performed, multiple definitions of FH have emerged, see (Palacios-Argüello and Gonzalez-Feliu, 2016b; Palacios-Argüello et al., 2017). Research on FH focuses on the role of specialized logistics platforms for food product collection and distribution (Morganti and Gonzalez-Feliu, 2013). This type of distribution system structure often helps to improve service, and the adaptability to demand and lower transport costs through consolidation, which encourages sustainable food transportation (Morganti, 2011). FH seek to coordinate the distribution of food products from the same origin to conventional or hybrid markets through agreements between the food chain stakeholders (Cunha et al., 2015; Matson and Thayer, 2016; Morganti, 2011; Morley et al., 2008).

The United States Department of Agriculture (USDA), defines the concept of a Food Hub as *"An organization that actively manages the aggregation, distribution, and marketing of source-identified food products primarily from local and regional"* to strengthen local capacities to meet the demands of wholesalers customers, retailers, and end customers (Barham et al., 2012).

In this research, a new Food Hub (FH) definition is proposed. FH is a collaborative system between producer, distributor, and trader, eliminating middlemen to shorten the food supply chain. Its main function is to strengthen the supply of agro-industrial products by adding value to the final product. The characteristics of FH can be related to their commercial or logistical interests. This is the case of FH aimed at increasing the organic-local products offered for catering.

FH typology

A FH typology is proposed based on the literature found about FH development (for more details about literature review see (Palacios-Argüello and Gonzalez-Feliu, 2016b;

Palacios-Argüello et al., 2017)). This typology proposed is divided into three FH elements: (1) Stakeholder, (2) Structure, (3) Functions.

FH stakeholders

LeBlanc et al. (2014) define that a FH can be focused on the retailer, on the producer, and on the consumer. Besides, Barham et al. (2012) defines FH focused on farm-to-business or on the institution model, on farm-to-consumer and those FH that can be considered as Hybrid FH that connect the producers with the final consumer but also with wholesalers. Lastly, Morley et al. (2008) propose FH led by retailer and by the wholesaler and food services.

FH structure

Barham et al. (2012); LeBlanc et al. (2014); Morley et al. (2008) affirm that a FH can classified according the structure. It can be non-profit or with profit organization. The first is developed from community-based initiatives. Besides, the profit can be FH in private hands aiming to have a profit from the products exchange. Other structure typology proposed is based on the stakeholder that manage the FH. It can be a FH led by primary or industrial producers as producer cooperatives, and FH led by public agents aiming to consider social, environmental and economic issues in the food supply system.

FH functions

The FH have specific characteristics linked to the functions that are developed. There are FH that work on the supply side to support and train producers; there are others that work on the demand side by coordinating efforts among actors to ensure the demand requested (Barham et al., 2012). Nevertheless, FH can classified according to a commercial nature (with the aim of strengthening the supply) and another logistical nature (with the aim of providing logistical services to improve the food supply and distribution).

Finally, this literature analysis allowed us to define a FH typology that is summarised in Table 4.3.

Food Hubs (FH) characterisation

To characterise the FH as a sustainable strategy, five FH have been studied to compare the literature with the reality. From the semi-structured interviews performed, the common goal of the five FH studied is to develop fair local agricultural market practices for producers; to make the consumption of fresh, quality and seasonal products available to all; and to develop the region's economy and agricultural jobs. Table 4.4 summarises the description of FH studied obtained from the data collected from the semi-structured interviews.

The first FH studied (FH1) is an association that aims to sustainably link local agricultural production with residents and professionals of the territory by setting up

Table 4.3: Elements of FH (Author's elaboration)

Food hub elements	**Description**	
Stakeholder	-Focused on the retailer -Focused on the producer -Focused on the consumers -Hybrid models -Led by the wholesale and food services	
Structure	-Non-profit organization: Developed from community-based initiatives. -External private structure: Limited liability company, or other corporate structure. -Cooperative owned either by producers and / or consumers -Led by the public sector	
Functions	**Commercial Functions**	**Logistical Functions**
	-Processing of convenience, i.e. activities that add value to the product, like washing, peeling, and cutting food, among others. -Aggregation, classification packaging. -Marketing, promotion, sales. -Training activities for accounting or commercial purposes -Payment and financial services.	-Food consolidation and distribution services (first and/or last mile). -Urban logistics areas and aggregation of logistics activities. -Warehousing and storage services. Inventory management. -Transport organization and planning.

supply solutions adapted to the constraints of stakeholders in the distribution. This platform was created as a project co-built by regional producers and consumers. Its philosophy is to make these products accessible throughout the territory by putting logistics at the service of consumer needs. This FH is looking to be certified as a cooperative society with non-profit status.

The second FH studied (FH2) is a cooperative-type company that brings together producers and processors from the region with the aim of developing profitable local agriculture for the producers.

The third FH studied (FH3) is a regional Food Hub for organic products created by ten local-organic producers motivated to work with institutional catering. They contacted other FH, and they work together to strategize the producers' network, producers' governance and cooperative work with other platforms. In 2011, FH3 became a non-profit entity.

The fourth FH studied (FH4) is a regional Food Hub for organic products created to facilitate the regular and gradual introduction of quality foods and more proximity in the catering and commercial markets. It has been a non-profit since 2012. FH4 prioritizes fair trade, and allows food service providers to work more directly with producers motivated by the democratization of local organic products in catering, promoting access to quality food for all, regular market insurance and fair remuneration for producers, and finally, raising young people's awareness of issues related to their daily food choices.

The last FH studied (FH5) is a regional Food Hub for organic products created in 2005 by five producers who were looking for a robust offer for the institutional catering market. In the same year, the local government created a program to promote the local market structure for organic products to improve the quality of meals served to students from local colleges. Since 2015 FH5 has had non-profit status.

Table 4.4: FHs characteristics

Characteristics	**FH1**	**FH2**	**FH3**	**FH4**	**FH5**
Creation	2005	2007	2006	2011	2005
Employees	5	4	6	11	11
Products	95% organic producers and 5% in organic conversion or non-organic	100% organic Meat, dairy products, fruits, vegetables, cereals	100% organic	100% organic	- 85% organic and local products - 15% foreing organic products
Number of producers	80 - 100	30	- 80 producers - Partnership with Biocoop Restauration	- 30 local producers. - 10 national and international producers.	- 140 producers - Partnership with Biocoop Restauration
Infrastructure	1 platform	1 platform	1 platform	1 platform	1 platform
Customers	70% institutional catering, 15% retailers and convenience stores and 15% individual customers.	100% institutional catering	90% institutional catering and 10% commercial restaurants.	90% institutional catering and 10% commercial catering	90% institutional catering and 10% commercial restaurants and convenience stores.
Logistic organization: Upstream (UP), Downstream (DO)	-UP: Coordinate collection of the products from the FH and/or direct deliveries from producer-customer - DO: 2 own light freight vehicles.	- UP: Coordinate collection of the products from the FH, 100% of the product flow passes through this platform. - DO: External carriers.	- UP: Coordinate collection of the products from the FH and direct deliveries from producer-customer. - DO: External carrier.	- UP: Coordinate collection of the products from the FH, 80% of the product flow passes through this platform. - DO: 80% External carriers, and 20% directly from producers to customers.	- UP: Coordinate collection of the products from the FH, 65% of the product flow passes through this platform. - DO: 65% external carriers, and 35% directly from producers to customers.

FH analysis: Comparison with the literature review

The analysis of the FH development compared the reality with the literature has been performed according to the FH typology proposed (e.g., stakeholder focus, structure and ownership, logistics functions and commercial services).

As established before, the deployment of a Food Hub depends on the primary stakeholder of focus. The Food Hub can be focused on the producer, the retailer, the customer, or it can be a hybrid model, with a focus on several stakeholders. Table 4.5 shows results from the interview analysis relating to differences in stakeholder focus between each of the regional FH.

Table 4.5: Stakeholder Focus of Regional FH

Stakeholders Focus	FH1	FH2	FH3	FH4	FH5
Focus on the retailer		x			
Focus on the producer	x		x	x	x
Farm-business (institutional model)	x	x	x	x	x
Signed commitment with the producers	x		x	x	x
Led by the producer entrepreneur	x		x	x	x

Regarding the structure of FH, Palacios-Argüello and Gonzalez-Feliu (2016b) affirm that FH can be structured as: non-profit organizations based on community initiatives; private organizations with a corporate structure; organizations owned by producers and/or customers making decisions in a decentralized manner and sharing risks; or public organizations led by the public sector. Table 4.6 shows the differences in structure among the five regional FH studied.

Table 4.6: Structure of Regional FH

Structure	FH1	FH2	FH3	FH4	FH5
Cooperative owned by producers	x		x	x	x
Non-profit organizations	x		x	x	x
Privately owned		x			

FH are collaborative systems between producers, distributors, and traders with the middlemen removed to shorten the food supply chain, and their main function is to strengthen the supply of agro-industrial products, so the nature and characteristics of FH can be commercial or logistical, which aims to add value to the final product.

Among their commercial functions, some FH: perform the marketing for local producers, adding value to the product by processing for convenience (i.e. food hub processes products to make them more convenient for the end customer. It includes washing, peeling, chopping, and/or bagging); are in charge of the producers' commercial training; offer physical services, such as aggregation, classification, packaging, sales and deliveries; and intangible services, such as payment coordination, marketing and product promotion. Among the logistics functions, there are FH that manage the first and/or the last mile distribution, those that perform the processing conservation (especially cold rooms), and those that offer logistics service to increase volumes and reduce logistics costs. Table 4.7 shows the differences in functions between each of the five regional FH.

Table 4.7: Functions of Regional FH

Functions		**FH1**	**FH2**	**FH3**	**FH4**	**FH5**
Commercial	Local producer markets who sales the producers' products		x			
	Retail or diversified (wholesalers and retailers)		x			
	Processing of convenience		x			x
	Physical Services: physical aggregation, classification, packaging, sale and delivery of products	x	x	x	x	x
	Intangible Services : specialists in coordinating, payment, marketing and product promotion	x	x	x	x	x
Logistical	Producer cooperatives offer logistics services in order to increase processed volumes and reduce logistics costs	x	x	x	x	x
	First mile consolidation: Works directly with producers to collect and store different products from various communities to centralized locations.	x	x	x	x	x
	Last mile Distribution: Distributes products to end customers.	x	x	x	x	x
	Processing conservation: Processes food for product preservation including canning, pickling, and preserving in cold rooms, among others.	x	x	x	x	x

Sustainability impacts of FH studied

Moreover, the deployment of FH must consider a sustainable development logic, bringing positive economic, social, and environmental impacts to communities. Those impacts are listed below. Some extracts from the interviews are detailed for improving the understanding of the impact assessment.

Economic impacts
Regarding the economic impacts (see Table 4.8), all of the FH work with a social integration enterprise, which promotes fair prices, consistent with the market and remunerative for producers, maintaining local employment. The organic farms that supply these platforms employ about 25% more manpower than regular farms. They work closely with the producers to ensure the right prices and stability of volume delivered every season.

Extract from the interview with a FH Manager linked to economic impacts.

"We have associated organic farming with proximity to develop a fair offer in the sense that we create a north-north exchange, that is, a price that corresponds to the benefit of the producer but also corresponds to an offer that values the territory".. FH Manager

Extract from the interview with a FH Manager linked to economic impacts.

"There is a price construction work that is done between the producer and the platform... we are not there to make a profit because we have an associative principle".. FH Manager

Social impacts
Regarding the social impacts (see Table 4.9), all of the FH participate in the development of locally responsible agriculture. They develop the social bond by encouraging exchanges between agricultural actors and inhabitants. These FH give priority to farms on a human scale, farm are oriented or willing to move towards short circuits. They work with a social integration enterprise; exchanging best practices among the producers and training them.

Environmental impacts
Regarding the environmental impacts (see Table 4.10), these FH encourage producers to go towards certified good agricultural practices, particularly organic farming. In so doing, FH are able to offer a set of healthy local-organic products with a high nutritional quality, obtained more naturally, without treatment or synthetic chemical additives, and avoiding pesticide residues. Such producers' practices help to preserve the producers' soil fertility, water quality, air quality and biodiversity, respecting animal welfare. Shorter circuits

Table 4.8: Economic Impacts of Regional FH

Economic impacts	FH1	FH2	FH3	FH4	FH5
- Improves rural/local economy through job creation and local production increase, strengthening agricultural communities and food systems in a sustainable way over time.	++	++	++	++	+++
- Increases farmers' income, profitability, and viability for producers by making them more attractive to buyers and having the advantages of larger-scale economies.	+++	++	+++	+++	+++
- Promotes good communication and information traceability, allowing producers to understand the operational costs of production, processing, transportation, and marketing. Promotes diverse product differentiation strategies to get better prices.	++	+	++	++	+++

1

Extract from the interview with a FH Manager linked to social impacts.

"We work with producers to develop new products, to guide them in the organic conversion, and to approach them to the institutional catering market".. FH Manager

Extract from the interview with a FH Manager linked to social impacts.

"In order to have a more robust and perineal offer, we are in a more associative approach with producers".. FH Manager

Extract from the interview with a FH Manager linked to social impacts.

"we have a social compromise with producers to ensure that they are not in competition for collective catering through a delivery policy provided by a platform for specific territories'.. FH Manager

also encourage reduced packaging and fewer transport externalities, by optimizing routes of food collection and distribution.

Finally, it can be concluded that FH are considered collaborative systems between producers, distributors, and customers that in fact shorten the food supply chain in geographical proximity by eliminating middlemen that do not add value to the final product. All of the FH studied perform various commercial and logistics functions that allow the producers to increase their benefits by adding value to the final product.

Table 4.9: Social Impacts of Regional FH

Social impacts	**FH1**	**FH2**	**FH3**	**FH4**	**FH5**
- Provides training and professional development for farmers, promoting the creation of the next generation of farmers.	+		+	+	++
- Provides access to local food markets and promotes the availability of fresh and healthy food products to reduce health care costs.	+ +	+	+ +	++	+++
- Works closely with the producers, improving their living conditions.	++	+	++	+	++

Extract from the semi-structured interview with a FH Manager linked to environmental impacts.

"We offer shared governance to producers and we encourage them to produce in a sustainable way because we are a platform created for producers by producers".. FH Manager

Table 4.10: Environmental Impacts of Regional FH

Environmental impacts	**FH1**	**FH2**	**FH3**	**FH4**	**FH5**
- Reduces environmental costs for food transportation that travels over long distances and/or through complex distribution networks.	+	++	+	+	+
- Encourages farmers to improve their productive capacities to develop more reliable supplies of local and regional products grown sustainably.	++	+	++	++	+++

Designs assessment of a Food Hub-based distribution system

General considerations

This subsection explains the organic-local producers considered, the FH's distribution scenarios considered, and the VRP's parameters configuration. The data was collected from Regional Organic Agriculture Observatory, and 153 producers offering organic products (e.g. vegetables and fruits) were considered for the construction of the Vehicle Routing Problem. Table 4.11 shows the locations of the producers considered for this study.

Table 4.12 shows the location of the FH, the department where the products come from (product origin) and the department where the majority of the FH' customers are located (product destination).

Nowadays the food distribution is performed according to each FH policy. With the aim of comparing the performance of two different logistic organization, two distribution

Table 4.11: Producers per department

	Number of producers			
Department	**Fruits**	**Vegetables**	**Multi-product (F + V)**	**Total Producers**
Ain	2	2	-	4
Ardèche	11	17	2	30
Cantal	0	1	1	2
Drome	21	28	7	56
Isère	1	4	-	5
Loire	3	14	1	18
Haute-Loire	2	10	-	12
Puy-de-Dôme	2	7	2	11
Rhône	3	3	2	8
Savoie	2	1	-	3
Haute-Savoie	1	3	-	4
			Total	**153**

Table 4.12: FH Locations, Product Origins and Customer Locations. (L) Food hub location; (O) Origin; (D) Destination.

	Regional Food hubs for organic-local products														
	FH1			**FH2**			**FH3**			**FH4**			**FH5**		
Department	**L**	**O**	**D**	**L**	**O**	**D**	**L**	**O**	**D**	**L**	**O**	**D**	**L**	**O**	**D**
Ain											x	x			
Allier					x	x									
Ardèche		x	x								x				
Cantal					x	x									
Drome	x	x	x								x				
Isère											x	x	x	x	x
Loire								x	x		x				
Haute-Loire					x	x									
Puy-de-Dôme				x	x	x									
Rhône							x	x	x		x				
Savoie										x	x	x			
Haute-Savoie											x	x			

scenarios are proposed: (i) Producer delivers the products to the Food Hub (Scenario 1), and (ii) Coordinated collection of products from the Food Hub (Scenario 2). The last scenario is proposed by following the principle of transportation pooling (Pan, 2010), where the transport is coordinated among the producers and the FH. Figure 4.2 shows the distribution configuration analysed by scenario.

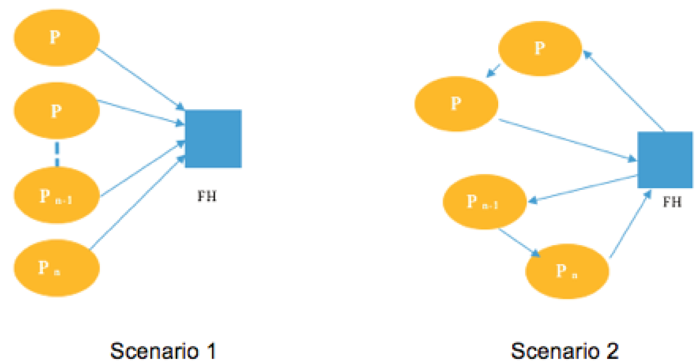


Figure 4.2: FH Distribution Scenarios

The VRP was configured according to the following parameters:

- a fleet of vehicles serves a set of producers;
- the product collected from each customer per visit must be satisfied by a vehicle assigned on the route;
- each vehicle leaves and returns to the FH;
- the vehicle capacity should not exceed 900 kg (light vehicles of 3.5 tons);

For the proposed test case, it is important to note that the time window restriction for the collections was not considered for this study.

Producers' allocation based on administrative subdivision

An interesting finding, which determines the design of the distribution system and thus its efficiency and sustainability, is the allocation of local producers to each Food Hub. This allocation is currently based on administrative subdivisions in France (i.e., Departments) and is not based on proximity or convenience.

The FH' and producers' locations, in relation to administrative subdivision, is shown in Figure 4.3. This means that all of the FH deserve only producers located in their own department. Mapping the producers and food hubs was done using QGIS, which is open-source cross-platform for geographic information system.

To compare the effects on vehicle-kilometres travelled of Scenario 1 and Scenario 2 based on the current allocation Table 4.13 shows the results in distance obtained with the VRP Spreadsheet Solver based on Excel .

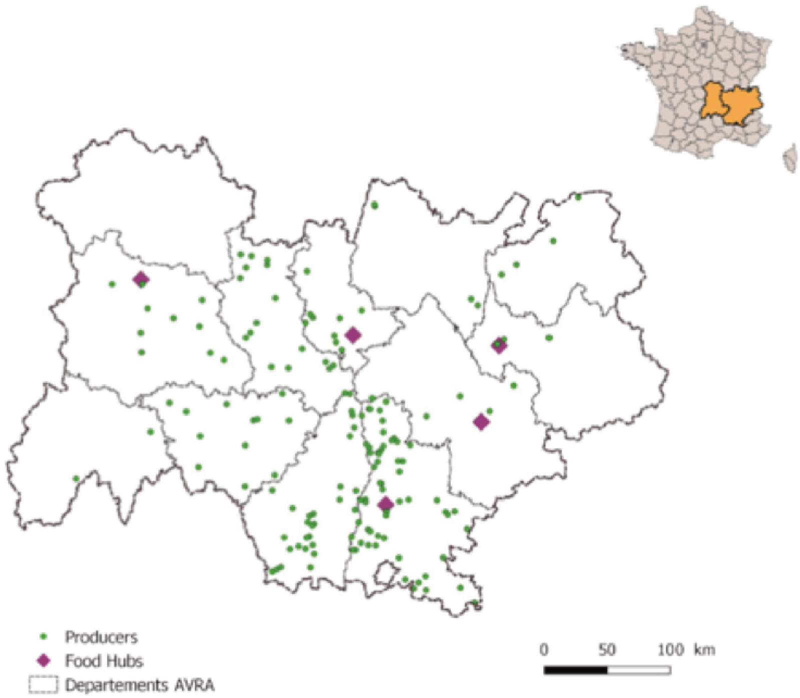


Figure 4.3: Producers' allocation based on administrative subdivision using QGIS.

Table 4.13: Distance results for producers' allocation based on administrative subdivision

FH	Nb Producers	Distance Sc 1	Distance Sc 2
FH1	87	10 096	1 384
FH2	26	3 483	604
FH3	24	5 308	1061
FH4	5	436	260
FH5	11	1 715	631

Producers' allocation based on geographical proximity

The short food supply chain is characterized by a proximity dimension that considers both relational and geographical proximity (Bosona and Gebresenbet, 2011). Geographical proximity is defined as *"the explicit spatial/geographical locality and distance/radius, within which food is produced, retailed, consumed, and distributed"*. It refers to a specific area, community, place or geographical boundary that the food can come from, and it implies minimizing distance and reducing food kilometres.

To analyse the producers' allocations based on geographical proximity, it is necessary to calculate the distance between each producer and each Food Hub with the aim of minimizing the food transport distance.

The producers were first clustered in terms of their geographical proximity. In the clustering procedure, using the VRP, five clusters of producers were formed, and allocated to the closest Food Hub. Figure 4.4 presents the five FH and the producers allocated to them, according to the Ellipsoidal distance, which iterates through each feature on the producers and the FH locations, and finds the closest distance.

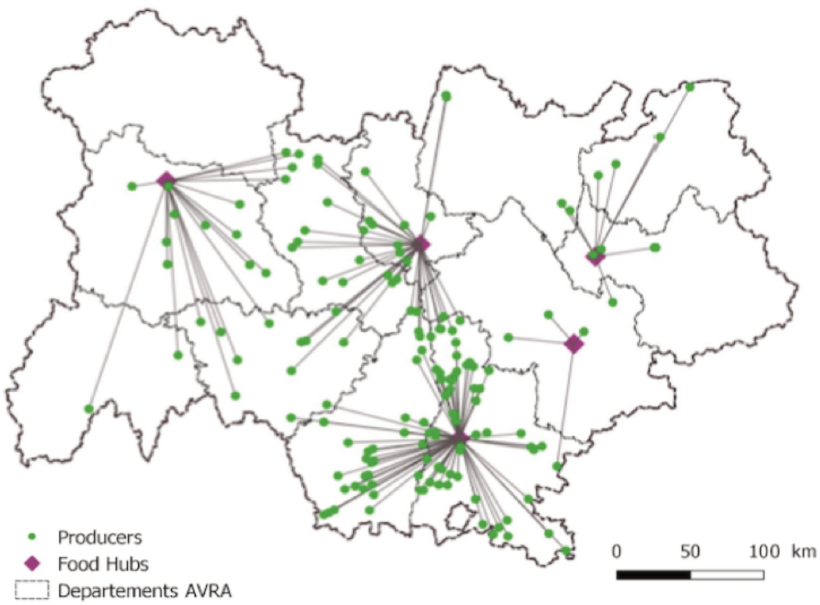


Figure 4.4: Producers' allocation based on geographical proximity using QGIS

To compare the effects on vehicle-kilometres travelled of the geographical proximity-based allocation strategy, Table 4.14 shows the results in distance obtained with the VRP.

Table 4.14: Distance results for producers' allocation based on geographical proximity

FH	Nb Producers	Distance Sc 1	Distance Sc 2
FH1	55	5 992	721
FH2	17	3 190	628
FH3	34	8 536	747
FH4	16	2 532	771
FH5	31	5 265	763

Figure 4.5 show the producers' allocations based on geographical proximity using optimised routes obtained with the VRP.

In summary, to increase the competitiveness of local food producers, it is necessary to improve the performance of their logistics by promoting the sustainability of local food systems and the development of FH. Indeed, the results show that after comparing the effects on vehicle-kilometres travelled of the allocation based on administrative

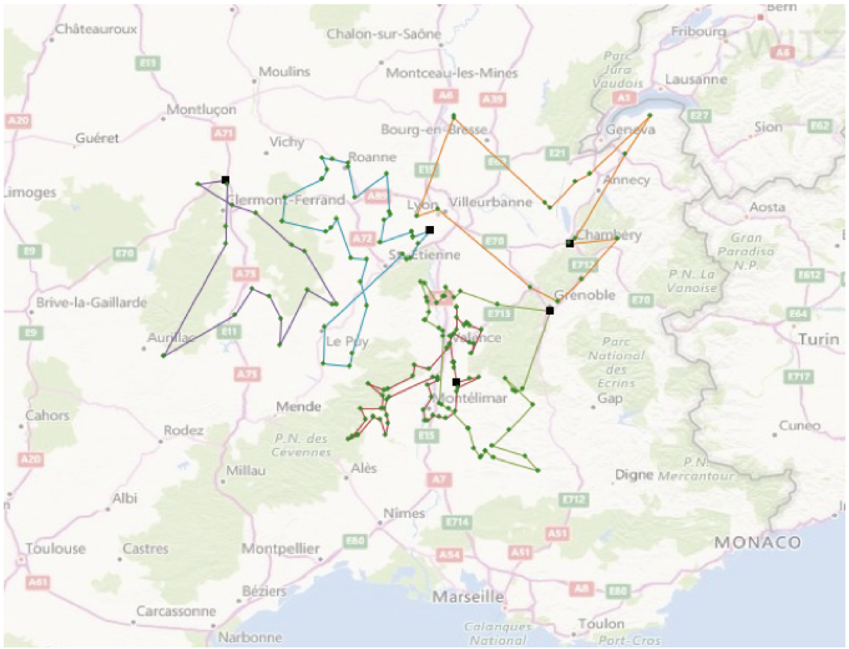


Figure 4.5: Producers' allocation based on geographical proximity using VRP

subdivision and that of a geographical proximity-based allocation strategy. The latter could lead to reductions of about 8% of vehicle-kilometres travelled using coordinated collection of products from the Food Hub.

4.5 Discussion

Food Hubs (FH) are an important solution to respond to the demand for organic-local products, because they allow producers to fill the demand of institutional catering's stakeholders regarding the limited number of intermediaries between the local producers and the consumer, and they strengthen the social connections between the organic-local offer and the demand by offering a fresh product.

By working with a Food Hub, a producer could reduce the food distance travelled by consolidating freight, maintaining the high quality of the products and decreasing transportation costs; avoiding producers' trips that may be poorly conceived, with vehicles whose loading is not optimised.

Once a Food Hub is developed, it is important to analyse the allocation strategy. The notion of restricted territory is not clearly defined, but geographic or political limitations may be considered. When referring to local products, the distances between the producers and consumers are generally on the order of 100km to 200km, which corresponds to a departmental scale and refers to producers' allocation according to the administrative subdivision.

However, based on the VRP analysis, there are some distance issues to consider.

Considering geographical proximity defined as the distance within which food is produced, retailed, consumed and distributed, another producer's allocation must be considered. The VRP shows that there is a distance gap between the allocation made by geographic proximity and administrative subdivision. Taking into account that the regional FH collect the producers' products, the average distance is: (i) 26km per producer in an allocation by administrative subdivision; and (ii) 24km in an allocation by geographical proximity. This means that the best strategy is not always to allocate producers according to administrative subdivision in terms of reducing food distance travelled. Moreover, it is necessary to consider the differences between the number of producers allocated to one FH in the administrative subdivision strategy. These difference are 5 producers to one FH and 87 producers to another FH. Therefore, it is necessary to consider the geographical proximity allocation in terms of producers allocated to one FH, against to administrative subdivision allocation in order to analyse if it is necessary to open a set of FH for few producers.

Policy-makers could intervene to foster collaboration among the FH to have a more efficient solution for producers and consumers, by analysing the producers' allocations. These collaborations will help FH take advantage of their location, by conceiving optimized networks to minimize the producers' transport costs, and thus becoming more competitive than they may be within conventional distribution channels. These findings confirmed the positive effects of logistics pooling studied by Pan (2010).

Perspectives of FH's role for organic products distribution

Within the next few years, the demand for organic foods in institutional catering is estimated to to increase very quickly, influenced as it is by local policy. Will current FH be capable to supply this demand?

Based on the interviews conducted, it is clear that some FH currently have enough suppliers to supply the increasing demand for organic products. The suppliers see an increase in demand as a natural trend (ambitious but realistic) in the current market; they have already started to work to respond to the potential increase in demand for organic and local products.

In fact, today there is a French policy that is looking for a national requirement of 50% quality foods, including 20% organic products, in school canteen menus for 2022, and that this 20% represents the school canteen that is one-third of the institutional catering sector. This policy refers to the law number 2018-938, October 30th of 2018 known as *"loi pour l'équilibre des relations commerciales dans le secteur agricole et une alimentation saine, durable et accessible à tous"* (LOI).

Nevertheless, there are several points of vigilance that have been evoked during the interviews that must be maintained to meet these goals:

- In terms of the volume of organic demand requirement, it will be necessary to start looking for organic product offerings in other regions in France or in Europe, which will decrease the local initiative and decrease the value or relevance of proximity. As a result, an overall balance must be struck between the organic and local demand.

- Age of producers: Currently, more than 50% of the French organic-local producers are people over 60, which means that in ten years those producers will no longer be active producers for the institutional catering sector. Should demographic trends of young people going to the city to work, and not being drawn to or continuing with farm jobs, the ageing of the organic agricultural work force will be a weakness.
- The number of organic farms must increase. To meet organic demand, a high percentage of local producers need to begin a process of organic conversion using the current lands.
- Local and organic demand fulfilment: Considering the organic and local products demand, it is necessary the FH work together to have a robust offer for all departments.
- Meal menu costs: local and organic products will increase the meal menu cost. One reason for this is increased logistic costs, which can be reduced by increasing food consolidation, economics of scale and route optimization as strategies of collaboration between the food supply chain stakeholders.

4.6 Conclusion

This research describes the role of FH in enabling short supply chains and allowing an increase in the share of local and organic products available for institutional catering. The research also provides a classification of different FH, and an assessment of producers' allocation strategies to FH.

This chapter identified and defined the roles and characteristics of five Food Hubs (FH) in relation to catering sector demands for local-organic products. The five FH were characterised according to the typology proposed by Palacios-Argüello et al. (2017). All of them are considered collaborative systems between producer, distributor, and customer that shorten the food supply chain in geographical proximity and by removing middlemen that do not add value to the final product.

Concerning the stakeholder focus of the FH, four out of five are focused on the producer, and are conceived as a farm business led by a collective of producer entrepreneurs. Regarding the FH structure, one out of five is managed privately, while the others are non-profit organizations or cooperatives owned by producers. All five of the FH perform various commercial and logistics functions that allow the producers to increase their benefits by adding value to the final product.

Several other positive sustainable impacts are generated after the FH deployment: there are some differences among the FH concerning the economic impacts based on structure; four out of five have the same social impacts (except the one that is privately owned); and the same environmental impacts were recalled during the interviews with the five FH managers.

Regarding the producers' allocations, two allocation strategies were discussed: producers allocation based on administrative subdivision, and producers allocation based on geographical proximity. In terms of distance efficiency, the second scenario provides better results; the proximity-based allocation represents about a 10% of gain compared to an allocation based on administrative subdivision, using the strategy of collection of products by the FH. This suggests that to strengthen the supply of agro-industrial products, one must consider the producers' allocation in terms of geographical proximity and accessibility of the FH, which influences the food distance travelled and the food collection efficiency in terms of distance.

In terms of research limitations, the assessment of the role of the FH and their benefits in this research is based on limited number of interviews with stakeholders involved in the distribution system, and does not measure real impacts on local producers. The allocation analysis presented is limited to the study of potential producer allocations to FH, assuming that the current allocation may be the consequence of current legislation.

However, it is possible that there are some connections between producers and FH that are not considered. It is also possible that a change in the allocation of producers could also have some effects on collaborations and trip consolidations for the first mile. This research does not consider the costs associated with the operation of FH, costs that could influence the decision to assign producers to a particular Food Hub.

The results of this research provide valuable information to distribution companies designing short supply chains with FH, as well as to policy-makers aiming to increase their share of local and organic food in institutional catering. Finally, the results of this research could be extrapolated to other regions, and to a broader aim to increase organic and local foods, or short supply chains.

Chapter 5

Logistic decisions in food supply and distribution

Contents

The work discussed in this chapter has been presented in ILS 2018 Conference Palacios-Argüello et al. (2018c). This work was mainly conducted during the ELUD project that was financed by l'Université de Lyon with the labex IMU (Intelligences des Mondes Urbains). The clustering work described in this chapter had been performed with the collaboration of A.Regal from Universidad del Pacífico, Peru.

Having analysed the Food Hub as a food supply chain strategie that enable sustainable food distribution, this chapter aims to answer to the fourth research question: *Which are the logistic decisions impacts on food supply chain organization when considering food supply chain strategies that enable sustainable food distribution ?*

With this aim, this chapter proposes a framework to define and analyse impacts of logistic decisions on food supply chain organization considered to develop the strategies presented in the previous chapter.

5.1 Introduction

The issue of feeding cities is an ancient question which is still of actuality (Gonzalez-Feliu, 2018b). Although urban logistics is now a popular subject, only a few works deal with urban food logistics (Cretella and Buenger, 2016; Morganti and Gonzalez-Feliu, 2015a; Sánchez-Díaz, 2018; Tozzi et al., 2014). In most cities, collective catering represents a recurrent issue in terms of both nutrition and logistics issues. Indeed, several cities in the world try to deploy more healthy menus, mainly based on organic products (Palacios-Argüello et al., 2018b), and the trends go to the development of urban food systems based on a local production promotion. Consequently, there is an increasing interest in short food circuits by policymakers. Short food circuits aim to satisfy the demand of local food produced approximately within a set of kilometers radius (De Fazio, 2016). Some of those are direct sales from producers to consumers, producers' shops, urban farmers' markets, and e-commerce for local quality products among others (Bosona and Gebresenbet, 2011).

As cities have identified local products consumption as an important part of the strategies to feed their citizens in a more sustainable way, the logistics problem of integrating local production into urban food systems has become a key challenge (Allaoui et al., 2018). This question is crucial since some studies show that the only use of short food circuits to bring consumers and farmers closer and local production demand is not a sufficient condition to reduce the impacts of logistics on the environment (Vaillant et al., 2017), and logistics reorganization seems necessary. Indeed, aiming to improve performance on logistic and transport overall the food supply chain, it is necessary to develop new logistic organizations (Daoud and Mellouli, 2015).

Certainly, fresh foods distribution network design differ from the traditional network design problems because of the desired food quality and logistic requirements (Akkerman et al., 2010; Bortolini et al., 2016a). To deal with food supply requirements, the control entities and supply chain stakeholders have promoted local food production and consumption (Stroink and Nelson, 2013).

The challenge of local producers is to deal with the food supply and effective logistics management requirements such as the respect of the time deliveries, volume demanded and product quality, among others. Therefore, new consolidation strategies emerge making that the producers perform directly more logistical activities such as packaging, distribution, and final delivery of the products to the customers (Ahumada and Villalobos, 2009). Those requirements do not only refer to have a robust offer in terms of product's quality and quantity availability, but also to be able to distribute it in the right condition, to the right place, at the right time, for the right cost.

Consequently, effective logistic management requirements are the main barrier to have more local food. Considering these logistic requirements, the producers must consider very carefully transportation planning and inventory decisions regarding the product's perishability aiming to reduce the product's deterioration and preserving its value (Ahumada and Villalobos, 2009). Indeed, the producers often do their own transport and that leads to sub-optimal distribution. This greatly affects the producers income, working time, food price, the satisfaction of consumers and in consequence the producers have higher costs making them less competitive (Bosona and Gebresenbet, 2011).

In local supply, a large set of small producers is available and the choice and assignment of those producers is necessary. Indeed, nowadays small producers are not organized and they assume their transport, resulting in a plethora of non-optimized routes (Vaillant et al., 2017). Taking into account that in school canteen distribution, it is common the use of central kitchens, there is a logistics operator that traditionally manages the supply, transformation/ cooking, and final distribution processes from central kitchen to canteens, it is important to re-design the school canteen supply chain to introduce local producers and collect the supplies in an organized and optimized way (Palacios-Argüello et al., 2018b).

Consequently, in the design and planning of a distribution-based supply chain it is important to distinguish between supply chain echelons (production and warehousing stages, plus retailing and eventually final consumption) of the chain and the transportation stages (since when linking two echelons, multi-stage transport can be defined) (Gonzalez-Feliu, 2013a). Moreover, in a context of short circuit and local food supply, various small and medium suppliers are involved, so potential suppliers need to be identified and the quantities of goods sent by each supplier need to be defined (with respect to classical distribution problems, the demand of each supplier is not fixed but is a result of the planning problem). Then, to that it is important to consider: (1) the type of transport systems used to bring goods from the suppliers to the transformation centres, and then, (2) the definition of the distribution systems to deliver final consumers, and in the case of collective catering, to deliver restaurants where food is consumed.

The problem addresses two horizons of planning (i) a strategic one that focuses on re-designing the distribution system including the number of facilities and their locations, as well as the type and number of vehicles required; and (ii) a tactical one that focuses on allocation of customers and routing. In that context, network design problems can then be adapted to answer to both the assignment and the network configuration issues, to deal with strategic planning issues. Then, in a second time, routes can be constructed using vehicle routing approaches for tactical planning issues.

Furthermore, in current logistics practices, the choice of suppliers, and then of the demand policy that will define quantities to deliver, are defined at a strategic level, whereas route construction belongs to tactical/operational level. However, those approaches are not really studied as connected, and in practice, the choice of suppliers and the quantities to deliver are not related to transport costs, but only to commercial and product availability reasons. Thus, an integrated planning approach can result in more efficient transport plans.

With this scope in mind, this chapter starts with the literature review, presenting the definitions of logistic decisions and more precisely, the distribution decisions considered at strategic, tactical and operational level. Then, the methodology is explained by applying the proposed framework to a case study in the Auvergne-Rhône-Alpes region in France, analysing the food distribution decisions in the institutional catering sector. Finally, six different cases are proposed and compared to analyse the efficiency of the food distribution system in terms of distance and time, when considering food supply chain strategies that enable sustainable food distribution.

5.2 Literature review: Logistics decisions in food distribution

Logistics decisions

The logistics decisions are divided in several dimensions based on various criteria defined in the literature review. The common classification that was found, divides the decision into: strategic, tactical and operational levels (Cirullies et al., 2012; Semini et al., 2008). Moreover, the logistic decisions are linked to a time frame, resource requirements, or level of managerial responsibility (Ahumada and Villalobos, 2009). Lambert (2008) affirms that the long-term decisions consider a time-frame of 2 - 5 years, the mid-term decisions consider 1 - 2 years, and the short-term decisions consider a day-to-day time frame. Besides, Riopel et al. (2005) propose three main levels of logistic decisions: (i) strategic planning level (ii) network level and (iii) operational level. In addition, Hsiao et al. (2010) divide the logistics decisions according to four levels of the complexity of the activities : (i) basic activities, (ii) value-added activities, (iii)planning and control activities, and (iv) top activities.

The figure 5.1 compiles the logistic decisions and its interactions found in the literature review based on the 48 decisions described by Riopel et al. (2005), and completed with :

Strategic decisions cited in (Ahumada and Villalobos, 2009; Akkerman et al., 2010; Aras and Bilge, 2018; Bai and Liu, 2016; Cortinhal et al., 2015; de Keizer et al., 2012; Hsiao et al., 2010; Lambert, 2008; Semini et al., 2008; Wanke and Zinn, 2004). *Network decisions* cited in (Baghalian et al., 2013; Bortolini et al., 2018; Cirullies et al., 2012;

Cortinhal et al., 2015; Daoud and Mellouli, 2015; de Keizer et al., 2017; Khalili-Damghani et al., 2014; Lopes et al., 2010; Miranda et al., 2009; Vollebregt et al., 2010; Zhao and Lv, 2011). *Operational decisions* cited in (Lambert, 2008).

Distribution decisions

In fact, food system requires the coordination of different aspects of distribution system (Etemadnia et al., 2013). According to Bortolini et al. (2016b); Igl and Kellner (2017), the aim of distribution decisions on food distribution systems is to define the network's best configuration, mainly in terms of allocation of markets' demand to producers, and the selection of a shipment strategy to distribute the products. Besides, it involves several levels of hierarchical decisions, that can be classified as (S) strategic network design (long-term), (T) tactical network planning (mid-term), and (O) operational transportation planning (short-term) (Akkerman et al., 2010).

Figure 5.2 compiles the distribution decisions and its interactions found in the literature review from the distribution decisions described by Akkerman et al. (2010), and completed with: (i) strategic network design decisions cited in (Bortolini et al., 2018; Firoozi et al., 2014; Vollebregt et al., 2010); (ii) network planning decisions cited in (Khalili-Damghani et al., 2014); (iii) transportation planning decisions cited in (Sprenger and Mönch, 2012).

These logistics decisions determine a distribution system's sustainability, for instance, safety of the food product as a result of the time a product is subject to quality degradation during distribution, meaning that there is a linear relationship between quality and transportation time (Akkerman et al., 2010).

Besides, distribution network design and planning are popular subjects in freight transport planning literature (Crainic and Laporte, 1997) and, they are mainly associated to the definition and setting of the service parameters of a freight transportation system. Although, the problem is a simplification of a real network that allows to represent systems composed of various echelons. Moreover, linear programming and exact methods can solve various variants of the problem, which makes it very popular in practice (Crainic, 2000; Wieberneit, 2008).

Distribution network design

The distribution network design is one of the most critical logistic decisions that the firms face nowadays due to its impact on costs, time and quality of customer service. It defines the number of actors involved, how far products travel and how wide they get spread geographically (Akkerman et al., 2010).

Distribution network design concerns long-term decisions. There are two main distribution decisions: (i) facilities location and (ii) demand/facilities allocation. Together are known in the literature as facility location-allocation problems (Akkerman et al., 2010). These decisions involve other decisions such as supplier selection, transportation mode selection and product range assignment (Akkerman et al., 2010;

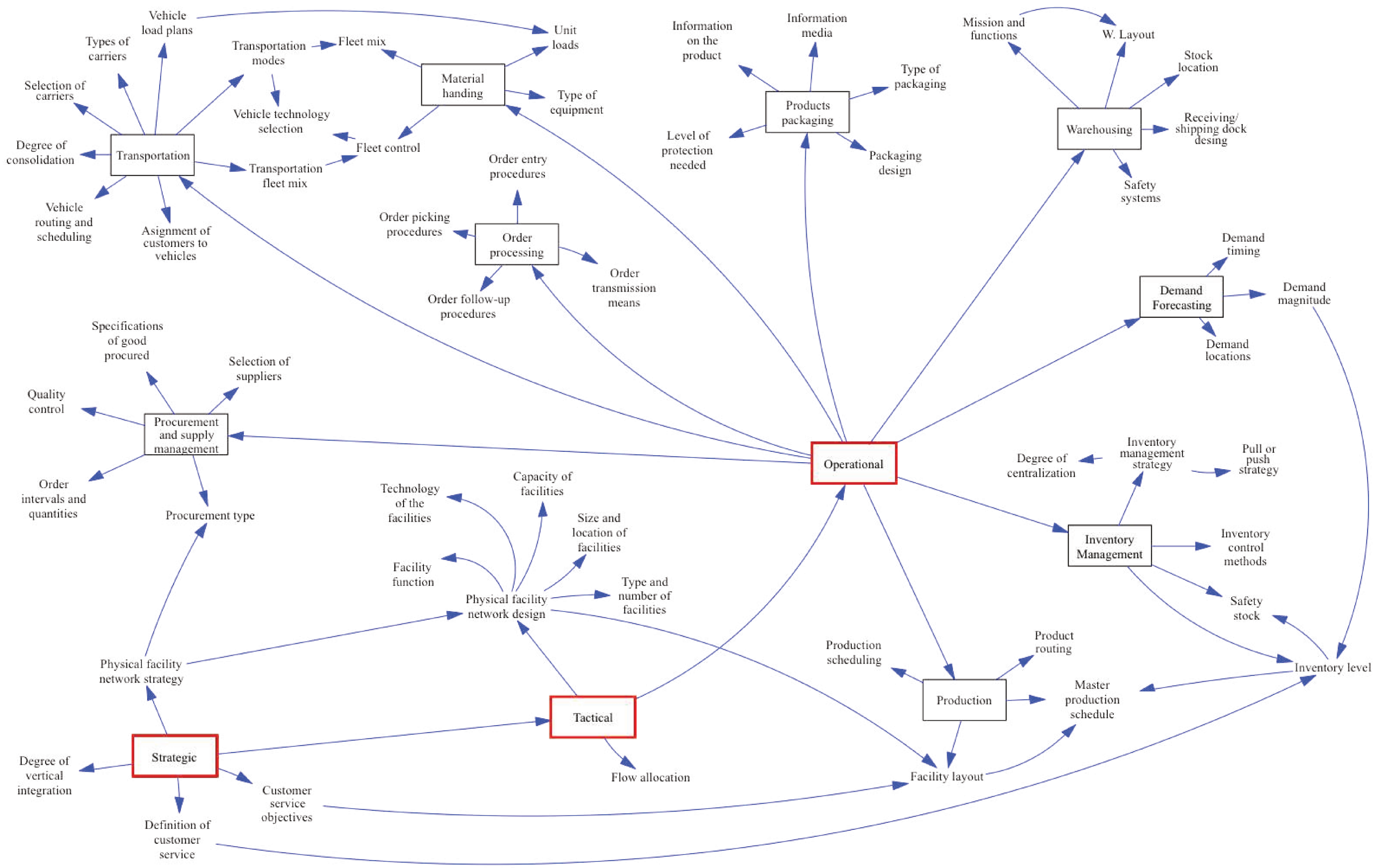


Figure 5.1: Logistic decisions extracted from the literature analysis. Figure designed in Vensim software

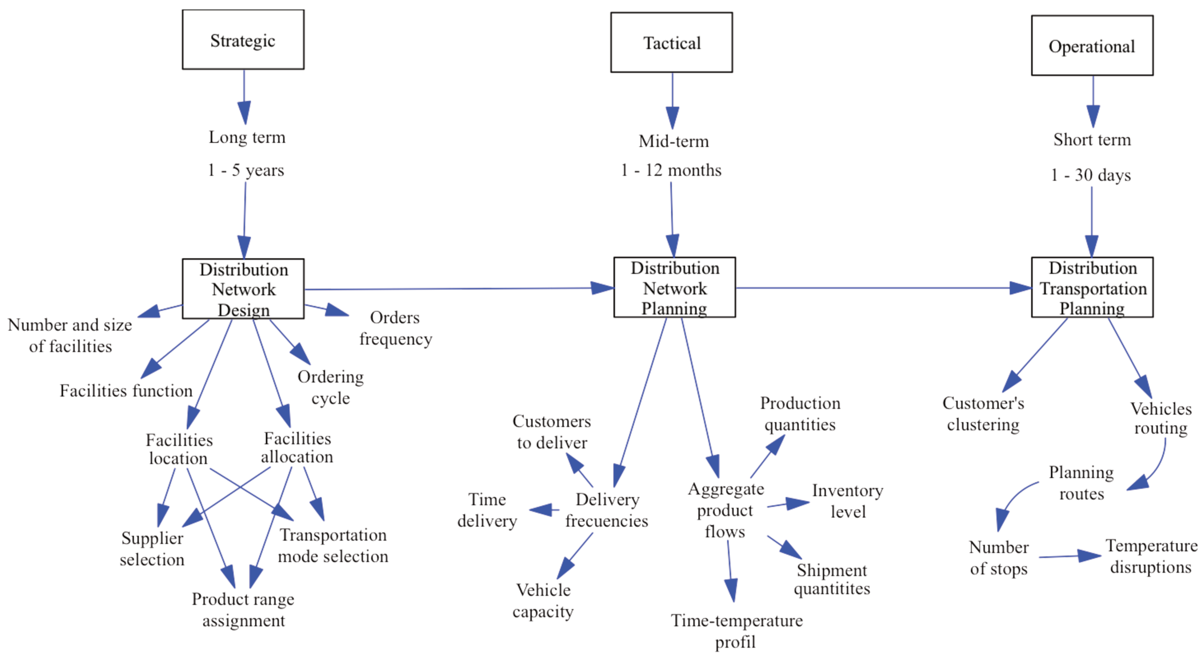


Figure 5.2: Distribution decisions extracted from the literature analysis. Figure designed in Vensim software.

Bortolini et al., 2018). Besides, Bortolini et al. (2018) affirm that facility capacity, shipment mode and facility function are distribution network design decisions to be considered.

These decisions impact the cost associated to the transportation and replenishment, affecting: (i) the optimal inventory policy defined; and consequently, (ii) the delivery frequency that is established (Firoozi et al., 2014).

Distribution network planning

Compared to distribution network design decisions, distribution network planning requires more detailed modelling of production and distribution. Therefore, Akkerman et al. (2010) define two types of distribution network planning decisions related to: (i) aggregate flow planning and (ii) delivery frequencies definition. The first typology defines the product flows for each time period and consequently defines the inventory levels at each facility location, explaining the product's temperature during storage and distribution process. The second typology defines how often and when exactly the product will be delivered, considering the vehicle type and load capacity.

Since the distribution system can include both full truckload (FTL) and less-than-truckload (LTL) transport modes in the distribution between the facilities (Gendron and Semet, 2009). Network planning allows to define a base network that will be used, but it does not allow to define explicit routes and service times.

For that reason, vehicle routing approaches are needed to define the routes construction when it refers to an application, direct transport being a consequence of network design when transported quantities are enough to justify FTL policies. The literature on VRP is very extensive and many variants are defined to consider different constraints and specificities of the various application fields (Toth and Vigo, 2014). In the context of canteen distribution, since time periods of distribution are of about four to eight hours and each canteen has the same time constraints, time windows do not seem to be relevant, meaning that there is not preference of delivery one canteen in priority. Besides, in a context of defining average routes, dynamic approaches and time-dependent variants do not seem relevant. Concerning the definition of the network, since the problem is defined globally, multi-stage distribution systems, and then N-echelon Vehicle Routing Problem (N-VRP) and N-echelon Location Routing Problem (N-LRP) approaches, seem to be relevant (for more details on those approaches, please see (Crainic et al., 2009; Cuda et al., 2015; Gonzalez-Feliu, 2012)).

According to Gonzalez-Feliu (2011), if the quantities assigned to each intermediary platform are known, a N-VRP problem resumes to N sets of VRP, the number of VRP for each echelon being the number of active intermediary platforms, or depots for the first echelon. Moreover, Crainic et al. (2009) showed that a complex multi-stage transport planning model can be solved by splitting it into sub-problems.

Transportation planning

This type of decisions concerns the short-term planning of the distribution decisions. According to Akkerman et al. (2010), it deals with: (i) the clustering of customers into zones, that are sometimes constructed based on the drivers' knowledge of the specific regions, and (ii) the product's deliveries planning (vehicle routing execution) considering the product's temperature disruption related to how often the temperature-controlled cargo hold has to be opened (number of vehicle's stops) .

5.3 Material and methods: Framework for analysing food distribution decisions

This section explains the proposed framework to define and analyse impacts of decisions on food supply chain organization. It integrates a planning method to define distribution networks for school canteen supply in real conditions, at a regional level, including local and organic producers. The proposed framework combines a strategic, a tactical and an operational phase. Nevertheless, only the first two will be developed in this chapter.

The strategic phase includes a demand estimation or demand forecasting model, demand allocation and a network design problem. The strategic planning method is a linear programming model able to be solved by a commercial solver. Besides, the tactical phase uses the results of the strategic phase in terms of a network to define more precisely the routes to deliver goods to the different echelons of the short-circuit supply chain. The tactical planning method is based on a vehicle routing heuristic algorithm able to solve real-life sized instances and, that reproduces commercial tools.

To illustrate the framework, a case study of a regional-based canteen supply system is presented. It includes a set of 161 school canteens in two of the main cities of Auvergne-Rhône-Alpes region in France; 153 producers located in different departments of the region; and, the relevant intermediary structures to ensure a good supply to those canteens.

This framework involves different decisions to be considered for the food supply and distribution in the school canteen system. The steps detailed in Figure 5.3 are explained as follows:

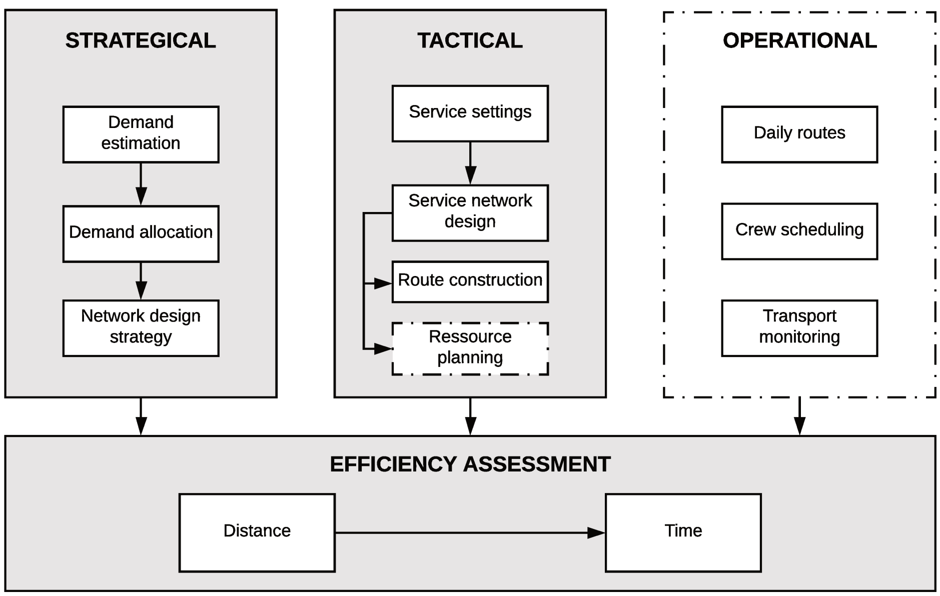


Figure 5.3: Framework for analysing food distribution decisions in institutional catering.

1. Network description: It aims to define the number of actors and echelons of the food distribution system.

2. Demand and offer estimation: To estimate the demand for the school canteens and the central kitchens and producers' offer.

3. Facilities location: Once the demand and offer are estimated, the number and location of the FH facilities must be established. With this aim, two different methods are proposed: (i) Empirical, using the current facilities described in Section 4.4. (ii) Computational, using clusters to integrate logistic networks for producers by proposing new facilities' location. For this, two algorithms are used, the Affinity Propagation and K-means.

4. Demand/offer allocation to facilities: Once the number and location of facilities are defined, the demand/offer allocation is defined. For this, two methods are used: (i) Analytical: producers' allocation according to the geographic proximity and according to the administrative subdivision, described in previous chapter. (ii) Mathematical modelling, proposing a linear programming model that allows assigning the freight to each echelon producers and FH considering the distance and demand of each central kitchen and each school canteens aiming to minimize the total logistic cost.

5. Routes construction: Once the assignment of producers to FH and the assignment of FH to central kitchens is made, tactical planning issues, mainly route construction issues, can be done. The distribution schemes will be characterized by: (i) a hierarchical structure such as the number of transport stages and a load redistribution, (ii) the vehicles used in each transport, and (iii) the vehicle utilization policy such as full truckload (FTL) or a less than truckload (LTL) policy.

6. Efficiency assessment: Regarding the previous logistic decisions considered, the efficiency assessment of the food distribution system will be defined in terms of distance and time.

Network description

Considering the whole supply chain of fresh food and the different destinations together when planning; it allows partitioning the set of producers spatially in order to assign them to the closest destination (ensuring, of course, total demand satisfaction) and reduce the number of trips for inbound supply. To do that, it is important to first define the main stages of that supply chain. The supply chain structure can be represented as a four echelon supply chain (Lambert, 2008):

- The first echelon is that of raw materials production. Raw fresh food is produced at regional grounds which are spread around the region. Those producers are mainly small and medium agriculture surfaces, which need to collaborate and be grouped to satisfy the overall demand of their customers. The overall production is sold to wholesalers, marketplaces and collective catering, including school canteens.

- The second echelon considers collecting and consolidating those products and allows satisfying the demand of each customer. Those are the food platforms or food hubs (FH) that are defined in the territory. They propose several services to producers and customers, but act mainly as consolidation and distribution centres (Morganti, 2011; Palacios-Argüello and Gonzalez-Feliu, 2016b).

- The third echelon is that of meals preparation and cooking. In school canteen supply chain, the food for school canteens can be prepared directly at the canteen or in central kitchens. In the current work, the supply chain with central kitchens is analysed.

- The last echelon is that of school canteens, which are delivered daily with semi-prepared meals and make the final cooking/heating to propose meals to students and employees.

Food demand is mainly managed at central kitchens, which make the most of the food processing processes (cooking, pre-preparing, etc.). In the current situation, each central kitchen manages its own demand, but produces and supplies separately. This research explores the possibility of a joint supply management, i.e. each central kitchen manages its own demand and production but the supply management is made for a network of central kitchens, using the food hubs as intermediary platforms for supply management purposes. Moreover, strategic planning is considered, i.e. to the definition of the suitable distribution network that takes into account a common supply strategy for a set of school canteens. In a first time, to explore the problem, an average weekly delivery is considered, i.e. no different periods are considered and the vegetable seasonality is not considered so an average weekly planning is suitable to propose a first network characterization to support strategic planning decisions.

Demand and offer estimation

School canteen and central kitchen demand estimation

To estimate the demand for vegetables and fruits, the following methodology is proposed (for more details see Palacios-Argüello et al. (2018b,c)).

Indeed, at the central kitchen, the demand quantities for each school canteen are converted in needs of prepared food, which allows to estimate the quantities of raw products needed (which delivery frequencies and other characteristics are related to the organization of each central kitchen). To generalize that, it can be stated that for each canteen, the demand can be counted in number of meals, which is related to the number of potential customers, in the following way:

$$N^s_{meals} = K \times N^s_{students} \tag{5.1}$$

Where N^s_{meals} is the number of meals per day at school s (for tactical planning, an average daily number of meals is a suitable indicator), $N^s_{students}$ the number of students registered at school s and K a coefficient estimated by yearly statistics of a set of homogeneous school canteen.

After defining the daily number of meals N^s_{meals} of each school canteen, and taking into account the food logistic system (which will be described in next section when presenting an example of application), it is necessary to define the quantities to deliver. To do this, once the number of meals is known, the quantities of food necessary to provide meals to each school canteen can be estimated by converting the total number of meals managed by the central kitchen per day into average weights of food to compose the meals. The interviews showed that one central kitchen establishes the same menu for all canteens assigned to it. Moreover, in order to make a suitable estimation, we estimate the quantities of food needed and then we forecast an average daily quantity. More precisely, the proposed estimation procedure works as follows:

1. Estimation of the food portion (weight per meal). First, we classify the school canteen type (Primary, Middle or High School). It is represented by the amount of food consumed (in g/meal) according to the age of the students and the nutritional requirements established by the national government. Then, the average composition per meal G^c_{meals} is estimated, where c is the category of school (p: primary school; m: middle school; h: high school).

2. Calculation of the daily demand of the central kitchen, from the overall needs of cooked food and conversion tables (to take into account the eventual losses related to the cooking processes and/or food waste at canteens). The loss coefficient α (which allows to consider the food loses) has been established via primary and secondary data on an average basis, without entering in detail on the management of canteens and the type of cooking preparation and distribution (hot or cold distribution).

The yearly quantity of food required by central kitchen (in kg or tons) ($Q^c_{Kitchen}$) is estimated with the following relation:

$$Q^c_{Kitchen} = \left(\sum_s (N^{s-c}_{meals} \times G^c_{meals}) \right) \times (1+\alpha) \tag{5.2}$$

$$\tag{5.3}$$

Once the total quantities needed by the central kitchen are known, the quantity of fresh fruits and vegetables Q_k is estimated as follows:

$$Q_k = Q^c_{Kitchen} \times K^{fresh} \tag{5.4}$$

where K^{fresh} is a percentage established in the national legislation of school canteens, and adjusted by local authorities. To estimate the daily food quantities for each school canteen, the relation remains similar:

$$Q^c_{school} = N^{s-c}_{meals} \times G^c_{meals} \tag{5.5}$$

Offer estimation

Considering the assumption of a mono-commodity for demand constraints, the fact of fixing the producer capacity $CapP$ as the supply limit at producer (i) allows to estimate the demand allocated to each producer and each FH. To illustrate the proposed methodology, two producer's capacities are proposed:

- The producer capacity ($CapP$) (in kg per producer) is fixed by dividing the total demand by the number of producers available. In that way, all producers need to be consulted to ensure the total demand of all central kitchens. Each producer needs then to be assigned to a central kitchen. This capacity has been estimated from the collected data from the interviews.

- The producer capacity ($CapP$) (in kg per producer) is fixed considering that each producer has the double capacity. This means that not all producers need to be assigned to a FH, so in this case, it can be evaluated which subset of producers (accounting to half of the total) is the most relevant and optimal.

Facilities location

Once the demand and offer are estimated, the number and location of the FH facilities must be established. With this aim, two different methods are proposed.

FH empirical location

The FH locations that are currently used have been defined from secondary and primary data collected from the stakeholders interviewed detailed in previous chapters (data input: addresses of each FH and each producer).

FH computational location

With the aim of integrating logistics networks for producers, the computational clusters building for producers can be analysed as a collaboration strategy for food collection in the institutional catering. This food collection strategy links the available food producers, enabling the food distribution collaboration by selecting a set of producers that will represent the producers that belong to one cluster, reducing the food collection complexity (Erdoğan and Miller-Hooks, 2012; Li et al., 2010).

With this in mind, the clusters are used to partition the producers to evaluate route constructions in terms of time/distance differences between optimal vehicle routing solutions and possible re-locations of representative producers.

For this purpose a set of experiments were ran. The experiments are based on producer's location, where the two input variables for the algorithms are latitude and longitude coordinates. Since the input features are already defined and no dimension reduction is needed, the first step is to choose an algorithm.

With this definition, an evaluation metric is necessary to evaluate the partition obtained by the algorithm. In this case, the Silhouette Coefficient $s(i)$ proposed by Rousseeuw (1987) is used to measure the cohesion within a cluster and the separation between clusters. The mathematical framework behind this is detailed in Equation 5.6. In this equation, $a(i)$ represents the average distance from a data point i to each data point within the same cluster. The second component, $b(i)$, represents the smallest average distance of data point i to all data point from different clusters.

$$s(i) = \frac{b(i) - a(i)}{\max\{a(i), b(i)\}}. \tag{5.6}$$

The algorithm used to cluster the producers for the first experiment is the Affinity Propagation proposed and applied by Frey and Dueck (2007). The objective is to find the most representative producer within each cluster (the centroids). The main notions of this algorithm are centred around data points passing messages between them. These messages are "availability" $a(i,k)$ (Equation 5.7) and "responsibility" $r(i,k)$ (Equation 5.8). These two metrics use a data set D and exemplars, which are the equivalent of centroids, to represent how appropriate it would be for a point $i \in D$ to choose another point $k \in D$ as its exemplar and how well suited a point $i \in D$ is to serve as an exemplar for another point $k \in D$ based on a similarity function $s(i,k)$.

$$a(i,k) \leftarrow \min\left\{0, r(k,k) + \sum_{i' s.t. i' \notin i,k} \max\{0, r(i',k)\}\right\}, \tag{5.7}$$

$$r(i,k) \leftarrow s(i,k) - \max_{k' s.t. k' \neq k}\{a(i,k') + s(i,k')\}. \tag{5.8}$$

Since a data point is determined to be an exemplar, it suits the task of selecting a producer to represent a cluster of producers based on geographic position. Additionally, this algorithm considers as one of its hyperparameters a damping factor λ defined between 0 and 1. This factor serves the purpose of reducing the impact of very high availabilities.

The algorithm used to cluster the producers for the second experiment is k-means proposed by (Lloyd, 1982). This algorithm is used to arrange the producers into k clusters, where the centroids are used as proposed FH in a vehicle routing problem. More formally, given a data set $X = \{x_1, \ldots, x_n\}$, where each x_i is a multi-dimensional vector, k-means looks to partition the data set into k sets $S = \{S_1, \ldots, S_k\}$. This partition looks to minimize the within cluster variance (Equation 5.9).

$$\arg\min_S \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} \|\mathbf{x} - \boldsymbol{\mu}_i\|^2, \tag{5.9}$$

where μ_i represents the mean values of the data points in S_i.

Demand and offer allocation

This phase deals with the demand and offer's allocation and network's configuration. In this step, freight quantities needed by each central kitchen (k) are allocated to each FH (j) and at the same producers (i) are assigned to a FH(j) to satisfy their overall freight needs.

Demand and offer analytical allocation

As described in Chapter 4, the producers' allocation can be made according to the geographic proximity (see Section 4.4) and according to the administrative subdivision (see Section 4.4). Nevertheless, for this analysis it will be considered the working time constraints for the driver and vehicle on each route should not be violated and can not exceed 10 hours. Moreover, in Palacios-Argüello et al. (2018c), is explained the demand and offer analytical allocation using the gravity modelling to locate FH. To compare the effects on vehicle-kilometres travelled of the geographical proximity-based allocation strategy without exceeding the working time constrants, Table 5.1 shows the results in distance obtained with the VRP.

Table 5.1: Distance results for producers' allocation based on geographical proximity considering working time constrants

FH	Nb Producers	Distance travelled
FH1	43	776
FH2	24	998
FH3	26	893
FH4	40	793
FH5	20	912

Demand and offer mathematical modelling allocation

A model that allows assigning the freight to each echelon is proposed to know which producers (i) and Food hubs (j) will be used, considering the demand of each central kitchen (k) and for each school canteens (s). To do that, a graph with three types of nodes is defined:

- Set V_p includes the producers.
- Set V_{fh} includes the FH.
- Set V_{ck} includes the central kitchens.

Figure 5.4 shows the nodes considered.

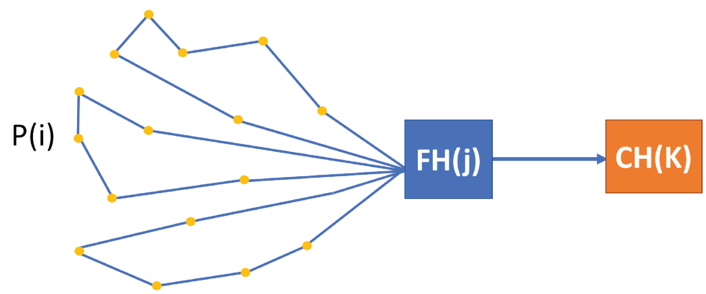


Figure 5.4: Graph with three types of nodes considered

The demand of each school canteen is assumed to be known, since in school canteen tactical planning an average daily demand is assumed by logistics managers (Palacios-Argüello et al., 2018b). Moreover, since meals are prepared in central kitchens, and each school canteen belongs to a zone, so to a pre-assigned central kitchen, the question of producer assignment (and then their respective freight quantities to be delivered) is between producers, FH and central kitchens. Furthermore, since an average demand is considered for school canteens and their assignment to central kitchens is known, the routes between central kitchens and school canteens are the same independently of the network configuration. For that reason, the fourth and last echelon of the school canteen supply chain (central kitchens to school canteens) is not considered in the assignment phase. This can be explained by the fact that since all school canteens are already assigned to a central kitchen and that part of the network is known. Then according to the logistic decisions considered, the routes will be estimated using a vehicle routing algorithm.

For the model deployment and the comparison of different cases such as the producers allocation by geographical proximity or by administrative subdivision, the following index values are calculated from the data collected in previous chapters (see Table 5.2).

Table 5.2: Index description

Index	Description
$Tcap_1$	Light trucks' capacity per case.
$Tcap_2$	Heavy trucks capacity per case.
f_1	Energy consumption per light truck in euros per case per km.
f_2	Energy consumption per heavy truck in euros per case per km.
Lc_1	Daily leasing cost in euros per case per light truck.
Dc_1	Daily driver cost in euros per case per light truck.
Lc_2	Daily leasing cost in euros per case per heavy truck.
Dc_2	Daily driver cost in euros per case per heavy truck.

The parameters proposed for the model are defined as follows:

- Q_k Demand at central kitchen (k) of fresh fruits and vegetables in cases.

- $C_{1_{i,j}}$ is the transport cost in thousands of euros from producer to FH per case;
- $C_{2_{j,k}}$ is the transport cost in thousands of euros from FH to central kitchen per case;
- $Cv_{1_{i,j}}$ Fixed cost in thousands of euros per truck from producer to FH in cases;
- $Cv_{2_{j,k}}$ Fixed cost in thousands of euros per truck from FH to central kitchen in cases;

The decision variables defined are:

- $Q_{1_{i,j}}$ shipment quantities from producer to FH in cases;
- $Q_{2_{j,k}}$ shipment quantities from FH to central kitchen in cases;
- $T_{1_{i,j}}$ Number of trucks from producer to FH in cases;
- $T_{2_{j,k}}$ Number of trucks from FH to central kitchen in cases;

Finally, the linear programming model to optimize is:

$$\begin{aligned} \min \sum_{i \in V_p; j \in V_{fh}} (C_{1_{i,j}} \times Q_{1_{i,j}}) + \sum_{j \in V_{fh}; k \in V_{ck}} (C_{2_{j,k}} \times Q_{2_{j,k}}) \\ + \sum_{i \in V_p; j \in V_{fh}} (Cv_{1_{i,j}} \times T_{1_{i,j}}) + \sum_{j \in V_{fh}; k \in V_{ck}} (Cv_{2_{j,k}} \times T_{2_{j,k}}) \end{aligned} \tag{5.10}$$

Subject to:

$$CapP \leq \sum_{j \in V_{fh}} Q_{1_{i,j}} \forall i \in V_p, \tag{5.11}$$

where $CapP$ is defined as the producer's capacity.

$$\sum_{i \in V_p} Q_{1_{i,j}} = \sum_{k \in V_{ck}} Q_{2_{j,k}} \forall j \in V_{fh} \tag{5.12}$$

$$\sum_{j \in V_{fh}} Q_{2_{j,k}} \leq Q_k \forall k \in V_{ck} \tag{5.13}$$

$$T_{1_{i,j}} \leq \frac{Q_{1_{i,j}}}{Tcap_1}; i \in V_p; j \in V_{fh} \tag{5.14}$$

$$T_{2_{j,k}} \leq \frac{Q_{2_{j,k}}}{Tcap_2}; j \in V_{fh}; k \in V_{ck} \tag{5.15}$$

$$Q_{1_{i,j}, Q_{2_{j,k}} \in real}; T_{1_{i,j}}, T_{2_{j,k}} \in int \tag{5.16}$$

The objective function to minimize is the total logistic cost that includes handling cost at producers platforms $C_{1_{i,j}}$ and $C_{2_{j,k}}$; and transport cost $Cv_{1_{i,j}}$ and $Cv_{2_{j,k}}$. The detail on how the costs are estimated is reported in Appendix 1.

Considering the assumption of a mono-commodity for demand constraints, the constraints (5.11) fix the producer capacity $CapP$ as the supply limit at producer (i) in order to estimate the demand allocated to each producer and each FH. The constraint (5.12) establishes the demand allocated to each FH to satisfy demand at FH (j). Finally, the constraint (5.13) establish that the demand of the central kitchen must be the same as the total demand of FH and in consequence satisfies the demand at central kitchen (k).

Constraints (7.5) limit the number of trucks from producers to FH and establish that the shipment quantity from producers to FH, $Q_{1_{i,j}}$ cannot exceed the vehicle capacity. In the same way, constraints (5.15) estimate the number of trucks from FH to Central kitchens and to establish that the shipment quantity from FH to Central kitchens $Q_{2_{j,k}}$ cannot exceed the vehicle capacity.

Taking into account the linear programming problem (LP) presented above, its complexity is of order O^3 and can be solved using a commercial tool. For this research General Algebraic Modelling System (GAMMS) with simplex algorithm is used.

Service network configuration: routes construction

In this step, which deals mainly with tactical planning, demand is known (as a consequence of the first and previous phase) and the main decisions concern route construction and resource management (mainly vehicles). Three main decisions are considered:

- Choice of first-stage routes: from producers (i) to producer platform (j))
- Transport system definition for intermediary routes (second-stage, from FH (j) to central kitchen (k))
- Final delivery routes planning (from central kitchen (k) to school canteens (s), pre-cooked meals, including also other products).

In literature, three categories of methods can be observed; empirical procedures (González-Feliu et al., 2014; Segalou et al., 2004); analytic models (Combes, 2016; Daganzo, 2005) and route construction procedures (Cattaruzza et al., 2017; Mancini et al., 2014). The first two methods are quicker to implement and require fewer resources, but do not allow routes to be spatialized. Moreover, there is a practical reason of deploying route construction methods since many Transport Management Systems (TMS) are based on those methods (Partyka and Hall, 2010). Moreover, when aiming to take into account real traffic conditions and plot the routes on a city map route construction procedures based on algorithms are required. Those route construction procedures in urban logistics relate mainly to vehicle routing problem (VRP) algorithms (Melo et al., 2010).

Besides, it is important to characterize: (i) a hierarchical structure such as the number of transport stages and a load redistribution, (ii) the vehicles used in each transport, and (iii) the vehicle utilization policy such as full truckload (FTL) or a less than truckload (LTL) policy. Once the hierarchical structure and the vehicles used are characterized, FTL or LTL transport is easy to assess once the origin and the destination are known.

Once the assignment of producers (and their respective FH) to central kitchens is made, tactical planning issues, mainly route construction issues, can be done. According to Gonzalez-Feliu (2012), in an N-echelon transport system, if the assignment of customers to each intermediary facility is known, the route construction problem is then a sum of N sets of vehicle routing problems, one set per echelon, and the number of VRP of each echelon is equal to the number of active depots of the echelon. Moreover, according to Crainic et al. (2009), a complex multi-echelon transport system can be solved by decomposition of tasks and echelons. In the current case, and since the assignment of school canteens to central kitchens is known and the assignment of central kitchens to consolidation centres then to producers is the result of the previous phase, three sets of vehicle routing problems can be defined:

- The first set includes a set of collection-VRP, one per consolidation centre, and aims to minimize the total cost of collecting the assigned demand of each consolidation centre from producers. It can be modelled as a classical Capacitated Vehicle Routing Problem (CVRP) since only collection routes are defined.

- The second set involves consolidation centres as depots and central kitchens as customers, but since demand assigned is known can be modelled as a set of independent CVRPs

- The third set is that of final distribution to school canteens and includes a number of CVRPs equal to the number of central kitchens, since each central kitchen has its own set of pre-assigned school canteens.

In order to propose a coherent set of routes, close to those in practice, it is proposed to use the VRP Spreadsheet solver developed by Erdoğan (2017). This algorithm is a standard one, close to those used in practice. The aim is not to propose a strong optimization but a solution close to what can be done using commercial solvers to reproduce reallistic situations. For the proposed test case, the VRP was configured according to the following parameters:

- a fleet of vehicles serves a set of delivery points;
- the demand of each customer per visit must be satisfied by a vehicle assigned on the route;
- each vehicle leaves and returns to the depot;
- the vehicle capacity should not be exceeded;
- the working time constraints for the driver and vehicle on each route should not be violated.

Efficiency assessment: Assumptions and models parameters definition

Service time

The working time can be estimated as the sum of driving time and service time. The first one is calculated in function of the distance and average speed from the VRP and the service time is calculated from a statistical analysis of a dataset extracted from the urban logistics routes database proposed by Gonzalez-Feliu and Morana based on the French surveys in urban goods transport (Ambrosini et al., 2008). It has been selected 72 route stops related to institutional catering and observed both the service time and the unloaded weight. To estimate a relation between service time and unloaded weight, a linear regression analysis is performed (for more details refer to Palacios-Argüello et al. (2018c)). First, the relations (with and without constant term) are estimated between both variables for the overall sample (72 stops). Then, the unloaded weigh is analysed to propose subcategories. Table 5.3 shows the service time categorisation proposed. This service time presents a statistical distribution that can be approximated via a normal law.

Table 5.3: Service Time

Conditions	Service Time (min)
If demand amount $<$10kg	3.32
If demand amount is between 10 and $\leq$ 60kg	4.50
If demand amount $>$60kg	6.75

Transportation cost

The transportation cost is estimated considering variable and fixed cost associated with each transportation stage. Table 5.4 shows the transportation cost extracted from primary (semi-structured interviews detailed in previous chapters) and secondary data collected from the National Federation of Road Transport in France (FNTR) . The truck capacity has been taken into account to calculate the number of vehicles needed, 3.5 tons from producers to FH, 14 tons from FH to central kitchen and 3.5 tons from central kitchen to school canteen. The truck capacity was fixed according to the preliminary data obtained from the interviews, $Tcap_1$ is 900 kg for the light vehicles and $Tcap_2$ is 7000 kg for heavy vehicles.

Table 5.4: Transportation cost extracted from primary and secondary data collected

Transportation cost	**3.5 ton**	**14 ton**
Energy consumption f_1 and f_2 (€/km)	0.26	0.36
Daily leasing cost Lc_1 and Lc_2 (€/truck)	83	166
Daily driver cost Dc_1 and Dc_2 (€/truck)	207	248

5.4 Findings

Case study description

Recently, in different French cities, the demand for a high percentage of local and organic products in the school canteen menu has been increased. Concerning the application context that motivated this research, the school canteen system of two French cities were studied, Lyon and Saint-Etienne. They are located on eastern central France, Saint-Etienne is located in the south-west of Lyon in the Auvergne-Rhône-Alpes region. Lyon is the capital of the Rhône department with about 2.3 million inhabitants in the metropolitan area. Saint-Etienne is the capital of the Loire department with about 508000 inhabitants in the metropolitan area.

Saint-Etienne has been a pioneer in the demand for a high percentage of local and organic products in the school canteen menu. Nowadays, the school menu proposes 80% organic products and 70% local products. One of the most important changes to achieve those goals is to replace the current industrial and national distribution chain by short circuits of small producers.

To that effect, the municipality made a public tender to contract by concession catering a meal contractor. The request of this tender is based on service quality, price, quality of the raw products, and organization management. According the semi-structured interviews performed in Chapter 3, to select the best offer, the municipality assess three main criteria:

1. The percentage of organic products in the offer (70%, 80%, and 90%).
2. The percentage of local products (over 60%).
3. The product variety regarding the menu proposed.

To integrate an organic-local product supply policy, it is necessary to analyse the logistic organization through the request of producers located not more than 250 km from the central kitchen to fulfil the local and organic requirement. A scenario assessment for the case of Saint-Etienne and Lyon is proposed with the aim to generalize the findings to school canteen systems.

Network description

- Producers : As described before, regarding the number of organic exploitation, Auvergne-Rhône-Alpes is the second region in France. It has nearly 5300 organic farms at the end of 2017 and it is the second largest region in terms of number of farms. 60% of organic farms sell at least part of their production by short circuits directly or through an intermediary only between producers and consumers.

  To locate the current organic and local offer in the region, the information from 153 producers that have an offer on organic vegetables and fruits was collected. This offer estimation is based on the information available of the Regional Organic Agriculture Observatory.

- Food Hub: To have a robust offer in short circuit for institutional catering, local producers collect their products through a regional platform called logistic platforms or Food hubs (FH). For this research, information from five FH, located in different departments, in Auvergne Rhône Alpes region was collected. The fruits and vegetables distribution from the producers to FH and to the central kitchen is performed by own Light Commercial Vehicles (3.5t), and from the FH to central kitchen is performed by own Heavy Commercial Vehicles (14t).

- Central kitchens: The central kitchen makes the main food transformation (cooking) and the satellite school canteens mix and heat the food. This central kitchen received all the fruits and vegetables coming from FH and then the meals are delivered to each school canteen, this means that the central kitchen supplies the satellite school canteens located at different points in the city. This facility is managed by the meal contractor.

- School canteen: This is the place where the meals are delivered and consumed by the consumer. The meals distribution from the central kitchen to the school canteen is performed by own Light Commercial Vehicles (3.5t) Euro 4.

Figure 5.5 shows the network design described before.

Lyon school canteen system

Regarding the Lyon school canteen system, this study is focused on 117 middle school canteens that represent almost 25000 meals per day in Lyon. There is only one central kitchen that is located in the north area of Great Lyon. The school canteen works on average 140 days per year.

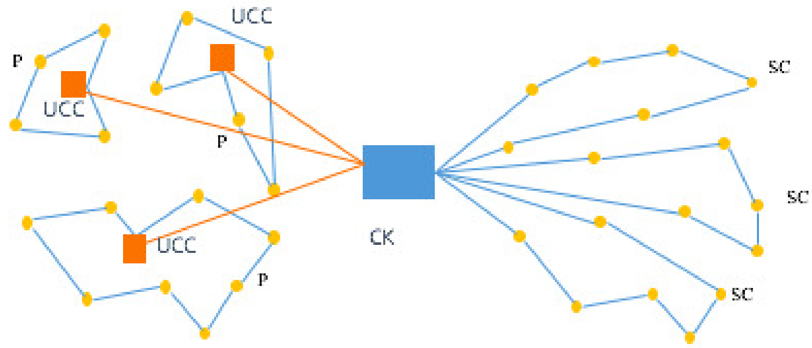


Figure 5.5: Network design
(P) Producer; (UCC) Food Hub; (CK) Central kitchen; (SC) School canteen.

Saint-Etienne school canteen system

Regarding the Saint-Etienne school canteen system, this study is focused on 44 middle school canteens that represent over 3000 meals per day, delivered to students from 81 primary and middle public schools in Saint-Etienne. The school canteen works on average 140 days per year.

Demand and offer estimation

Demand estimation

After calculating the demand by school canteen, the total demand for each Central kitchen (k) is calculated as follows:

- $Q_{k=1} = 3025kg$ per day
- $Q_{k=2} = 503kgper$ day

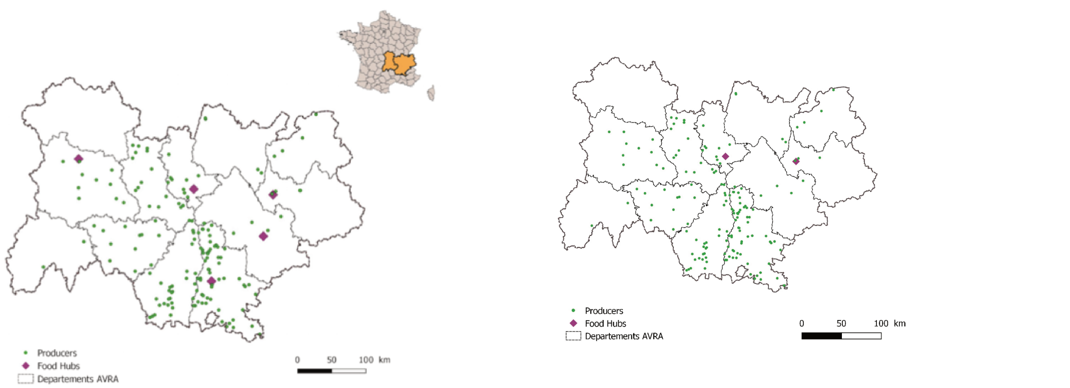
Offer estimation

Aiming to simplify the real life system, where various producers may have different capacities and may be specialised in different types of fruits and vegetables, in this research, the producer capacities $CapP$ considered are two: 21 kg and 42 kg per producer. The first one resulted from the division of the total demand into the number of producers available. The second one resulted from the assumption that establishes that each producer has the double capacity.

Facilities location

FH's empirical location

As described in Section 4.4, there are five current locations for FH. Figure 5.6 shows the producers and the current FH locations. Mapping the producers and food hubs was done using QGIS, which is open-source cross-platform for geographic information system.



(a) FH's empirical location: 5FH (b) FH's mathematical modelling allocation: 3FH

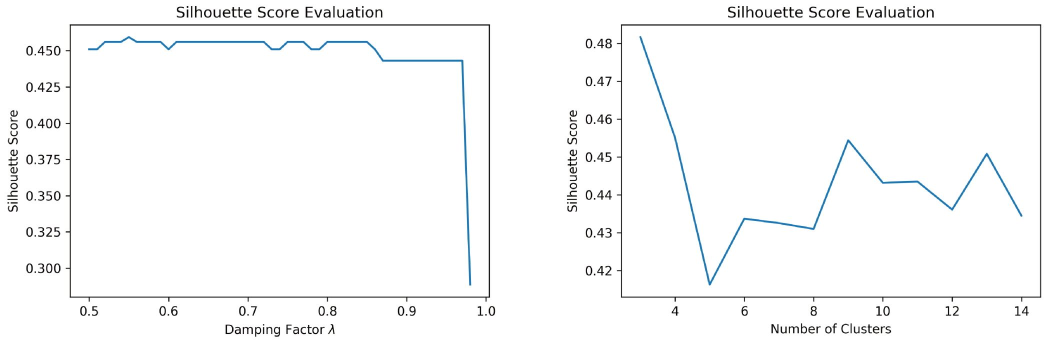
Figure 5.6: FH location. Figure designed in QGIS.

FH's computational location

Both experiments detailed in Section 5.3, were evaluated with the same procedure. To obtain the highest silhouette score, different values of partition the producers k (3-10) and different values of damping factor for reducing the impact of very high availabilities λ (0.50 - 0.99) were tested. In Figure 5.7, the Silhouette values when testing values of k and λ are presented.

Regarding the experiment 1 uses Affinity propagation algorithm, a value λ was tested to obtain the highest silhouette score. As a result, the optimal value of k to partition the producers was $k = 12$. Figure 5.8 shows the 3 clusters using k-means and the 12 clusters using affinity propagation obtained for the 153 producers. Besides, regarding the experiment 2 uses k-means, the partition when varying λ values does not vary in number of clusters (7) nor does it vary in silhouette scoring (0.7). The second insight is the optimal value of k to partition the school canteens. The highest score is obtained by $k = 3$, where other possible alternatives are $k = 9$ and $k = 13$.

Summarising the findings about the FH location based on two different methods (empirical and computational location), it is possible to compare the current FH's location and use with twelve new locations for the FH and the use of only three over the five FH that are currently used.



(a) Affinity Propagation Silhouette Score Evaluation

(b) K-means Silhouette Score Evaluation

Figure 5.7: Silhouette Score Evaluation

(a) FH using Affinity Propagation

(b) FH using K-means

Figure 5.8: FH clusters computational location

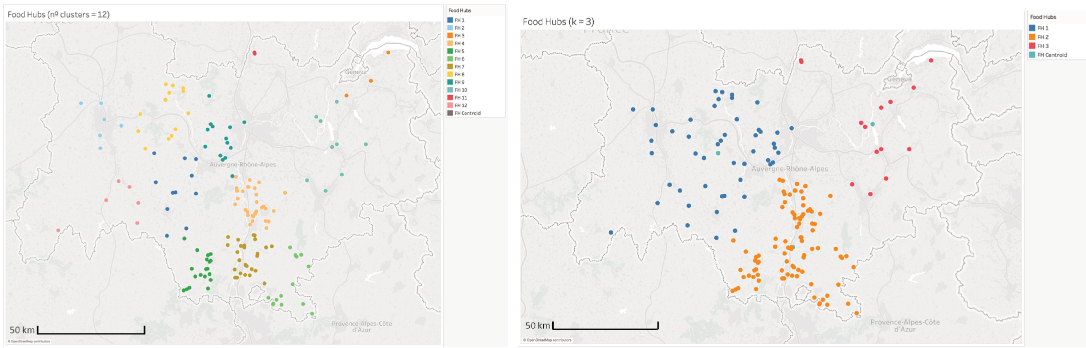
Demand and offer allocation

Regarding the demand and offer analytical allocation, as described in Chapter 4, the producers' allocation can be according to the geographic proximity (see Section 4.4) and according to the administrative subdivision (see Section 4.4).

Regarding the demand and offer mathematical modelling allocation, the results obtained from the GAMS linear problem for facility location-allocation, show that for case with producers capacity of 21 kg, it is necessary to use all 5FH. Nevertheless, for case with a producers capacity of 42 kg, it is only necessary to use two food hubs, FH4 and FH5 and allocate 76 producers.

Finally, regarding the offer computational allocation, Figure 5.9 shows the 153 producers divided into the 12 clusters obtained with Affinity propagation and 3 clusters obtained with K-means.

Summarising the findings about the demand and offer allocation based on three different methods (analytical, computational and mathematical allocation), it is possible to analyse how to allocate the demand and offer to an specific FH and Central kitchen based on the



(a) Affinity Propagation Cluster (b) K-means Cluster

Figure 5.9: Clusters allocation for producers

producers capacity, freight demanded by echelon and the distance between the producers, FH and central kitchens.

Routes construction and efficiency assessment

Figure 5.10 shows the logistic decisions to consider for this case study, aiming to analyse the impacts of the decisions considered and methods presented before. In this way, and following the logistic decisions flow, the routes construction and efficiency assessment will be presented through six different cases based on the previous methods of location and allocation considered.The cases are proposed as follows using the same demand estimation method presented before:

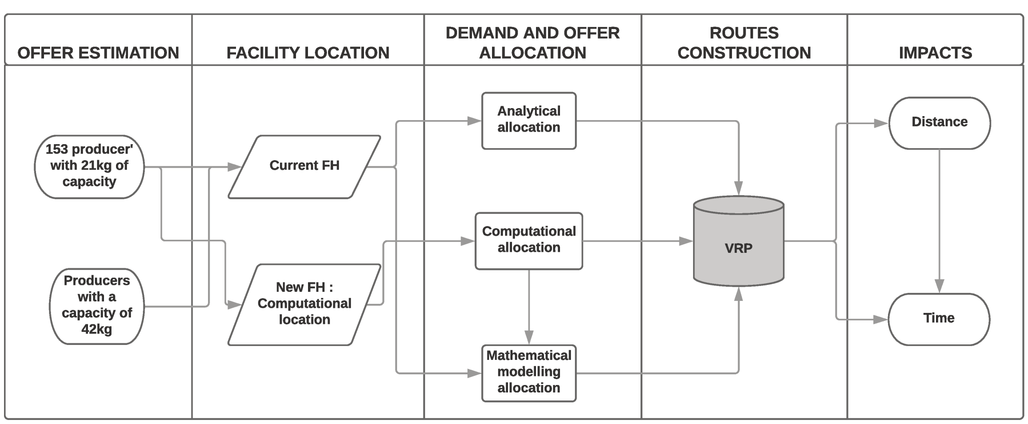


Figure 5.10: Decisions framework for the case study

- *Case 1: Based on administrative subdivision allocation*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the current 5FH location and using analytical allocation method regarding the geographical department.

- *Case 2: Based on geographical proximity allocation*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the current 5FH location and using analytical allocation method regarding the geographical proximity.
- *Case 3: Based on mathematical modelling allocation with a producer's capacity of 21kg*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the current 5FH location and using mathematical modelling allocation method.
- *Case 4: Based on mathematical modelling allocation with a producer's capacity of 42kg*: Working with producers with a fixed daily capacity of 42kg per producer, using the current 5FH location and using mathematical modelling allocation method.
- *Case 5: Based on computational allocation using Affinity propagation clustering*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the 12FH locations proposed by Affinity clustering algorithm and using computational allocation method.
- *Case 6: Based on computational allocation using K-means clustering*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the 3FH news locations proposed by K-means clustering algorithm and using computational allocation method.

Case 1: Based on administrative subdivision allocation

Table 5.5 shows the VRP results from Producers to FH for Case 1. It can be observed that for a fixed capacity of 21kg per producer, all the FH are open. Nevertheless, it is noteworthy that allocation of suppliers to a FH is very uneven, with 57% of producers allocated to FH1. Four vehicles are needed from the producers to the FH1, but for the other FH there is still one or two vehicles needed to transport the food required. Finally, the time spent for the distribution is important and it is not directly proportional to the volume delivered. For example for the FH1, it is necessary 34 hours and 2037 kg to be delivered; besides, for the FH4, it is necessary almost 5 hours and 105kg to be delivered. Besides, comparing number of producers vs distance travelled is not directly proportional. Regarding FH5, it is necessary to travel almost 631km for 11 producers and for FH2 for 26 producers it is necessary to travel less (604km).

Table 5.6 shows the VRP results from FH to central kitchens for the case 1. Regarding the Case 1, it is necessary to open all the FH as established before. On the one hand, to satisfy the Saint-Etienne's central kitchen demand it is necessary to allocate its demand to FH3. On the other hand, to satisfy the Lyon's central kitchen it is necessary to all five FH. Only FH3 delivers under 100kg to the central kitchen, compared with FH1 that delivers 2037kg which represents the 67% of demand requested.

To deliver the central kitchens even if the amount delivered is different, it is necessary the same number of vehicles, one per central kitchen. Regarding the distance and time

Table 5.5: Case 1: Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1	87	2037	4	1383.6	34:06
FH2	26	609	2	604.0	14:06
FH3	24	546	2	1060.6	19:06
FH4	5	105	1	259.7	04:42
FH5	11	231	1	630.6	09:48
Total	153	3528	10	3938.5	81:48

spent, FH2 only has 63.1km of distance travelled and one hour to deliver 609kg. On the other hand FH3 has 390.9km of distance travelled and almost four hours to Lyon's CK to deliver 43kg.

Table 5.6: Case 1:Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1 - LY	2037	1	282.5	03:12
FH2 - LY	609	1	63.1	01:00
FH3 - ST	503	1	335.8	03:24
FH3 - LY	43	1	390.9	03:54
FH4 - LY	105	1	224.7	02:24
FH5 - LY	231	1	205.8	02:06
Total FH - CK ST	503	1	335.8	03:24
Total FH - CK LY	3025	5	1167.0	12:36
Total FH - CK	3528	6	1502.7	16:00

Case 2: Based on geographical proximity allocation

Table 5.7 shows the VRP results from Producers to FH for Case 1. It can be observed that for a fixed capacity of 21kg per producer, all the FH are open. Consequently, the allocation of suppliers to a FH is very even, with 26% to 28% of producers allocated to FH1 and F4, and between 13% and 17% of producers allocated to FH2, FH3 and FH5. It is the same regarding the number of producers allocated and the time travelled. Nevertheless, regarding the distance travelled, it is not directly proportional to the number of producers allocated. For example, 43 producers are allocated to FH1 that represent 776 km, but almost the half of the producers are allocated to FH2 and it represents more distance travelled 998km. Finally, concerning the number of vehicles used are the same for all the FH.

Table 5.7: Case 2: Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1	43	1008	2	776.2	18:36
FH2	24	567	2	998.4	18:54
FH3	26	588	2	892.9	16:42
FH4	40	945	2	793.3	16:30
FH5	20	420	2	912.0	15:24
Total	153	3528	10	4372.2	86:00

Table 5.8 shows the VRP results from FH to central kitchens for the case 2 which are the same that for Case1. This can be explained by the fact of the same central kitchens are served by the same FH of Case1. The only difference is the quantity delivered by each FH.

Table 5.8: Case 2:Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1 - LY	1008	1	282.5	03:12
FH2 - LY	567	1	63.1	01:00
FH3 - ST	503	1	335.8	03:24
FH3 - LY	83	1	390.9	03:54
FH4 - LY	945	1	224.7	02:24
FH5 - LY	420	1	205.8	02:06
Total FH - CK ST	503	1	335.8	03:24
Total FH - CK LY	3025	5	1167	12:36
Total FH - CK	3528	6	1502.8	16:00

Case 3: Based on mathematical modelling allocation with a producer's capacity of 21kg

Table 5.9 shows the VRP results from Producers to FH for Case 3. It can be observed that for a fixed capacity of 21kg per producer, all the FH must be open. Nevertheless, it is noteworthy that allocation of suppliers to a FH is very uneven, with 94% of producers allocated to FH2. Nine vehicles are needed from the producers to the FH2, but for the other FH there is still one vehicle needed to transport the 42kg-84kg required. Finally, the time spent for the distribution is important and it is not directly proportional to the volume delivered. For FH3, ten hours are needed to deliver only 42 kg of products from two producers who are far away from the FH. These results are similar for FH1. Regarding FH4 and FH5 the time spent is between 2.5 and 2.8 hours. Especially for the last one (FH5) which spent less time considering more producers than FH4.

Table 5.9: Case 3:Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1	2	42	1	653.1	07:06
FH2	143	3318	9	4668.0	88:12
FH3	2	42	1	875.6	10:00
FH4	2	42	1	189.3	02:48
FH5	4	84	1	159.2	02:30
Total	153	3528	13	6545.1	110:36

Table 5.10 shows the VRP results from FH to central kitchens for the case 3.

Table 5.10: Case 3:Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1 - ST	42	1	297.9	03:30
FH2 - ST	419	1	98.7	01:42
FH2 - LY	2899	1	282.6	03:09
FH3 - ST	42	1	323.8	03:19
FH4 - LY	42	1	223.6	02:28
FH5 - LY	84	1	205.8	02:10
Total FH - CK ST	503	3	720.4	08:31
Total FH - CK LY	3025	3	712.0	07:47
Total FH - CK	3528	6	1432.4	16:18

Regarding the Case 3, it is necessary to open all the FH as established before. On the one hand, to satisfy the Saint-Etienne's central kitchen demand it is necessary to allocate its demand to FH3, FH1 and FH2. The first two deliver only 42 kg each and the last one delivers almost 419 kg that represents the 84% of the demand requested. On the other hand, to satisfy the Lyon's central kitchen it is necessary to open FH4, FH2 and FH5. The first one delivers 42 kg, the last one 84 kg, and the second one delivers the almost 2900kg that represents the 96% of demand requested.

Case 4: Based on mathematical modelling allocation with a producer's capacity of 42kg

Table 5.11 shows the VRP results from Producers to FH for Case 4. For a fixed capacity of 42 kg per producer, only two FH must be open, FH2 and FH5 and 76 producers are consulted. This means that the total demand has been allocated only to the 50% of total producers. From 76 producers consulted, 97% of the producers deliver FH2 and only 3% deliver FH5. This rate is directly proportional to the amount of freight quantity delivered. Regarding the total distance and time spent for the distribution, it can be inferred that the allocation decision is associated to the geographical proximity of the FH due to the distance and time spent compared to Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg. Taking into account the number of producers, Case 4 allocated the demand to 74 against to 143 producers of Case 3, spends less than 61% of the distance and 58% of the delivery time than Case 3. In consequence to the change of the producers capacity, fewer vehicles must be used, even if FH5 is open only for two producers and uses one vehicle for 84kg delivered.

Table 5.11: Case 4:Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH2	74	3444	4	1803.3	37:06
FH5	2	84	1	21.0	00:42
Total	76	3528	5	1824.3	37:48

Table 5.12 shows the VRP results from FH to central kitchens for Case 4. The results established that it is necessary to open two FH. In both cases 3 and 4, FH2 delivers both central kitchen and FH5 delivers only the Lyon's central kitchen. Case 4 which consider a larger capacity per producer, shows that only 3 vehicles are necessary, which means 50% less than Case 3. The gap in distance and time is more important than Case 3, but there is a great reduction in time and distance especially regarding the Saint Etienne's central kitchen. Compared to Case 3, there is a reduction in about 621 km and 6.3 hours. In the case of Lyon's central kitchen, there is a more important reduction in distance rather than in time spent.

Regarding the total distance and time required to deliver both central kitchens from FH2 and FH5, when in Case 3 the total distance and time was 1432.4 km and 16.3 hours, in Case 4 was only necessary 556.7 km and 8.2 hours. Means a reduction of 61% in distance and almost 50% in time.

Case 5: Based on computational allocation using Affinity propagation clustering

Table 5.13 shows the VRP results from Producers to FH for Case 5. This case considers

Table 5.12: Case 4: Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH2 - ST	503	1	98.7	1:42
FH2 - LY	2941	1	252.2	04:19
FH5 - LY	84	1	205.8	02:12
Total FH - CK ST	503	1	98.66	01:42
Total FH - CK LY	3025	2	458.1	06:30
Total FH - CK	3528	3	556.7	08:12

a fixed daily capacity of 21 kg per producer and uses computational allocation by affinity propagation clustering. As a result, 12 FH must be used, that are located in current producers' location. Nevertheless, it is noteworthy that allocation of suppliers to a FH is very uneven, there is one FH with 30 producers and other with 2 producers. In the same way, the total time is not linked with the daily demand delivered. FH7 has 609kg with a total time of 9.2 hours and FH has 714kg with a total time of 8.4kg. Besides, 12 vehicles are necessary. Nevertheless, regarding the working time, it could be possible to reduce it to 10 vehicles thanks to the combination of FH2,FH3 and FH11 delivery operations of one vehicle respecting the working time limit.

Table 5.13: Case 5:Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1	11	231	1	353.7	07:00
FH2	6	126	1	176.6	03:36
FH3	3	63	1	155.1	02:48
FH4	30	714	1	315.0	08:24
FH5	19	441	1	315.0	07:30
FH6	14	315	1	375.0	07:42
FH7	26	609	1	332.9	09:12
FH8	13	315	1	265.1	05:48
FH9	14	336	1	314.2	08:00
FH10	9	189	1	368.4	06:42
FH11	2	42	1	3.6	00:12
FH12	6	147	1	294.8	05:24
Total	153	3528	12	3269.4	72:18

Table 5.14 shows the VRP results from FH to central kitchens for Case 5. Regarding the Case 5, it is necessary to open all the 12 FH as established before. On the one

hand, to satisfy the Saint-Etienne's central kitchen demand it is necessary to allocate its demand to FH1 and FH9. On the other hand, to satisfy the Lyon's central kitchen it is necessary to rely on the other ten FH and also on FH1 for a small quantity (64kg). Nevertheless, it is noteworthy that allocation of FH to CK is very uneven, there is FH4 with 714kg that represents the 23.6 % compared to FH11 with only 42kg.

To deliver the central kitchens even if the amount delivered is different, it is necessary to have the same number of vehicles, one per central kitchen. Regarding the distance and time spent, FH9 only has 93.9km of distance travelled and 1.6 hours to Saint-Etienne's CK to deliver 336kg. On the other hand, to deliver 147kg, FH12 has 521.9km of distance travelled and 5.1 hours to Lyon's CK.

Table 5.14: Case 5:Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1 - ST	167	1	112.0	01:48
FH1 - LY	64	1	252.3	03:24
FH2 - LY	126	1	348.4	03:36
FH3 - LY	63	1	306.2	03:06
FH4 - LY	714	1	204.6	02:42
FH5 - LY	441	1	398.0	05:06
FH6 - LY	315	1	409.1	05:24
FH7 - LY	609	1	316.8	03:24
FH8 - LY	315	1	231.7	02:48
FH9 - ST	336	1	93.9	01:30
FH10 - LY	189	1	205.9	02:12
FH11 - LY	42	1	173.5	02:06
FH12 - LY	147	1	521.9	05:06
Total FH - CK ST	503	2	205.9	03:24
Total FH - CK LY	3025	11	3368.5	37:48
Total FH - CK	3528	13	3574.4	42:30

Case 6: Based on computational allocation using k-means clustering

Table 5.15 shows the VRP results from Producers to FH for Case 6. For a fixed daily capacity of 21 kg per producer and using clustering by k-means, three FH must be used. This FH are located in new addresses near to the producers.

Nevertheless, it is noteworthy that allocation of suppliers to a FH is very uneven, there is one FH with 90 producers and other with 14 producers. In the same way, the total time is not linked with the daily demand delivered. FH1 has 1134kg with a total time of 33.4 hours and FH2 has 2100kg with a total time of 12.9 hours. Moreover, it is necessary 10 vehicles.

Table 5.15: Case 6:Distance and time from Producers to FH

	FH				
	Number of Producers	**Daily demand (kg)**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1	49	1134	4	1600.5	33:24
FH2	90	2100	4	1440.1	35:30
FH3	14	294	2	782.3	12:54
Total	153	3528	10	3822.9	81:54

Table 5.16 shows the VRP results from FH to central kitchens for Case 6. The results suggest that it is necessary to open all the 3 FH as established before. On the one hand, to satisfy the Saint-Etienne's central kitchen demand it is necessary to allocate its demand to FH1. On the other hand, to satisfy the Lyon's central kitchen it is necessary to allocate its demand to all three FH. Nevertheless, it is noteworthy that allocation of FH to CK is very uneven, there is FH2 with 2100kg that represents the 69.4 % compared to FH3 with only 294kg.

To deliver the central kitchens even if the amount delivered is different, it is necessary the same number of vehicles, one per central kitchen. Regarding the distance and time spent, FH1 only has 125.6km of distance travelled and 2.2 hours to Saint-Etienne's CK to deliver 503kg. On the other hand the same FH1 has 286.7km of distance travelled and 3.5 hours to Lyon's CK to deliver 631kg.

Table 5.16: Case 6:Distance and time from FH to Central kitchens

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
FH1 - ST	503	1	125.6	02:12
FH1 - LY	631	1	286.7	03:30
FH2 - LY	2100	1	283.3	03:00
FH3 - LY	294	1	215.0	03:18
Total FH - CK ST	503	1	125.6	02:12
Total FH - CK LY	3025	3	784.9	09:54
Total FH - CK	3528	4	910.5	12:06

Demand allocation for Central kitchens for all cases

To estimate the routes for all cases presented above, the VRP is used and Table 5.17 shows the results. It shows the results in time and distance for the outbound distribution from the central kitchens until the school canteens. To satisfy the demand from the 161 school canteens, the total distance required is 308.9km, performed by five vehicles of 3.5 tons that represents 18.6 hours of total time spent.

Table 5.17: Distance and time from Central Kitchens to School Canteens

	CK - SC			
	Daily demand (kg)	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
Lyon	3025	4	217.18	12:10
Saint-Etienne	503	1	91.75	06:26
Total CK - SC	3528	5	308.9	18:36

5.5 Discussion

With the aim of comparing the different cases presented before, Table 5.18 shows the VRP results from Producers to FH for all cases. Case 4 Based on mathematical modelling allocation with a producer's capacity of 42kg, shows the best results in terms of number of vehicles used, the less distance travelled and the less time spent from the producers to the FH. Nevertheless, if the same number of producers are compared, Case 5 shows the best results but use more vehicles than the average.

Table 5.18: Comparison of distance and time from Producers to FH among the cases

	FH				
	Number of Producers	**Number of FH**	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	153	5	10	3938.5	81:08
Case 2	153	5	10	4372.2	86:00
Case 3	153	5	13	6545.1	110:36
Case 4	76	2	5	1824.3	37:48
Case 5	153	12	12	3269.4	72:18
Case 6	153	3	10	3822.9	81:54

Similarly, with the aim of comparing the different cases presented before, Table 5.19 shows the VRP results from FH to central kitchens for all cases. Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg, seems to have the best results in number of vehicles used, the less distance travelled and the less time spent from the FH to the CK. Nevertheless, if the same number of producers are compared, Case 6 shows the best results and Case 5 shows the most of the distance travelled and the most of time spent.

Table 5.19: Comparison of distance and time from FH to Central kitchens for all cases

	FH - CK Lyon & FH - CK Saint-Etienne			
	Daily demand (kg)	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	3528	6	1502.7	16:00
Case 2	3528	6	1502.7	16:00
Case 3	3528	6	1432.4	16:18
Case 4	3528	3	556.7	08:12
Case 5	3528	13	3574.4	42:30
Case 6	3528	4	910.5	12:06

Finally, to compare the overall results of the cases, Table 5.20 shows the VRP results from producers to school canteens for all cases. Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg, shows the best results in terms of number of vehicles used, the less distance travelled and the less time spent from the FH to the CK. Nevertheless, if the same number of producers are compared, Case 6 based on computational allocation using k-means clustering, shows the best results and Case 1 based on administrative subdivision allocation, shows the larger distance travelled and Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg, shows the larger of time spent.

Table 5.20: Comparison of total distance and time from Producers to School canteens for all cases

	Producers - FH - CK LY & SE - SC			
	Number of vehicles (3.5t	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	15	6	5750.1	116:24
Case 2	15	6	6183.8	120:36
Case 3	18	6	8286.4	145:30
Case 4	10	3	2689.9	64:36
Case 5	17	13	7152.7	133:24
Case 6	15	4	5042.3	112:36

Regarding the demand allocated for producers to delivery the FH, the time spent for the distribution is important and it is not always directly proportional to the volume delivered as several cases showed. Then, regarding the overall comparison from the producers to the school canteen distribution system, Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg, represents a great reduction in distance and time (more than 47% in distance and minimum 43% in time). Besides, comparing the same number of producers, using only three FH changes all the distance/time assessment as the Case 6 based on computational allocation using K-means clustering shows. This last one represents an important distance/time gap compared to the other three cases. This can explain the impact of logistic decisions regarding the distribution network design when it is necessary to establish the number and location of facilities to use.

Moreover, regarding the producers capacity fixed previously in the model (21kg for Case 1,2,3,5,6 and 42kg for Case 4), it has an important impact on the network design as well as the FH's capacity reflected on the efficiency assessment in terms of distance and time. Lastly, in can be concluded that the proximity location is one of the key aspects to consider when the demand and offer allocation to producers, FH and CK must be analysed.

5.6 Conclusion

This chapter addressed a set of logistic decisions concerning school canteen distribution system considering short circuits and local chains. This chapter proposed a framework that involves different strategic-tactical decisions to be considered for the food supply and distribution in the school canteen system. This framework proposes six steps, from the network description to efficiency assessment considering demand and offer estimation, facilities location and allocation, and finally routes construction. To illustrate the proposed framework, six cases based on a real case study are proposed. Results suggest that the proposed framework can add insight to answer the question of which are the logistic impacts on food supply chain organization, when considering food supply strategies that enable sustainable distribution.

The results suggest that the introduction of local and organic products in the school canteen's menu should consider an efficient logistic organisation involving local and organic producers. It has been observed that different key decisions impact the distribution system efficiency in terms of distance and time, such as:

- Demand / offer estimation: Two different producer's capacities were used: 21kg and 42kg. This decision was considered with the aim of analysing which and how many producers must be used when the capacity is twice as the first one considered.

- Facilities location: This is one of the most important logistic decisions to be considered. Two methods were considered, empirical and computational location. It was used 3, 5 and 12 FH locations: the current five current FH locations, twelve current producers locations and three new FH locations.

- Facilities allocation: Regarding the method used to allocate the demand/offer to the FH and to the CK change all the distribution schema, impacting the efficiency of the system.

- Routes construction: The fact of considering different vehicle's type and load capacity, impact the number of vehicles used to perform the food distribution.

Besides, the vehicle utilization policy such as full truckload (FTL) or a less than truckload (LTL) policy impact the distance and time spent.

- Efficiency assessment: This last decision considers two metrics of system's efficiency, distance travelled and time. These two metrics can be used to compare the efficiency of the different logistic decisions previously considered.

Indeed, the fact of reducing the producer's capacity results into higher distances travelled and working times. The increase on the producers' capacity results in a reduction of minimum 44% of the distance travelled and 48% in working times regarding the distribution scheme from producer to FH. Therefore, regarding the distribution scheme from FH to central kitchens, it represents a reduction of 39% in distance travelled and 32% in working times. However, the outbound flows with respect to the distribution scheme from central kitchens to school canteens have a non-negligible impact on the total logistics performance. Finally, regarding the overall efficiency assessment from producers to school canteen distribution system, it represents a reduction of 47% in distance travelled and 43% in working times.

Besides, considering the context, logistics organization is an important element to deal with the increasing demand for organic and local products and reduce transportation flows. Indeed, as Mundler and Laughrea (2016) affirm, large quantities, transported over long distances, in an optimized manner, may have "greenhouse gases emissions" per ton transported smaller than small quantities. Those quantities are usually, transported over small distances in light trucks, often old and polluting, and often empty as Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg shows (by opening several food hubs with less than 3% of the demand amount requested).

Nevertheless, if the logistics are optimized (average transport adequacy, transported volume, optimization of different transport schemes, filling of the truck, "clean" vehicle ...), the organic-local product supply can be very efficient from the viewpoint of the transport distribution. Those optimization processes can be real if steered by specific intermediary logistics operators.

Finally, these analysis allow to conclude that the logistic organization and design of the distribution system considering the producers' capacity are crucial in local and organic supply chain management and can contribute to the system efficiency in terms of distance and time. Nevertheless, even if the assumptions considered are inspired from the real-life through the primary and secondary data collected, it is necessary to recognize that this case is a simplified case compared to real life. Indeed, the producers may not only provide food for the Lyon and Saint-Etienne canteens, but also for other local canteens of the surroundings that may also be distributed by the FH. Besides, seasonality and diversity of fruits and vegetables provided by the producers were not considered. These factors may seriously increase the complexity of the models and data required, and consequently change efficiency assessment results.

Part III

Food supply chain assessment

Chapter 6

Impacts of food distribution system

Contents

The work described in this chapter has been presented in the VREF 2016 Conference (Palacios-Argüello and Gonzalez-Feliu, 2016a) and was published on the journal of European Transport Research Review (Palacios-Argüello et al., 2018b). This work was mainly conducted during the ANNONA project that was financed by the French National Agency for Research (ANR).

In this chapter, it will be presented and explained a methodology to answer the research question (RQ3b) about how the changes of a current food distribution system can be identified and quantified by integrating the indicators that can be used to assess the economic and environmental impacts of a food distribution system (RQ3a). Next, a case study on institutional catering will be presented to validate the methodology proposed.

This methodology integrates a literature analysis, a relevant analysis in relation to the scenario construction, the definition and calculation of indicators extracted, and a scenario assessment is finally presented. This last one includes tests and feedback from the experts to validate scenarios and possible choices in terms of economic and environmental impacts for the different configuration of food distribution schemes that have been proposed.

6.1 Introduction

Food security is currently one of the main topics that involves public and private stakeholders with the common goal of helping the World's population (Erokhin, 2018; Gonzalez-Feliu et al., 2018). Moreover, since World's urban population is increasing, the analysis of sustainable and equitable urban food system has been identified as a priority (Heilig, 2012; Pisano et al., 2014). In the literature, many works about urban food systems can be found (a Scopus-based lexical search showed more than 300 results).

The main subjects of those works include agriculture, food policy, food planning and food security, but few works deal explicitly with food transport and distribution to or within cities (Nichols et al., 2006). Even when regarding the literature on city/urban logistics only few works deal with food supply and distribution (as shown in the three most recent reference books in city/urban logistics (Gonzalez-Feliu et al., 2014; Macharis and Melo, 2011; Taniguchi et al., 2001)). Most of those works deal with non-food distribution to retailers and/or consumers. Some of them include food and non-food flows (both) (Pan, 2010). Nevertheless, works addressing explicitly food distribution remain a small minority.

Nevertheless, some of those works are relevant and can be considered pioneers on the field. The first work found in the literature review dates from the 70's (Blakey et al., 1977); authors establish a public oversight of the local food supply and distribution function, and formalize the main issues of supplying cities with food. Likewise, Morganti (2011) explains the importance of urban food planning and its influence on food logistics and sustainability, Morganti and Gonzalez-Feliu (2015a,b) study the perishable products distribution by proposing the Food hub concept as a consolidation solution to avoid negative impacts on the food distribution by decreasing the food miles. In Morganti (2011), a case study in Parma, Italy is presented, where the food hub concept is successfully implemented. The authors define also the notion of last food mile (Morganti and Gonzalez-Feliu, 2015b), to consider the specificity of food distribution in city logistics.

One of the most important findings in urban food distribution is the relationship between the urban food transportation and sustainability, Goggins and Rau (2016); Prosperi et al. (2015) enhance the impact of sustainable urban food strategy. They propose six goals of the sustainable Food Cities: (1) promoting healthy and sustainable food to the public; (2) tackling food poverty, diet-related ill-health and access to affordable healthy food; (3) building community food knowledge, skills, resources and projects; (4) promoting a vibrant and diverse sustainable food economy; (5) transforming catering and food procurement; and (6) reducing waste and the ecological footprint of the food system.

However, all those works remain either conceptual or mainly qualitative (quantification ones are only descriptive or based on specific surveys and measurements). Few works dealing with quantitative food flow assessment and performing an analysis in catering sector have been found (Eriksson et al., 2017; Gebresenbet et al., 2011; Zhang and Sheng, 2010) .

Zhang and Sheng (2010) study the catering logistic transportation to reduce the transportation cost. They built a transportation path model to acquire the optimal path by using N shortest paths algorithm. Moreover, Gebresenbet et al. (2011) evaluated the performance of an integrated food distribution network in a Sweden catering industry by using Geographic Information System (GIS) tools and location analysis techniques.

Beside those works, there are other solutions linked to the logistic solutions presented before. Eriksson et al. (2017); Lagorio et al. (2018) analyse food waste in institutional catering by seeking to quantify the food waste linked to a social, economic and environmental impact on institutional catering. Eriksson et al. (2017) estimated the mass of wasted and served food during three months and within 30 public kitchens in Sweden. They found that the satellite kitchens have a higher food waste quantity than the other kitchens that cook and serve the food by their selves, and finally some waste reduction strategies are proposed. Besides, Lagorio et al. (2018) propose a strategy to reduce food waste by involving the institutional catering stakeholders, with an implementation of an almost zero-cost solution. The stakeholders collaboration and involvement in the decisions are key success factors highlighted, that may be linked to the impacts assessment.

It is necessary to assess the institutional catering food distribution system not only in terms of distance and time, but also to combine those assessments with the evaluation of economic and environmental impacts that may be generated for the proposed distribution schemas. With this aim, the goal of this chapter is to propose a methodology to assess the economic and environmental impacts of different food distribution scenarios and consequently to support decision making in urban food logistics strategic and tactical planning.

This chapter is organized as follows: a background about the food distribution assessment is presented. Then, the methodology to identify and quantified the indicators that can be used to assess the economic and environmental impacts of a food distribution system is explained. By following the steps presented in the methodology, the findings are described. Finally, the chapter ends with the discussion and conclusion from the results obtained.

6.2 Background: Food distribution assessment

Impacts linked to logistics decisions

As mentioned before, there are increasing food regulations that encourage the logistic organization on food supply chains considering environmental, economic and social impacts (Akkerman et al., 2010).

Indeed, regarding the environmental impacts on urban food distribution, the logistic decisions especially the decisions about facility's location could have an influence in terms of emissions, pollution, noise, vibrations and life quality (Faccio and Gamberi, 2015; Zissis et al., 2017). These impacts are referred in the literature as consequence of a low transportation efficiency (Pan, 2010). These logistics decisions can be : the vehicles used for high volume/weight that are unsuitable for urban transportation; the lower vehicle's saturation; the great number of vehicles moving within the city centre, the number of vehicles performing a delivery to the same customer, the long distance covered by all vehicles, among others (Faccio and Gamberi, 2015). Besides, according to Akkerman et al. (2010); Moldan et al. (2012), the quality of products has a linear relationship with: transportation time and travelling distance. Therefore, local food supply chain has become linked to the reduction of environmental impact. Nicholson et al. (2011), argue in favour of more localized food supply chains to reduce GHG emissions.

Regarding the influence of the distribution system design on the economic impacts, logistic decision such as facility location influence costs of food supply chains and on the price for food paid by consumers (Nicholson et al., 2011). Besides, transportation plays a key role in today's economy impacts, accounting for up to two-thirds of the total logistics cost (Akkerman et al., 2010). According to Sawik et al. (2017), the most common costs associated with the delivery of goods are those related to driving distances, including: fuel consumption, driving times, maintenance (amortization) of vehicles, or drivers' salaries.

Considering the social impacts, according to Manzini and Accorsi (2013), food distribution decisions affect not only costs, but the level of quality of food products with a direct and indirect social impacts on consumers safety, health and well-being. Akkerman et al. (2010); Ilbery and Maye (2005); Validi et al. (2014) affirm that the social impacts include: employees' health and safety, ethical trading in procurement of raw materials, and animal welfare; fairly or co-operatively traded between producers, processors, retailers and consumers as well as non-exploiting of employees in the food sector in terms of rights, pay and conditions. Table 6.1 describes other impacts of logistic decisions.

Akkerman et al. (2010) propose to combine key distribution decisions considering the logistic decisions above mentioned. Some of those are: (i) network design with network planning; (ii) location decisions with transportation planning; and (iii) inventory decisions with transportation planning. Besides, Firoozi et al. (2014) propose to combine facility location and inventory control decisions by stating that those are the key decisions responsible for distribution of perishable products.

The reason behind these strategies is that the total cost of the distribution system

Table 6.1: Impact of logistic decisions

Decision nature	Impacts	Author
Network design	- It can improve efficacy and efficiency in organizations	Khalili-Damghani et al. (2014)
	- It can enhance competitive advantage	Khalili-Damghani et al. (2014)
	- The later operational decisions of flow management throughout the chain	Baghalian et al. (2013)
	- Strategic locating and capacity setting costs	Baghalian et al. (2013)
	- The resulting operational inventory holding	Baghalian et al. (2013)
	- Transportation costs	Baghalian et al. (2013)
Facility location	- The transportation cost of raw materials between suppliers and facilities	Aras and Bilge (2018)
	- The cost of transporting finished goods between plants and demand points	Aras and Bilge (2018)
Stock and process allocation	The performance of a logistics network	de Keizer et al. (2017); Pan (2010)
Vehicle mode and load capacity	- The costs of operating a fleet	Lopes et al. (2010)
	- The required level of service established	Lopes et al. (2010)

can be minimized by considering these distribution decisions together (Akkerman et al., 2010). Those costs are linked to costs for local delivery from warehouses to customers, costs for shipments between plants and warehouses and costs for the depots, among others. Nevertheless, in food distribution management, these strategies are related to the inclusion of food quality and safety requirements. In fact, the result of these strategic and tactical distribution decisions making and the optimal routing planning, the transport distance will decrease and therefore, the total number of transport unit kilometres and the number of freight movements may be reduced (and thus environmental pollution) (Vollebregt et al., 2010). Certainly, the fact of improving transport efficiency, will be beneficial for the quality of perishable goods (Firoozi et al., 2014).

Finally, regarding the catering sector, Akkerman et al. (2010) affirm that the aim of the caterers is to pursue a low stock level by demanding frequently ship in smaller amounts due to the high variations in the demand. The fact of having frequently deliveries may impact the length of the chain, making a common strategy the direct deliveries from the producers. In addition, regarding the logistic decisions linked to the production activities, the caterers not always confined it to the initial food manufacturing stage, but they use additional production steps, adapting postponement strategies to perform the final meal assembly and preparation at the central kitchens.

Impacts assessment on food distribution systems

Moreover, the need of suitable decision support methods for public and private planning in terms of urban distribution has led to the development of decision support systems, some of them being operational nowadays (Parra-Herrera et al., 2017), like the CLASS platform (Comi and Rosati, 2013)(for urban consolidation and retailing land-use issues), PLUME software (Guyon et al., 2010) (for parcel delivery platform location), and some transport flow generation software tools (Ambrosini et al., 2008; Holguín-Veras et al., 2011), mainly based on demand models. However, those systems are related to non-food distribution. Indeed, although some of them propose food and non-food distribution flows, they are developed and calibrated based on classical parcel and pallet distribution schemes, related to non-perishable non-fragile goods.

Aramyan et al. (2006) developed a conceptual framework to assess the performance, considering specific characteristics of agri-food supply chains. They propose over 30 indicators divided into four main categories of performance indicators: efficiency, flexibility, responsiveness and food quality (regarding product and process). Moreover, based on this framework, Moazzam et al. (2018) showed the importance of adding a new category, the environmental impacts to the food supply chain assessment. Besides, works as Bourlakis et al. (2014); Croom et al. (2018); León-Bravo et al. (2018) have implemented this framework in the industry. Furthermore, Kirwan et al. (2014) propose a set of 24 sustainable attributes, that Galli et al. (2015) divided into social, economic, environmental, ethical and health dimensions. This last one dimension is linked to local food by association of freshness, seasonality and trust. The same categorization was proposed in the European research project GLAMUR, that investigated sustainability assessment on global and local food supply chain (Brunori and Galli, 2016; Brunori et al., 2012). Another European project that can be cited is SCALE (Step Change in Agri-food Logistic Ecosystems), that proposed a sustainable framework applied in companies from Netherlands, UK and France (Bloemhof et al., 2015). As a result, this project found a set of indicators that the companies may use to assess the sustainable performance on the strategies adopted.

Recently it has been shown that a "unique" model able to represent any situation is not suitable for urban logistics since each city has particularities that need to be taken into account and then modelled (Gonzalez-Feliu, 2018a).

However, before analysing the most accurate approach to assess the different impacts in the distribution system, it is important to analyse the meaning of assessment. Gonzalez-Feliu (2018a) explains that the assessment is the process to measure a phenomenon by quantifying and qualifying it, considering its relation with a reference situation and with the objectives to be achieved. Besides, this assessment is linked to the interest of stakeholders involved in the distribution system. There can be identified two types: (i) Ex-ante evaluation, related to the hypothetical situation assessment, and (ii) Ex-post evaluation, related to before-after analyses to measure the state of the context before and after implementation. Thus, and considering the assessment type, a methodology to assess the economic and environmental impacts of scenarios of food supply systems is proposed.

6.3 Material and method: Proposed methodology for food distribution assessment

The proposed methodology proposes four steps:

1. Literature analysis: to define a set of indicators addressed in the literature review.
2. Relevance analysis: Once the indicators are extracted from the literature review, those are analysed in relation to the scenarios construction considering the data needs.
3. Indicators definition and calculation: Once the set of indicators is defined, the data base for calculation is established and validated by the stakeholders.
4. Scenario assessment: The resulting efficiency assessment input data is used to estimate the economic and environmental indicators. Different scenarios are assessed and discussed.

Figure 6.1 shows the research methodology to select the economic and environmental indicators for the food distribution assessment.

Literature analysis

To identify and extract the indicators addressed in the existing literature, a rigorous, systematic and reproducible literature review was conducted.

The collection of material is mainly based on a documentary gathering. The Scopus database was used to quantify the published articles,and then databases from major publishers and library services, such as Science direct, Emerald and Springer were then selected to compare and complete the list of articles.

Regarding the inclusion criteria, firstly, the main keywords of the research problem were defined as: (i) Related to food: such as food distribution, food supply chain, food hub, urban consolidation centre; (ii) Related to evaluation: such as assessment, performance and efficiency; and, (ii) related to the impacts: such as economic, environmental and social. Table 6.2 shows the main inclusion criteria considered and the logic used to generate these combinations.

Then, the keyword equation and the time period (2008 - 2019) were defined. Then, the field codes that were considered are abstracts, titles and keywords of published

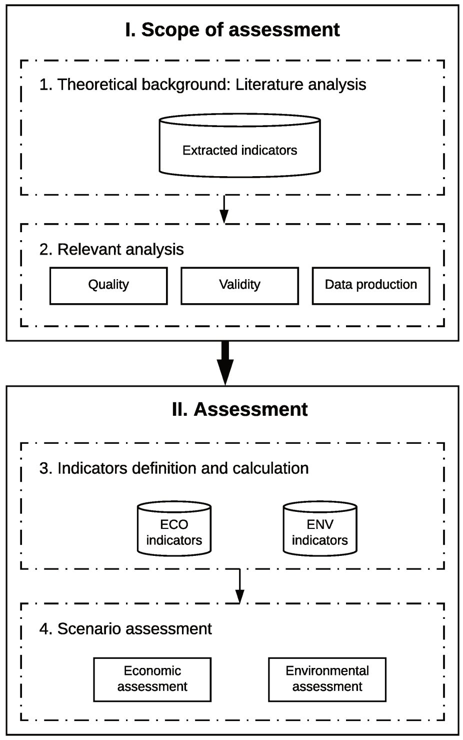


Figure 6.1: Research methodology for the food distribution assessment

papers. The document type selected includes conference proceedings, journal paper, book chapters and grey literature (i.e. technical reports and work in progress). Figure 6.2 shows the flowchart of literature review and the screening process.

The total number of documents found is 568. Therefore, the list of selected papers was refined by reading the full text and searching for references using citation-tracking databases. After a discussion among the researchers involved in this research, 43 papers were finally selected according to their content.

Relevance analysis

It is important to emphasize that relevance analysis is not only linked to the assessment objectives, but also to the quality of the indicators, the stakeholders interests, and last but not least on the availability of data. Relevance analysis is an important step on the methodology.

Moreover, besides having indicators that measure performance, it should provide a useful tool for decision making. With this aim, indicators should be clear, understandable, policy-relevant, significant, accessible and reliable to accomplish a quality criteria mention in the literature (Melo and Costa, 2011).

Moreover, regarding the relevance analysis should consider the data needs, approaches based on data production that are cited in the literature review.

Table 6.2: Inclusion criteria

Keyword 1	**Boolean**	**Keyword 2**
Food distribution	AND	assessment, performance, efficiency, environment∗, economic∗, social
Food supply chain	AND	assessment, performance, efficiency, environment∗, economic∗, social
Food hub	AND	assessment, performance, efficiency, environment∗, economic∗, social
Urban consolidation centre	AND	assessment, performance, efficiency, environment∗, economic∗, social

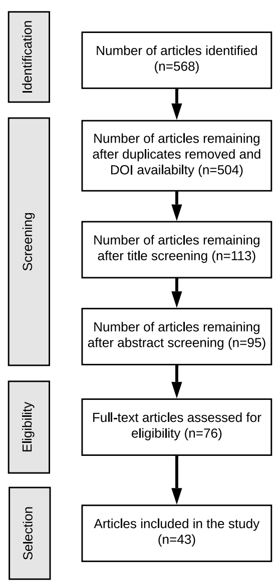


Figure 6.2: Flowchart of literature review and screening process

Indicators definition and calculation

It is necessary to clarify that the resulting travelled distances are also converted into travelling times (using the average distances calculated via cartographic data), since those times are necessary to the estimation of different indicators.

The estimation of the transportation costs is estimated according to the primary and secondary information obtained. The secondary data was complemented with primary data collected through structured telephone interviews based on the indicators extracted from the literature review. These interviews were performed with stakeholders of the institutional catering supply chains in the Auvergne-Rhône-Alpes region in France that were previously contacted. In total, four semi-structured interviews were conducted. The duration of each interview was between 20 and 30 minutes. All interviews were conducted in French. Table 6.3 shows the position of the stakeholder interviewee, and the date of the interview.

Table 6.3: Information about interviewees

Stakeholder	**Position of the interviewee(s)**	**Date of the interview**
Producer	Producer of fruits and vegetables	20/03/2019
FH	Sales manager, in charge of central kitchens, corporate restaurants and institutional catering	27/03/2019
Public authority	Manager of the meal distribution for school canteens at Valence	28/03/2019
Meal contractor	Manager of the meal distribution for school canteens at Saint-Etienne	02/04/2019

Economic impact estimation

The economic evaluation is based on a cost analysis described in (Gonzalez-Feliu, 2018a). Indeed, three approaches are mainly used: cost analyses, margins on variable costs and cost benefit analyses. All three methods need the identification of costs, which can be calculated on the same basis. For that reason, it is proposed to start by a cost analysis (since the scenarios assessed are related to the system service settings and no hypothesis on fees and funding strategies is for the moment considered).

According to Gonzalez-Feliu (2018a), when defining costs related to urban food distribution, there are two main approaches to classify costs:

- The first, mainly used in long-term planning issues (mainly related to cost-benefit analysis in a multi-year horizon), sees costs as being related to investment (to be paid before use and that need to be refunded in a multi-year period) and operational (to be paid operationally at each use of the system and having to be covered by monetary benefits each year);
- The second, used when making cost only analyses or for operational assessments (mainly for a given use period that is a day, a week or a year), is to consider costs

related to the use of vehicles: fixed costs are those not related to the travelled distances nor working times, and variable costs are those related to them.

In the present work, the second approach is adopted. Fixed costs are not related to vehicle use, so they are defined by a fixed quantity for the given used period. Variable costs can depend on travelling distances, on travelling times, but also on the quantities to manage (mainly for central kitchen or inventory facilities). Then, it can be formalized the calculation of total daily costs of a scenario a, noted, Ca as follows:

$$C_a = f_{cost}(d_a, t_a, dem_a) \tag{6.1}$$

$$C_a = C_{fixed} + UC_d \times d_a + UC_t \times t_a + UC_w \times dem_a \tag{6.2}$$

Where C_{fixed} are the fixed costs, UC_d the unitary costs depending on travelled distances; UC_t the unitary costs depending on working time (not only travel time, but also time passed for loading and unloading, breaks and other needs of drivers during their working times) and UC_w the unitary costs (depending on a quantity of freight) related to central kitchen and warehousing activities. Moreover, d_a, t_a and dem_a are respectively the total travelled distances, the total working times and the total demand assessed for each case or scenario a.

In the present work, fixed costs are considered as those associated to drivers (since the number of working hours will be the same for each driver, independently of the driving hours) and to the vehicles (i.e., the number of vehicles, different for each scenario, will provide the vehicle fixed costs). Variable costs are those associated specifically to vehicle use, mainly to travelled distances (i.e., fuel consumption).

Moreover, regarding the economic evaluation related to the facility, Kin et al. (2018); Otto et al. (2009) explain two types of costs:

- Related to the facility capacity: The cost attributed to rent and fixed costs.
- Related to the facility operations: The cost attributed to picking (such as:annual number of picks, time needed per pick and hourly wage for a picker)

Besides, Daganzo (2005); Lin et al. (2016) explain that there are : (i) Rent cost (or storage cost) attributed to the renting of space, machinery needed to store the items in place, and maintenance cost; and, (ii) Inventory cost (or waiting cost) , attributed to the capital opportunity cost locked in storage, and the item value lost while waiting.

Furthermore, Janjevic and Ndiaye (2017) show a cost comparison among several European urban consolidations centres (UCC). They defined that the total cost of the facility can be calculated in function of the lease price per square metre and the surface. This considering only a lease rangement and not building a new facility. Additionally, they consider the human resource cost, the equipment cost and the vehicle cost, explained as follows:

- Human resource: They consider three categories of salary cost: (i) the driver staff; (ii) the operational and clerical staff; and, (iii) the managers.
- Equipment cost: They consider two main types: (i) forklifts, and (ii) electric pallet jacks. It is considered annual leasing of the equipment.
- Vehicle cost: Those costs result from the total travelled distances and times, as well as the choices in terms of vehicles and service settings, such as (i) the total number of vehicles used; (ii) the total distance (km); (iii) the total time spend (hours); (iv) the total quantity of food distributed (kg)

Table 6.4 shows the main cost categories to consider for economic evaluation related to the facility and the distribution process.

Table 6.4: Main cost macro-categories

Macro category	**Category**	**Unity**
Fixed costs	Platform use	€/ m^2
	Vehicle purchasing or leasing	€/ vehicle
	Employees fixed costs (not depending on vehicle use)	€
	Other operational costs	€
Variable cost	Linear infrastructure use	€/km
	Vehicle use (fuel consumption, insurances, etc.)	€/km
	Employee variable costs	€/h

To estimate those costs, it is started from the definition of the main macro-categories of costs, adapting the works of (Gonzalez-Feliu, 2017, 2018a) to a food distribution. Then, and via the results of the semi-structured interviews, those costs were completed by identifying more precisely the assumptions and variables to consider. After that, a first given costs was established with secondary data (mainly issued from (Faure et al., 2014), and a second round of interviews (more directive) was established to complete and update them in order to represent the main current practices (Vaghi and Percoco, 2011a). Nevertheless, it is important to take in mind that there is a limited availability of information on costs because they are commercially sensitive for the current FH. However, with the cost presented before, it was possible to understand which cost items are the most significant for the food distribution system.

Environmental impact estimation

For evaluating the environmental performance of the system, only exhaust direct emissions from the use of vehicles were considered. François et al. (2017) identified nine environmental indicators for the urban transport sector. However, and as shown in Andriankaja et al. (2015); Melo et al. (2010); Vaghi and Percoco (2011a), the different stakeholders involved in urban logistics consider mainly global warming and particulate matters.

To each vehicles category considered, the emission functions (which relate each of the considered emissions per kilometre and average speeds) are defined:

$$E_a^i = f_{emission}^i(truck_{cat}, speed_{average}) \times distance_{traveled} \tag{6.3}$$

With $i \in (CO_2, FC, NO_x, VOC, PM)$

The emission factors and vehicle kilometres are in most cases split into certain classes of road types (as the use of the average speed for its calculation implies) and vehicle categories. The function $f_{emission}^i$ is extracted from the emission database of COPERT V (Computer Programme to calculate Emissions from Road Transport Methodology and emission factors) (Gkatzoflias et al., 2007). The database used for function definition is from 2017 and includes the different euro norms (from 3 to 5). The weather conditions considered are detailed in Appendix .7.

Scenario assessment

To propose a methodology for scenario assessment, it is necessary to define the type of analysis to carry out. Gonzalez-Feliu (2018a) proposes five types of scenario assessment: (i) before-after assessment: where the initial and final situation are assessed based on the baseline scenario defined; (ii) comparison of contrasting alternatives: it aims to compare alternatives without defining an initial situation; (iii) incremental analyses: it aims to compare several situations, each obtained from the last one by gradually modifying parameters and input data; (iv) combined analysis: it combines analyses (ii) and (iii) aiming to generate a comparison to identify scale effects or synergies between different solutions; and finally (v) back-casting assessment: it is used for long-term issues evaluation by analysing in retrospective future scenarios aiming to define how these scenarios can best met.

Indeed, the output of scenario construction-due to a set of logistic decisions considered (see Section 5.5)- is a given information for each scenario about total distance, average speed, and total duration considering service time. The scenario assessment of the methodology computes economic and environmental impacts using these outputs, and considering before-after assessment. This type of analysis is often used in urban logistics (Allen et al., 2012; Leonardi et al., 2012; Vaghi and Percoco, 2011b). Figure 6.3 shows the methodology proposed for the impacts assessment.

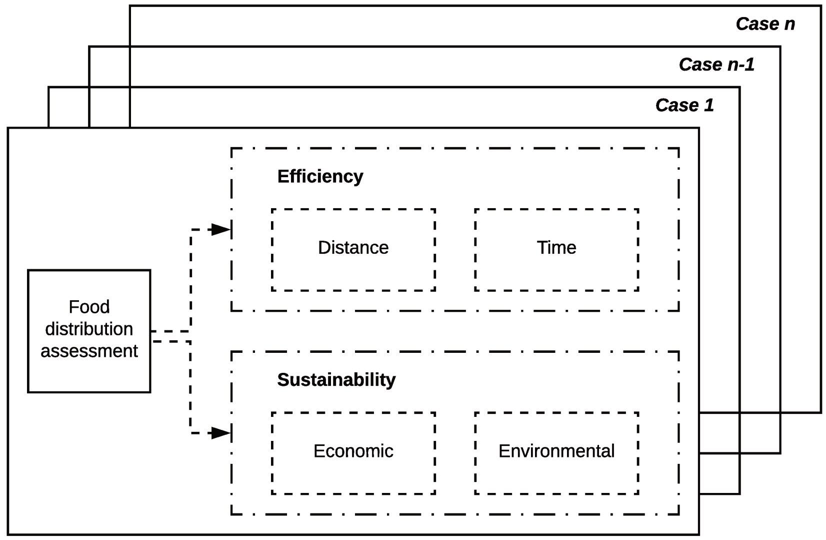


Figure 6.3: Methodology for food distribution assessment

6.4 Findings: Assessment of food distribution system for the school canteens

Indicators extracted from the literature analysis

Before defining the indicators that are suitable for food distribution assessment, it is necessary to consider the interest and criteria of the food distribution system actors. In Chapter 3 has been already described the food distribution actors and the logistic requirements by actor. Nonetheless, regarding the economic, social and environmental impacts, Melo and Costa (2011) affirm that the main interest of the stakeholders is to minimize the collection and distribution cost, and to maximize their profits. Similarly, they seek to improve the distribution efficiency reflected in their turnover. Moreover, regarding the public stakeholders' interest, this is based on the well-being of all the stakeholders considering quality of life and economic viability.

Therefore, as Melo and Costa (2011) defined, the expected sustainability on the distribution system should be *"the transport and goods distribution with lower environmental impacts within the city, minimum cost for the city and the industry, and minimum externalities for society"*.

Considering this last statement, many works address urban logistics assessment and evaluation, and propose a plethora of indicators. Indeed, there are several works aiming to define a sets of indicators and dashboards for impacts assessment. Henriot et al. (2008); Patier and Browne (2010), propose 30 indicators divided into five categories (economic, environmental, societal, ergonomic and regulatory). Melo and Costa (2011); Melo et al. (2010) define around 50 indicators divided into four categories (economic, social, environmental and mobility). Additionally, Morana and Gonzalez-Feliu (2015a,b) propose over 80 indicators classified under the four typologies (awareness, act and shift, avoidance and anticipation indicators) showing the relevance of using 8 main indicators divided into economic, environmental, social and service quality nature. Besides, in the most recent literature review performed by Bandeira et al. (2018), they extracted from the literature 15 indicators divided into the same three categories, nevertheless, after a content analysis they propose a set of 10 indicators related to impacts assessment. Bloemhof et al. (2015) present a set of indicators that are considered by food companies and logistic service providers in France, UK and Netherlands. Moreover, Aljohani and Thompson (2019); Lebeau et al. (2018) propose over 30 indicators linked to the main objectives considered by the stakeholder. Finally, focusing only in environmental analysis, Andriankaja et al. (2015) propose a set of 20 indicators to assess the impact of delivery goods per day.

Table 6.5 presents a set of indicators extracted from the literature review. Although, most of them have a common point: they can be calculated from the estimation of total distance travelled s and times. The economic aspects can be evaluated by defining the costs and benefits of the urban logistics system and assessing the system's viability. The environmental assessment can be carried out to identify the main impacts of the system on the environment and estimate them.

Relevance analysis

Considering quality

The indicators should be selected by following the principles proposed by Melo and Costa (2011). Those are scientific validity, representativeness, relevancy and easy understanding, evidence of links of cause and effect, responsiveness to change, comparability to target, transferability accuracy, and cost-effectiveness. However, it is difficult to accomplish all these principles simultaneously.

Furthermore, the indicators selection requires two other steps: (i) to consider the consequences or impacts that need to be measured; and (ii) to relate the impacts to a set of causes. Taking into account this last one, it is necessary to consider the evaluation tool (Melo and Costa, 2011).

Indeed, in a general assessment framework, indicators should address economic, environmental and social impacts. Nonetheless, and as shown by recent works in literature (Gonzalez-Feliu and Morana; Macharis and Melo, 2011; Melo and Costa, 2011), most social indicators are qualitative and/or obtained from satisfaction or acceptability surveys. Those indicators are still discussed at an initial stage, and their quantification arises numerous questions, which are still unanswered.

Indeed, regarding social evaluation and assessment, it is still difficult to produce quantitative consensual evaluations, although congestion, employment and satisfaction seem affordable indicators to quantify. A serious social assessment would require a more qualitative approach, with interviews with the main interested parties (for example

Table 6.5: Indicators for distribution assessment

Dimension	Indicator
Economic	Road transport (tonne km) Total per capita transport expenditures (vehicle parking, roads and transit services) Motor vehicle fuel prices and taxes (for gasoline and gas/diesel) External costs of transport activities (congestion, emission costs, safety costs) by transport mode Subsidies to transport Taxation of vehicles and vehicle use Loading at warehouse rating (%) Level of service rating (%) Delivery service rating (%) Delay service rating (%) Platform service rating (%) Transportation cost per (t.km) Load factor or occupancy rate (loaded vehicles trips by weight rating (%) and by volume rating (%) Average operational speed (km h) Reciclying of used tires Reciclying of end of use vehicles Time spent in traffic Productivity Quality of service
Environmental	VOC emissions (per capita) SOx emissions (per capita) O3 concentration (per capita) N20 emissions (per capita) Energy consumption by transport mode (tonne oil equivalent per vehicle km) Fuel consumption (vehicle km by mode) Habitat and ecosystem disruption Land take by transport infrastructure mode Polluting accidents (land, air, water) Hazardous materials transported by mode Use of renewable energy sources (numbers of alternative fuelled vehicles) use of biofuels Total expenditure on pollution prevention and clean up CO2 emissions (kg CO2 eq.) CH4 emissions (kg CH4 eq.) NOx emissions (kg Nox eq.) Noise emissions (dBA) Land acidification (kg SO2eq) Particulates (kg PM10 eq) Fossil depletion (kg oil eq) Metal depletion (kg Fe eq) Urban land occupation (m2 a) Fossil energy (GJ)
Mobility	Average vehicle journey time Average vehicle journey length per mode Daily number of trips Structure of trip purposes Daily average time budget Modal split Average distance travelled
Social	Ratings pertaining to the retraining of employees (%) External collaborations (number of hours person intra enterprise) Jobs created (eq. Full time) Jobs to convert (eq. Full time) Shipper loyalty rating (%) Carrier loyalty rating (%) Fatality and injured of traffic accidents per vehicle Income generated per t.km Tax generated per t.km

employees, inhabitants of the city, customers of the food service). For those reasons, the social impact estimation is not considered in the present work.

Considering validation process

Melo and Costa (2011) validated the set of indicators listed before with a set of members of the Portuguese Transport Studies Group. They validated a set of indicators to evaluate the economic, social and environmental performance on urban good distribution initiatives with regards on public and private stakeholders. Besides, Bandeira et al. (2018) selected ten indicators to use when assessing urban freight distribution efficiency through an analysis of the literature review using content analysis.

In contrast, Gonzalez-Feliu (2018a) validated the set of indicators proposed with a panel of decisions makers by considering: (i) a maximum number of indicators to select; (ii) the inclusion of the three pillars of sustainability as axes of analysis; (iii) the point of view of several stakeholders. Then, two different methods were carried out to establish the final set of indicators, the expert and the co-constructive method. The first one aims to consensus-build the indicators, and the second one aims to seek out an explicit agreement between the stakeholders.

Table 6.6 presents the indicators validated by these works, considering the data requirement or data source for the indicators calculation.

Considering the previous set of indicators validated, and compared with the stakeholders objectives (from those selected in the work of Aljohani and Thompson (2019); Lebeau et al. (2018)), these indicators may allow to:

- Logistic services providers: to minimise the total duration between picking and delivering products and optimise vehicle capacity to utilise vehicles properly.
- Receiver: to maintain receiving frequent deliveries on time.
- Shippers: to ensure successful and on-time delivery to receiver.
- Local authorities: to establish a liveable city for citizens with limited nuisance (less noise, emissions and accidents) and to reduce the number of freight vehicles and reduce congestion near homes and shopping areas.
- Citizens: To prevent accidents near homes and shopping areas and reduce the number of freight vehicles.

Considering data production

Gonzalez-Feliu (2018a) shows a literature review about the data production needed according the nature of indicators (see Table 6.7).

Table 6.6: Set of indicators considering validation process

Dimension	Indicator	Data source
Economic	Distance travelled by Heavy-Duty-Trucks (HDT) and, Light Commercial Vehicles (LCV) (vehicle-km)	Surveys/Measurements
	Transportation cost per (t.km)	Surveys/Measurements
	Average operational speed (km h)	Surveys/Measurements
	Level of service rating (%)	Surveys/Measurements
	Delivery service rating (%)	Surveys/Measurements
	Delay service rating (%)	Surveys/Measurements
Environmental	Energy intensity (fuel consumption in litres by vehicle type)	Local regulatory laws Vehicle data sheet
	Fossil energy consumption (TEP t.1000km)	Local regulatory laws Vehicle data sheet
	Noise emissions (dBA)	European Directive 2002/49/EC Measurements
	Products transported per m2	Vehicle data sheet Surveys/Measurement
	Load factor or occupancy rate (loaded vehicles trips by weight rating (%) and by volume rating (%)	Vehicle data sheet Surveys/Measurements
	VOC emissions (per capita)	COPERT database
	NOx emissions (kg NOx-eq.)	COPERT database
	Particulates (kg PM10 eq)	COPERT database
	CO2 emissions (kg CO2-eq.)	COPERT database
Mobility	Delivery times	Surveys/Measurements
	Deliveries per day	Surveys/Measurements
	Average vehicle journey time on the area	Surveys/Measurements
	Travel time (sec. km)	Surveys/Measurements
	Delay time (sec.km)	Surveys/Measurements
	Proportion of goods vehicles in total traffic	Surveys/Measurements
	Density (vehicle km).	Surveys/Measurements
Social	Fatality and injured of traffic accidents per vehicle	Surveys/Measurements
	Income generated per t.km	Surveys/Measurements
	Tax generated per t.km	Surveys/Measurements
	Jobs created (eq. full-time)	Surveys
	Jobs to convert (eq. full-time)	Surveys

Table 6.7: Relevant validation considering data production. Adapted from (Gonzalez-Feliu, 2018a)

Dimension	Data production	Data sources	Source
Environmental	-To quantify transport flows taken from various data sources.	French Urban Goods Transport surveys, household trip surveys, and databases on construction and waste management logistics	Ségalou (1999)
	-To estimate the greenhouse gas emission rates for several pollutants (including NOx, SOx, CO and HC emissions) through a direct emissions model.	French Urban Goods Transport surveys, household trip surveys, and databases on construction and waste management logistics	Ségalou (1999)
	-To evaluate e-commerce delivery systems based on direct emissions from transport (i.e. greenhouse gases and other air pollutants).	Surveys and/or measurements	Esser and Kurte (2006)
	-To evaluate UCC systems based on direct emissions from transport (i.e. greenhouse gases and other air pollutants).	Surveys and/or measurements	Morganti (2011); Tozzi et al. (2014); Vaghi and Percoco (2011b)
	-To estimate the relationship between the level of CO2 emissions and GDP, transport intensity, traffic intensity (traffic levels) and technical capacity (ratio of CO2 emissions as a function of traffic intensity).	Surveys and/or measurements	Behrends (2016)
	-To estimate economic, social and environmental indicators considering the perspective of local authorities.	Surveys and/or measurements	Lindholm (2010)
	-To estimate the routes and hence the allocation of traffic, in order to estimate the road occupancy and ecological footprint, through the use of a demand-based model followed by an analytical model.	Databases	Muñuzuri et al. (2010)
Economic	-To propose a systematic and generic cost-benefit analysis (CBA). Through vehicle routing optimization, several medium termed UCC development scenarios are modelled and evaluated these monetary costs in accordance with the CBA.	Databases	De Langhe (2014); Gonzalez-Feliu (2014, 2016); Van Duin et al. (2008)
	-To analyse the operational costs of urban logistics	Databases, surveys and/or measurements	Combes (2016); Gonzalez-Feliu et al. (2013)
	-To analys the margins on variable cost.	Databases	Faure (2015); Faure et al. (2016)

It has been concluded that for relevance analysis considering, the quality of the indicators, the validation process and the data production, the social and the mobility indicators will not be considered. Moreover, the noise emission will not be considered regarding the data production issues considering the measures complexity (as Meyer et al. (2017) details) and the lack of researchers competences.

Finally, for the relevance analysis it is suitable to take in mind that those indicators should be selected and presented in the original context considering specific conditions and based on scientific information to avoid misinterpretation.

Indicators definition and calculation

Economic indicators

It is necessary to clarify that few works detail costs linked to transportation and linked to the facility, due the confidentiality of the data collected. Nevertheless, the estimation of the transportation costs have been estimated according to the primary and secondary information obtained.

The vehicle dependent cost were extracted from the interviews. The time and vehicle dependent cost were extracted from the interviews and from the web site of National Road Committee (CNR) (CNR). The distance and vehicle dependent cost were extracted from the interviews,the CNR and from the technical data given by the vehicles manufacturer. The main economic indicators are presented in the Table 6.8.

Table 6.8: Main economic values related to service settings

Cost type	**Cost detail**	**Value**	**Unit**
Vehicle dependent cost	Leasing vehicle 3.5t	1 000	€/month
	Leasing vehicle 14t	2 000	€/month
Time and vehicle dependent cost	Driver cost for vehicle 3.5t	2 500	€/month
	Driver cost for vehicle 14t	3 000	€/month
	Insurance cost for each vehicle	1.52	€/vehicle/h
	Taxes for each vehicle	0.14	€//vehicle/h
	Working days per year	140	days/year
	Working hours	10	h/day
Distance and vehicle dependent cost	Diesel cost	1.44	€/l
	Vehicle 3.5t consumption	18	l/100km
	Vehicle 14t consumption	25	l/100km
	Maintenance and repairs for each vehicle	0.03	€/vehicle/km
	Tires for each vehicle	0.04	€/vehicle/km

The diesel cost was consulted on an official French web site supported by the Ministry of Economy and Finance, where the French government provides the data of fuel price on France. The vehicle fuel consumption was directly retrieved from the technical data given by the vehicles manufacturer. The diesel consumption cost for vehicle 3.5 t is 0.26€/km and for vehicle 14 t is 0.36€/km. Then the taxes, insurance, maintenance and tires cost have been retrieved from the web site of the National Road Committee (CNR) (CNR).

Besides, the costs linked to the facility are presented in Table 6.9. Moreover, these costs were discussed and validated with the key stakeholders of school canteen distribution during the interviews.

Table 6.9: Main economic values related to the facility

Facility type	**Cost detail**	**Value**	**Unit**
Food Hub	Leasing facility	8	€/month per m2
	Human resource	35	% Turnover
	Equipment leasing	4	% Turnover
Central kitchen	Leasing facility	15	€/month per m2
	Human resource	35	% Turnover
	Equipment leasing	3	% Turnover

Environmental indicators

In this work, fuel vehicles are only considered, and not other technologies such as electric or natural gas vehicles. Therefore, direct emissions related to the vehicles utilization for delivery purposes are considered. Therefore, the following indicators are considered since they are the most relevant for the urban goods transportation sector, according to work cited before:

- Global warming potential estimated in CO2-equivalent emissions and directly linked with fuel consumption (FC).

Following the European Union emission regulations (Eur), the pollutants considered in this research are:

- Particulate matter emissions at exhaust (PM), focusing mainly in PM10.
- NOx emissions (NOx).
- Volatile Organic Compounds (VOC) that contribute to photochemical oxidant emissions.
- Products transported per m2, related to the vehicle type used.

To estimate the direct emissions, it is first necessary to define the vehicles that are used. As shown by the interviews responses, main vehicles for canteen distribution are :

- Light Commercial Vehicles (3.5 t): Multi-Temperature. Dimensions: 2.5m(l) x 1.9m (w)x 1.95m (h).
- Heavy-Duty Trucks (14 t): Multi-Temperature. Dimensions: 6.8m(l) x 2.5m (w)x 2.46m (h).

For the considered application, the data based extracted is from 2017 regarding Euro 4 for Light and HD Euro V for heavy vehicles are considered. As the trucks make their rounds quasi continuously during the day (with only small waiting times for the delivery of the packages), the cold emissions were considered negligible. Therefore, the estimated emissions are slightly underestimated.

The environmental evaluation from the VRP results were estimated for each scenario based on the total distance (km) and the average speed of routes in each scenario. The average speed is calculated by the VRP Spreadsheet Solver (VRP-SS) using Bing maps.

Scenario assessment

It is interesting to complement efficiency evaluation in terms of distance and time presented in the previous chapter, with economic and environmental assessment. The six cases considered are:

- *Case 1: Based on administrative subdivision allocation*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the current 5FH location and using analytical allocation method regarding the geographical department.
- *Case 2: Based on geographical proximity allocation*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the current 5FH location and using analytical allocation method regarding the geographical proximity.
- *Case 3: Based on mathematical modelling allocation with a producer's capacity of 21kg*: Working with 153 producers with a fixed capacity daily of 21kg per producer, using the current 5FH location and using mathematical modelling allocation method.
- *Case 4: Based on mathematical modelling allocation with a producer's capacity of 42kg*: Working with producers with a fixed daily capacity of 42kg per producer, using the current 5FH location and using mathematical modelling allocation method.
- *Case 5: Based on computational allocation using Affinity propagation clustering*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the 12FH locations proposed by Affinity clustering algorithm and using computational allocation method.

- *Case 6: Based on computational allocation using K-means clustering*: Working with 153 producers with a fixed daily capacity of 21kg per producer, using the 3FH news locations proposed by K-means clustering algorithm and using computational allocation method.

Economic assessment

The daily cost related to transport between producers and FH are estimated and detailed in Table 6.10 for the six cases.

Table 6.10: Daily cost related to transport between producers (P) and Food Hubs (FH)

		Distance and vehicle dependent cost			Time and vehicle dependent cost		
Cases	Leasing vehicles	Diesel consumption	Maintenance & repairs	Tires	Driver cost	Insurance	Taxes
Case 1	857.1 €	1 701.7 €	196.4 €	261.8 €	2 142.9 €	106.9€	9.8 €
Case 2	857.1 €	1136.8 €	131.2 €	174.9 €	2 142.9 €	122.1 €	11.2 €
Case 3	1 114.3 €	1 701.7 €	196.4 €	261.8 €	2 785.7 €	150.7 €	13.9 €
Case 4	428.6 €	474.3 €	54.7 €	73.0 €	1 071.4 €	48.8 €	4.5 €
Case 5	1 028.6 €	850.0 €	98.1 €	130.8 €	2 571.4 €	92.5 €	8.5 €
Case 6	857.1 €	994.0 €	114.7 €	152.9 €	2 142.9 €	115.8 €	10.7 €

Indeed, the lower daily cost related to the transport between producers and FH is Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg. In fact, compared with other cases, this gap is between 51% and 65% less expensive. This can be explained by the cost reduction when it is necessary to use only two FH. Besides, comparing the same number of FH needed, Case 2 based on geographical proximity allocation shows the lower transport cost, and comparing with the Case 1 based on administrative subdivision allocation and Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg, this gap is between 13% and 27% less expensive.

The daily cost related to transport between FH and CK are estimated and detailed in Table 6.11 for the six cases.

Indeed, the lower daily cost related to the transport between FH and CK is Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg. In fact, compared with other cases, this gap is between 28% and 79% less expensive. This can be explained by the cost reduction when it is necessary to use only two FH. Besides, comparing the same number of FH needed, Case 3 shows the lower transport cost, and comparing with the Case 1 and 2, this gap is less than 1%. These results show that the fewer distance travelled by the heavy vehicles is Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg.

The daily cost related to transport between FH and CK are estimated and detailed in Table 6.12 for the six cases. All cases show the same daily cost related to the transport between CK and SC.

Table 6.11: Daily cost related to transport between Food hub (FH) and Central kitchen (CK)

Cases	Leasing vehicles	Distance and vehicle dependent cost			Time and vehicle dependent cost		
		Diesel consumption	Maintenance & repairs	Tires	Driver cost	Insurance	Taxes
Case 1	1 028.6 €	541.0 €	45.1 €	60.1 €	1 542.9 €	23.5 €	2.2 €
Case 2	1 028.6 €	541.0 €	45.1 €	60.1 €	1 542.9 €	23.5 €	2.2 €
Case 3	1 028.6 €	515.7 €	43.0 €	57.3 €	1 542.9 €	23.9 €	2.2 €
Case 4	514.3 €	200.4 €	16.7 €	22.3 €	771.4 €	12.0 €	1.1 €
Case 5	2 228.6 €	1 286.8 €	107.2 €	143.0 €	3 342.9 €	62.3 €	5.7 €
Case 6	685.71 €	327.8 €	27.3 €	36.4 €	1 028.6 €	17.8 €	1.6 €

Table 6.12: Daily cost related to transport between Central kitchen (CK) and School canteen (SC)

Cases	Leasing vehicles	Distance and vehicle dependent cost			Time and vehicle dependent cost		
		Diesel consumption	Maintenance & repairs	Tires	Driver cost	Insurance	Taxes
Case 1	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €
Case 2	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €
Case 3	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €
Case 4	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €
Case 5	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €
Case 6	428.6 €	80.3 €	9.3 €	12.4 €	1 071.4 €	37.1 €	3.4 €

Besides, the daily cost related to facility are estimated and detailed in Table 6.13 for the six cases.

Table 6.13: Daily cost related to facility

Cases	**Cost linked to the FH facility**			**Cost linked to the CK facility**		
	Facility leasing	**Human ressource**	**Equipment leasing cost**	**Facility leasing**	**Human ressource**	**Equipment leasing cost**
Case 1	514.3 €	7 611.4 €	385.7 €	14 400.0 €	31 956.5 €	4 340.0 €
Case 2	514.3 €	7 611.4 €	385.7 €	14 400.0 €	31 956.5 €	4 340.0 €
Case 3	514.3 €	7 611.4 €	385.7 €	14 400.0 €	31 956.5 €	4 340.0 €
Case 4	205.7 €	3 085.7 €	154.3 €	14 400.0 €	31 956.5 €	4 340.0 €
Case 5	1 234.3 €	18 308.6 €	925.7 €	14 400.0 €	31 956.5 €	4 340.0 €
Case 6	308.6 €	4 525.7 €	231.4 €	14 400.0 €	31 956.5 €	4 340.0 €

Indeed, the daily cost related to the CK facility is the same for all cases. Besides, the lower daily cost related to the FH facility is Case 4 that uses only two FH. Compared to the other cases, this gap is between 3% and 9% less expensive. Moreover, comparing facility cost, even if cost related to the CK facility is the same for all cases, the FH facility cost is different. The gap between the Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg and other cases is between 3% and 9% less expensive. This is explained to the use of only two FH.

The total cost related to the food distribution system is detailed in Table 7.21 for all the cases.

Table 6.14: Economic evaluation for all cases

Cases	**Transport cost**	**Facility cost**	**Total daily cost**	**Total yearly cost**
Case 1	10 162.3 €	59 208.0 €	69 370.2 €	9 711 831.6 €
Case 2	9 461.8 €	59 208.0 €	68 669.7 €	9 613 761.8 €
Case 3	11 080.4 €	59 208.0 €	70 288.3 €	9 840 362.3 €
Case 4	5 335.9 €	54 142.2 €	59 478.1 €	8 326 937.5 €
Case 5	13 598.8 €	71 165.1 €	84 763.9 €	11 866 943.5 €
Case 6	8 155.7 €	55 762.2 €	63 917.9 €	8 948 512.2 €

In fact, comparing transportation cost, the gap between the Case 2 based on geographical proximity allocation compared to other cases is very important (between 35% and 61% less expensive). This can be explained by the fact of reduced distance and time estimated for the use of only two FH either than three, five or twelve.

Moreover, comparing facility cost, even if cost related to the CK facility is the same for all cases, the FH facility cost is different. The gap between the Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg and other cases is between 3% and 9% less expensive. This is explained to the use of only two FH.

Then, considering the total yearly cost, the lower cost is Case 4. In fact, compared with the other cases, Case 4 is between 7% and 30% less expensive. This can be explained by the reduced number of FH used for the distribution system that reflects less distance travelled and in consequences, fewer transport and facility cost. Comparing the cases with the same number of FH used, Case 2 shows fewer total yearly cost compared with Case 1 and Case 3. Nevertheless, the economic gaps between the three cases are very small (less than 2%). From these analysis, it can be inferred that the logistic decisions of facility location and allocation are crucial for decision-makers and have great economic impacts reflected in the transport and facility cost.

However, in all cases, the relation between distances travelled and total times on one side and transport costs on the other side were the same (and are linear for both variables, i.e. distances and times). In that context, the estimation of unitary costs is crucial to ensure a representative assessment. In the current application, unitary costs are estimated using carrier, municipality and caterer information. It should be needed to extend it by proposing a category of vehicles, platforms and drivers in order to be able to adapt the assessment framework to other contexts.

Environmental assessment

For the environmental assessment, the average speed calculated by the VRP Spreadsheet Solver (VRP-SS) using Bing maps is shown in Table 6.15 for each scenario: (P_FH) from Producers to Food hub (FH); (FH_CK) from Food hub (FH) to Central kitchen (CK); and (CK_SC) from Central kitchen (CK) to School canteen (SC) .

Table 6.15: Average speed used for the environmental assessment

	Average speed (km/h)		
Cases	**P_FH**	**FH_CK**	**CK_SC**
Case 1	55.1	77.1	25.6
Case 2	63.6	77.1	25.6
Case 3	77.6	82.7	25.6
Case 4	62.1	64.3	25.6
Case 5	55.1	69.9	25.6
Case 6	57.6	66.8	25.6

The emissions factors for the environmental evaluation of the transport between producers and FH is detailed in Table 6.16 for the six cases. These results show that for almost all the emissions, the Case 3 based on mathematical modelling allocation with producer's capacity of 21kg shows fewer emissions. Nevertheless, regarding Nox and CO, Case 1 based on administrative subdivision allocation and Case 5 based on computational allocation using Afinity propagation clustering show fewer emissions.

Table 6.17 shows the emissions factors for the environmental evaluation of the transport between FH and CK. These results show that for almost all the emissions, the Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg shows fewer emissions. The emissions saving are for CO between 3% and 9%, for Nox between

Table 6.16: Emissions factors for the environmental evaluation for the transport between producers and FH

Cases	**CO (g/km)**	**Nox (g/km)**	**VOC (g/km)**	**PM (g/km)**	**FC (MJ/km)**	**CH4 (g/km)**	**CO2 (g/km)**
Case 1	1.961	0.055	3.246	0.028	4.445	0.017	304.4
Case 2	2.041	0.057	3.245	0.025	4.383	0.017	300.0
Case 3	2.172	0.060	3.244	0.020	4.282	0.016	292.8
Case 4	2.027	0.057	3.245	0.026	4.394	0.017	300.8
Case 5	1.961	0.055	3.246	0.028	4.445	0.017	304.4
Case 6	1.985	0.056	3.246	0.027	4.427	0.017	303.1

11% and 29%, for VOC between 4% and 13%, for PM between 10% and 27%, for FC between 1% and 5%, for CH4 between 5% and 15%, and for CO2 between 1% and 5%.

Table 6.17: Emissions factors for the environmental evaluation for the transport between FH and CK

Cases	**CO (g/km)**	**Nox (g/km)**	**VOC (g/km)**	**PM (g/km)**	**FC (MJ/km)**	**CH4 (g/km)**	**CO2 (g/km)**
Case 1	0.730	1.408	0.021	0.059	5.780	0.001	427.0
Case 2	0.730	1.408	0.021	0.059	5.780	0.001	427.0
Case 3	0.709	1.252	0.020	0.053	5.695	0.001	420.7
Case 4	0.777	1.764	0.023	0.072	5.974	0.001	441.3
Case 5	0.756	1.608	0.022	0.066	5.889	0.001	435.0
Case 6	0.768	1.695	0.023	0.070	5.937	0.001	438.6

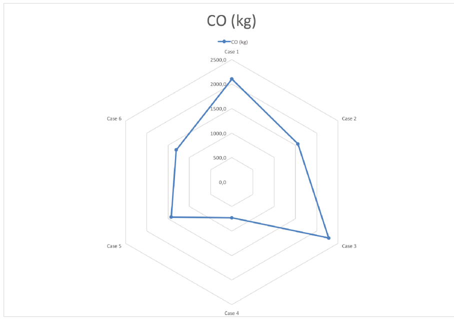
Table 6.18 shows the emissions factors for the environmental evaluation of the transport between CK and SC. These results shows that the emissions between CK and SC are the same for all cases.

Table 6.18: Emissions factors for the environmental evaluation for the transport between CK and the SC

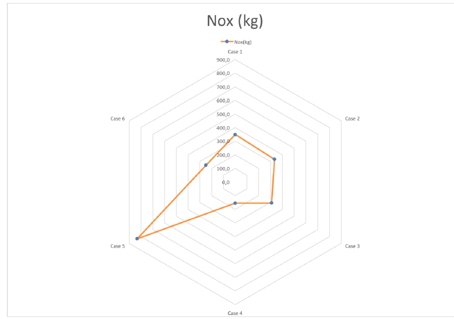
Cases	**CO (g/km)**	**Nox (g/km)**	**VOC (g/km)**	**PM (g/km)**	**FC (MJ/km)**	**CH4 (g/km)**	**CO2 (g/km)**
Case 1	3.518	0.061	3.256	0.035	6.170	0.017	426.5
Case 2	3.518	0.061	3.256	0.035	6.170	0.017	426.5
Case 3	3.518	0.061	3.256	0.035	6.170	0.017	426.5
Case 4	3.518	0.061	3.256	0.035	6.170	0.017	426.5
Case 5	3.518	0.061	3.256	0.035	6.170	0.017	426.5
Case 6	3.518	0.061	3.256	0.035	6.170	0.017	426.5

Besides, to compare the six cases, Figure 6.4 and Table 6.19 show the results of the yearly environmental assessment for the six cases.

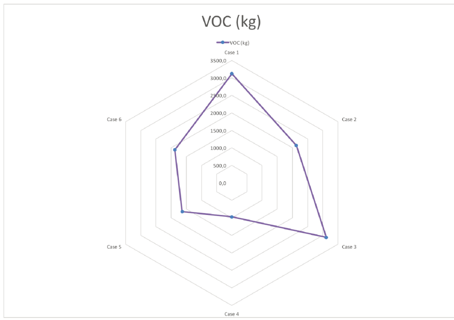
Considering the results of all the environmental indicators, the global warming potential (100 years) that is directly linked with fuel consumption, particulate matter



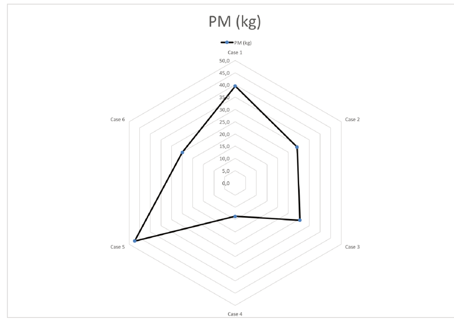
(a) CO(kg)



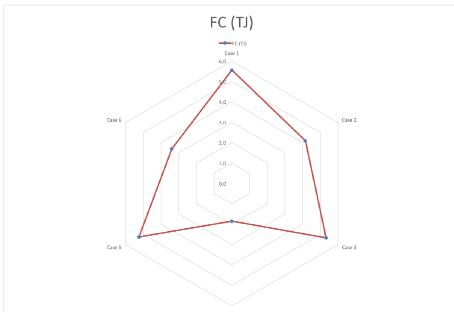
(b) Nox(kg)



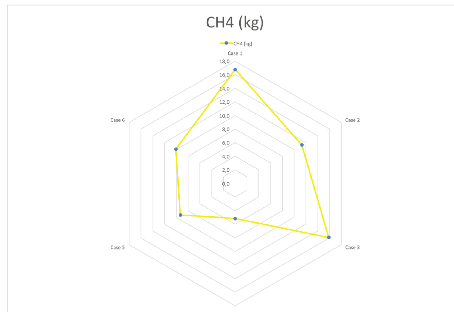
(c) VOC(kg)



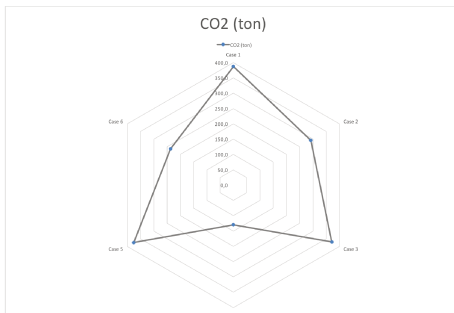
(d) PM(kg)



(e) FC(TJ)



(f) CH4(kg)



(g) CO2(ton)

Figure 6.4: Environmental assessment

Table 6.19: Yearly environmental evaluation for the transport between producers and the SC

Case	CO (kg)	Nox(kg)	VOC (kg)	PM (kg)	FC (TJ)	CH4 (kg)	CO2 (ton)
Case 1	2102.8	349.1	3119.7	39.5	5.6	16.7	387.2
Case 2	1555.0	333.6	2131.6	29.2	4.2	11.3	291.9
Case 3	2284.8	308.8	3117.0	30.5	5.3	15.9	371.2
Case 4	730.4	154.6	971.5	13.7	1.9	5.2	129.7
Case 5	1428.3	832.3	1637.6	47.5	5.2	9.3	375.5
Case 6	1312.3	248.5	1880.9	24.9	3.4	10.1	236.6

emissions at exhaust (PM), NOX emissions, Volatile Organic compounds that contribute to Photochemical oxidant emissions, the Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg shows fewer impacts than the others five cases.

Comparing the case 4 with the other cases, the emission savings are between in PM (45% and 71 %), FC (45% and 65%), CO2 (45% and 67%), NOX (38% and 81%) and for VOC (41% and 69%). This can be explained by the fact of using only two FH which means less vehicles and less distance travelled.

Regarding the cases where the same number of FH are used, the Case 2 based on geographical proximity allocation shows the fewer environmental impacts. Compared with the other cases, the emission savings are respectively in PM (4% and 26 %), FC (22% and 25%), CO2 (21% and 25%), and for VOC (32%). Nevertheless, for Nox the Case 3 based on mathematical modelling allocation with a producer's capacity of 21kg shows fewer impacts, compared with other cases, the savings is between (38% and 81%). This last one, can be explained by the fact of having a greater Nox (g/km) in the environmental evaluation for the transport between FH and CK.

In conclusion, environmental impacts are related to both distances travelled and average speeds. Since unitary emission factors of COPERT are strongly dependent on speeds, a small speed variation can result on non negligible gaps at unitary level, so even if distances are close, the use of different speeds and the use of fewer FH has a higher sensitivity in the environmental impact estimation. When proposing deployment impacts assessment, the definition of the most suitable speeds for assessing the cases seems to be crucial and needs to be analysed in depth.

6.5 Conclusions

This chapter proposed a methodology to assess economic and environmental impacts of city food logistics systems, and applied it to different distribution schemes for the school canteens supply in Lyon and Saint-Etienne (France) to address its application issues.

The proposed methodology is divided into four steps: the definition of a set of indicators; a relevance analysis; the indicators selection and calculation; and finally the scenarios assessment in terms of economic and environmental impacts.

To illustrate this methodology, the six different cases described in the previous chapter are assessed. Concerning the scenario assessment, the fact of modelling short food circuit distribution from independent or grouped producers (FH) and defining suitable transport schemes, impacts not only the system efficiency but also the economic and environmental performances.

This work contributes to the debate on urban food systems and the role of distribution. Preliminary results show that food systems need to consider different variables and settings, and the only food consolidation platforms are not enough to ensure its viability and consequent economic and environmental impacts. The scenario assessment will be a first step on including non-transport impacts mainly related to energy consumption in the food transformation and distribution chain.

In order to identify a policy, practical implications and proposal of actions for the municipality, the proposed systems imply a consequent modification of supply chain and transport practices. The proposed framework does not only quantify them, but addresses the main application issues via a qualitative analysis and a validation via semi-structured interviews. Indeed, those changes affect different stakeholders in the distribution chain, who have different objectives, issues and perspectives.

In that context, the proposed methodology needs to be applied in collaboration with the involved stakeholders, in an interactive way, i.e. making the decision makers part of the assessment process to improve the indicators selection to deal with their aims and goals. For that reason, a particular focus will be made on how the proposed urban food supply systems impact current practices and which are the risks related to their development.

The proposed assessment is dependent on the robustness and accuracy of the different models it uses, as shown in the economic and environmental assessment. Although gaps between the best case analysed which is Case 4 based on mathematical modelling allocation with a producer's capacity of 42kg, and the other five cases analysed are not small regarding distances, times and specially for costs. In fact, this gap in the economic assessment is between between 7% and 30% compared to others cases. Moreover, the sensitivity of the environmental impact assessment model used in COPERT, make the estimation of the average speeds as an important point to focus on.

A further direction of the research would be that of establishing average travelling profiles or defining a typology of roads and behaviours to have a higher detail of the different parts of a route (and the resulting speeds for each part).

Finally, the proposed methodology presents other limits considering the representativeness and suitability of the proposed indicators. Nowadays, there are not unified and standard databases to quantify food transport flows (only some general surveys on goods transport are available, but they are based on non-perishable goods transport mainly packaged in parcels and pallets). Moreover, canteen distribution data are issued in France mainly from private companies, which imply confidentiality issues and the need of reconstructing part of those data. For those reasons, a further work would analyse the relevance of different indicators for the different involved stakeholders in urban food distribution including all components mentioned above. Furthermore, concerning the environmental impact assessment, if various technological transport solutions should be compared in the assessment (e.g. oil vehicles against natural gases or electric vehicles) a Life Cycle Analysis (LCA) based assessment should be considered (see Andriankaja et al. (2015); François et al. (2017)).

Chapter 7

Framework generalisation

Contents

The work presented in this chapter has been presented in the VREF 2018 Conference (Palacios-Argüello et al., 2018d). This work was mainly conducted during the ANNONA project that was financed by the French National Agency for Research (ANR), and during the ELUD project that was financed by l'Université de Lyon and the ANR via the labex IMU (Intelligences des Mondes Urbains). The research mobility in Sweden was supported by the Bernard Sutter Grant from Grands Écoles Paris. The clustering work described in this chapter had been performed with the collaboration of A.Regal from Universidad del Pacífico, Peru.

As already showed in previous chapters, the proposed framework must involve different elements in the study to analyse how eco-responsible demand impacts the urban food distribution schemes aiming to better understand how the school canteen distribution configuration decisions could have environmental and economical impacts.

Indeed, analysing it as an overall problem, even if it is complex and difficult to address, it is necessary to consider all the steps in one framework and not, as shows the literature analysing only from the point of view of the food demand or from the food supply to assess the food distribution system. In other words, by applying a generalisable framework, it will help: (i) to provide a holistic view considering a combined approach for food demand and food supply; (ii) to have a food distribution system characterization and assessment more accurate.

With this aim, this chapter explains the framework for modelling urban food distribution schemes divided into four stages: (i) Logistic decisions to consider. (ii) Food system characterization. (iii) Scenario construction. (iv) Scenario assessment. Then, a case of study on a Swedish institutional catering will be presented to validate the generalisation of the proposed framework. The generalisation analysis addresses generalisation issues and managerial implications.

7.1 A general framework for analysing and planning food distribution systems considering economic and environmental impacts

From the findings and assessments presented in previous chapters, a general framework is proposed. This framework integrates: (i) a combined demand and supply approach by proposing a scenarios construction framework based on the definition and characterization of an initial situation, (ii) the analysis of a set of scenarios to be tested, and, (iii) the tests and feedbacks from the experts to validate scenarios and possible choices. Finally, a scenario assessment framework is proposed by including an analysis of how the modelling of urban food distribution schemes may allow to estimate indicators to represent the impacts generated. This includes, time, distance, economic and environmental impacts for the different food distribution schemes configuration proposed. Figure 7.1 depicts the proposed framework.

It is necessary to clarify that the first two steps of the framework are used to characterize the current food distribution system and from the third step it is considered new distribution network configuration to propose the scenario construction and assessment for the new food distribution schemes proposed. By considering the findings explained before, the following steps are considered in the general framework for analysing and planning food distribution systems considering economic and environmental impacts:

1. Distribution decisions identification: It involves the different logistic decision to be considered at (S) strategic network design (long-term), at (T) tactical network planning (mid-term), and at (O) operational transportation planning (short-term).

2. Characterization: It aims to characterize the food system by explaining the network description, food demand and food supply.

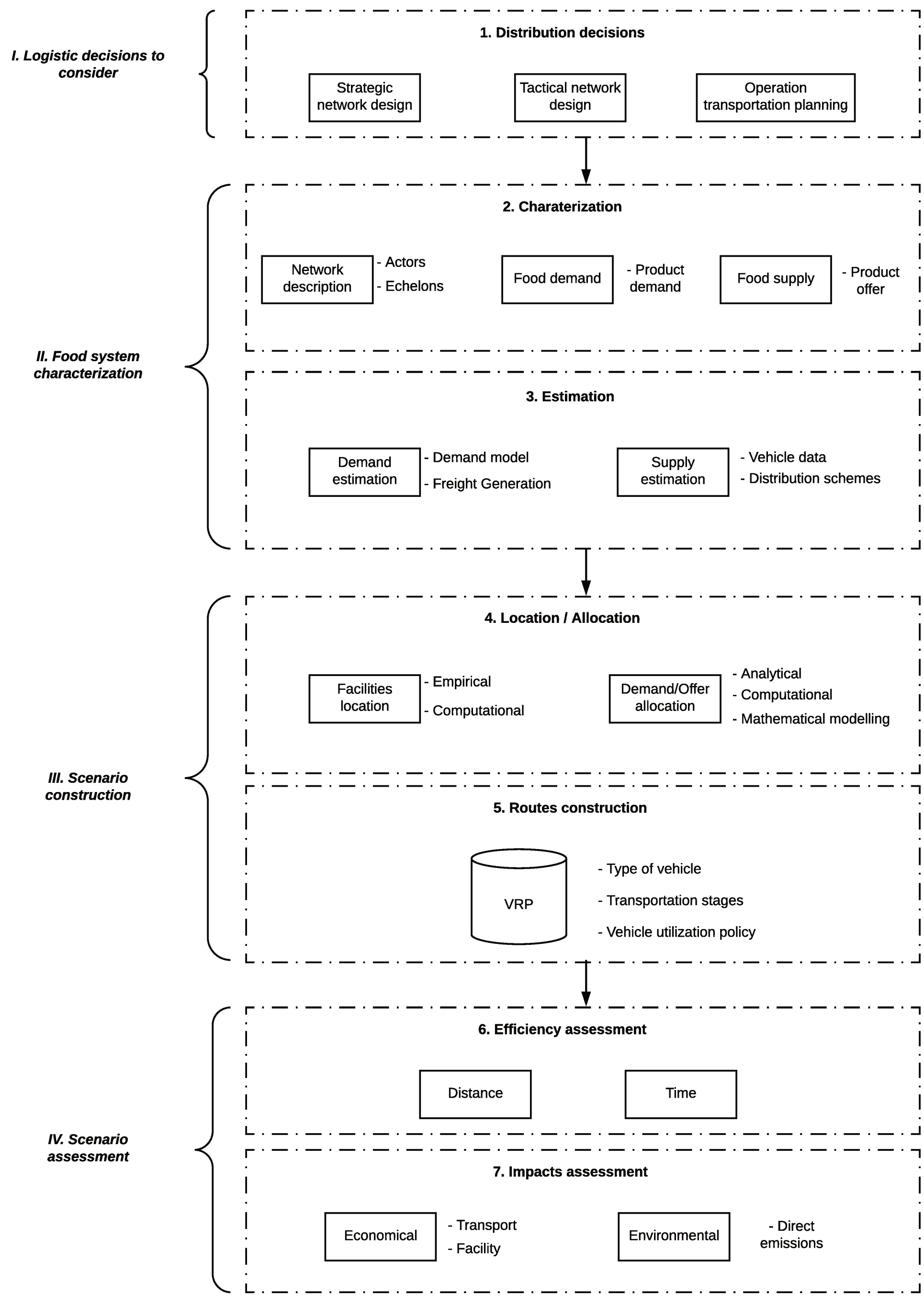


Figure 7.1: General framework for analysing and planning sustainable food distribution systems

(a) Network description: It aims to define the number of actors and echelons of the food distribution system, as well as their main interactions.

(b) Food demand: It aims to define the characteristics and requirements that may influence the demand, for both product and transport.

(c) Food supply: It aims to define the characteristics of the current product offer by defining the suppliers and product logistic supply characteristics.

3. Estimation: It aims to estimate the demand and supply at each echelon considered in the food distribution system.

   (a) Demand estimation: Define how the demand can be estimated by defining the weight of food in kilograms requested at each echelon and how much freight is generated and where.

   (b) Supply estimation: Define the supply estimation based on vehicle data used and distribution schemes adopted.

4. Location and allocation: It aims to allocate the demand/offer to a specific facility at each echelon considered.

   (a) Facilities location: Once the demand and offer are estimated, the number and location of each facility at each echelon must be established. With this aim, two different methods are proposed: (i) Empirical, using the current facilities described through the data collected. (ii) Computational, using clusters to integrate logistic networks of echelons by proposing new or existing facilities' location. For this, two algorithms are used, the Affinity Propagation and K-means.

   (b) Demand/offer allocation to facilities: Once the number and location of facilities are defined, the demand/offer allocation is defined. For this, two methods may be used: (i) analytical allocation, using the current system description. (ii) mathematical modelling, proposing a linear programming model that allows assigning the freight to each echelon considering the distance and demand at each echelon aiming to minimize the total logistic cost.

5. Routes construction: Once the demand and offer allocation are made, tactical planning issues, mainly route construction issues, can be done. The distribution schemes will be characterized by: (i) a hierarchical structure such as the number of transport stages and a load redistribution, (ii) the vehicles used in each transport, and (iii) the vehicle utilization policy such as full truckload (FTL) or a less than truckload (LTL) policy.

6. Efficiency assessment: Regarding the previous logistic decisions considered, the efficiency assessment will be defined in terms of distance and time.

7. Impacts assessment: Considering the efficiency evaluation results, the impacts assessment will be estimated in terms of economic and environmental issues.

    (a) Economical: The economic evaluation considers indicators related to the transport and to the facility.

    (b) Environmental: The environmental evaluation considers only direct emissions related to the transport.

Moreover, the proposed framework introduces a set of hypotheses, representation patterns and primary data (mainly for economic and environmental assessment) to simulate and then, assess scenarios of urban food distribution. The modular structure and the use of standard and transferable models allow to generate easily several potential scenarios and to compare each scenario with others considering economic, environmental and social issues. Nevertheless, the social issues are not considered in this thesis but could be added in a further development. Finally, it is necessary to mention that this framework is independent of the methods used (that can be different to those that were mentioned). To do this, requirements and data needs must allow the coherence of the assessment and the interoperability of the used methods.

7.2 Case of application results and generalisation

Aiming to generalise the framework, it is proposed a Swedish school canteen system case study to analyse the framework limits. This case study was possible thanks to a mobility with Chalmers University and Technology that took place from April to July of 2017.

For the case study construction, data collection includes primary and secondary data, combining both qualitative and quantitative data. A literature review allowed defining the specification of school canteen system in urban food distribution in Sweden. Then, a documentary analysis is made to describe the case and the context, with both scientific and technical/legislation documents.

To characterize the demand and supply chain structure, secondary data is complemented with primary data collected through semi-structured interviews with the Swedish stakeholders of the school canteens. The first exploratory data collection was made through a visit of the Municipality facility in Sweden. Three semi-structured interviews were done with the stakeholders of the school canteen system. The interview guide is available in Appendix .7.

The research focused on stakeholders of the school canteen distribution system. Each stakeholder was contacted by e-mail that included the purpose of the study, a description of the research area (food school canteen distribution), and an invitation to be interviewed. They were informed about the aim of the study and the structure of the case studies. In total, three semi-structured interviews were conducted (see Table 7.1). They lasted about 60 min and were primarily carried out in English. Moreover, during the semi-structured interviews, the school meal historical demand statistics was obtained as a data input for demand estimation.

Table 7.1: Information about interviewees for Kungsbacka municipality case

Stakeholder	**Position of the interviewee(s)**	**Date of the first interview**
Public authority	Regional Manager of logistic at Kungsbacka Municipality	18/05/2017
Public authority	Manager of school canteen at Kungsbacka Municipality	18/05/2017
Receiver	Manager of central kitchen	19/05/2017

General description and decisions identification

The geographical scope of the study focuses in an urban area of Kungsbacka. It is a municipality in Halland County on the Swedish west coast, some 30 km south of Gothenburg (as shows Figure 7.2). There are 22 urban areas in Kungsbacka Municipality. It has around 80 400 inhabitants.

Figure 7.2: Kunsbacka municipality location. Map taken from Google Maps

In this scope, there are 89 school canteens that supply meals to students from primary, middle and high public schools. These school canteens supply over 15.000 meals per day. Meals supply is managed directly by the municipality (non-outsourced). The school canteens are opened five days per week and are only closed four weeks per year. All the meals are served in self-service regardless of the level of school.

Considering the strategic network design, the municipality may apply two different distribution strategies for food supply linked the urban consolidation centre (UCC) managed by the municipality with the central kitchens (CK) and the school canteens (SC). The one that is going from the UCC to the CK and SC is managed by the municipality using own heavy vehicles. The other one that is going from the CK to SC is outsourced using light vehicles.

Besides, the tactical network planning proposed for the route construction, considers the different type of cook, the vehicles capacity and technology.

Characterization

Network description

Considering the downstream distribution system from the Urban consolidation to the school canteens, there are three main echelons, without considering the first echelon of raw materials production:

- UCC: Since October 2016, Kungsbacka uses an Urban Consolidation Centre (UCC) to centralize all the food purchased.
- Central kitchens: The central kitchen makes the main food transformation (cooking) and the satellite school canteens mix and heat the food. This system has 10 central kitchens that have a maximal production capacity of 4000 meals per day. The central kitchens received all the food coming from the UCC and then, one part of these meals are consumed there and the other meals are distributed to the school canteens located at different points in the city where the food is heated and served. This facility is managed by the municipality.
- School canteen: This is the place where the meals are delivered and consumed by the consumers.

Food demand

Kunsbacka Municipality set targets for 25% organic food. Therefore, they choose food that is produced with respect for the environment. The food is usually served "self-service" style, so the children take the food themselves. The meals are free of charge. Foods are served from the kitchen, and water and milk from taps/dispensers. No cartons or pre-packaged food is served. The vegetables, whether cooked or as part of the salad, are most often fresh, sometimes frozen but rarely from tins. From the interviews, some characteristics of the food demand are listed bellow:

- 80% of the students eat at the school canteen.
- Every responsible of the school canteen managed the number of the students who will eat at the school canteen.
- Only the students with allergies must inform if they are not coming to the school canteen.

- The food forecast is managed thought an information system (input: number of students + menu; output : kg raw materials).
- To reduce food waste, there are cooking classes to incentive the student to propose menus.
- For the demand forecast, it is considered that there are less demand if the menu has fish.
- The municipality build the menus for the entire year.

Food supply

There are two types of food flows in the system (see Figure 7.3):

- Cold: The food is going directly from the UCC to CK and from UCC to the school canteen.
- Hot: The food is going from the central kitchen to the school canteens.

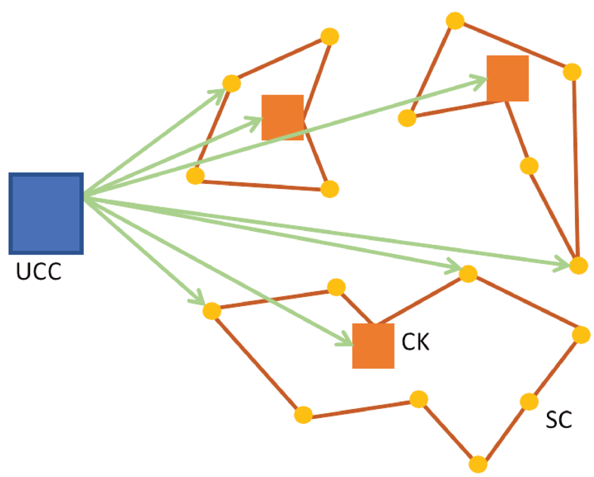


Figure 7.3: Hot and cold cook: Kungsbacka School Canteen Distribution System. UCC: Urban Consolidation Centre CK: Central Kitchens. SC: School Canteens. (Green line) Cold cook. (Orange line) Hot cook.

Considering the vehicle data and the previous distribution scheme adopted:

- Cold: The food distribution from the UCC to the central kitchens and from the UCC to the school canteens is performed by own Heavy Commercial Vehicles (14t).
- Hot: The meals distribution from the central kitchens to the school canteens is performed by outsourced Light Commercial Vehicles (3.5t) Euro 4.

Demand and offer estimation

Demand estimation

Demand model

To estimate the demand for Kungsbacka school canteen system, it is necessary to consider the type of products flows, the hot and cold cook.

For the cold cook, from the municipality data, the food delivered during one month is detailed from the UCC to the central kitchens and from the UCC to the school canteens. Then, the total demand for cold kitchen is: 17450kg per day.

For the hot cook, considering the number of students registered in one school ($N^{s}_{students}$) and taking into account that the 80% of the students registered eat at the school canteen (K), the demand of hot cook per central kitchen has been following the demand model proposed at subsection 5.3. Then, the total demand for hot kitchen is: 6313.5 kg per day.

Freight generation model

Considering the amount of freight generated in the food system based on the historical data provided by the municipality, a freight generation model is proposed. Urban freight demand modelling starts by identifying the quantity of freight that is produced and/or attracted by each echelon in the distribution system measured by tonnage or volume (e.g. m3) (Gonzalez-Feliu and Sánchez-Díaz, 2019). According to (Holguín-Veras and Sánchez-Díaz, 2016; Holguín-Veras et al., 2016), the fact of analysing the freight demand management (FDM) could improve the sustainable performance of urban freight systems. With this aim, the data to be collected include: origin and destination of the trip, the characteristics of the commodities being transported, characteristics of the vehicle used for the distribution, amount of demand requested by customer, among others (Gonzalez-Calderon et al., 2018).

With the aim of understanding economic interactions and the demand for goods movement in the institutional catering in Sweden, the primary data collected issued from Kungsbacka municipality. The freight data collection effort aims to characterize the freight activity in the three stages of the school canteen urban food distribution system. The key data collected includes: (i) origin and destination of the freight; (ii) commodities being transported (weight), (iii) vehicle type used (capacity), and (iv) number of students registered per school canteen and number of school canteen allocated to each central kitchen.

The freight generation model developed in this chapter is divided into three steps: (i) data processing and model construction preparation, (ii) assessment and comparison between models, and (iii) Root mean square error (RMSE) estimation of the model selected. The freight generation model is related to the monthly quantities (and frequencies) and the number of students/meals concerned.

A freight generation model is estimated as follows:

$$F^c_{sc} = f^c(St_{sc}; Meals_{sc}) \tag{7.1}$$

Where St_{sc} is the number of students registered at the school canteen (sc) and $Meals_{sc}$ is the number of meals of the school canteen (sc). The function f^c can be linear, potential or algorithmic, although constant-based model can be defined. In all these cases, to define which model is most suitable, the models need to be calibrated and compared to the data collected via MAPE or RMSE error measures.

(i) Data processing and model construction preparation:
The following tables shows the descriptive statistics to make a first description of sample size and dispersion. Table 7.2 shows the descriptive statistics for the central kitchens and Table 7.3 for the school canteen.

Table 7.2: Descriptive statistics for the central kitchens data collected

	Kg delivered / establishment	**Nb students registered at central kitchen**	**Deliveries frequency / month**
Average	13959.8	1724	13
Standard error	1291.8	562.79	1.39
Median	12901	1055	13.5
Standard deviation	4085.02	1779.69	4.4
Variance of the sample	16687396.4	3167298.89	19.33
Kurstosis	0.93	-1.24	2.12
Coefficient of asymmetry	1.32	0.78	1.24
Min	9758	70	9
Q1	11178.5	375	9
Q2	12901	1055	13.5
Q3	15017.5	3133.75	14.75
Max	22511	4440	23
Number of samples	10	10	10
Confidence level (95%)	2922.25	1273.11	3.15

(ii) Assessment and comparison between models:
The results in Table 7.4 and Table 7.5 show the models for each category selected regarding the amount delivered per establishment, the number of central kitchen and school canteens delivered, the parameters for the FG models, the RMSE, and the adjusted coefficient of determination when applicable. As explained in the methodology, the FG models can take two different functional forms: (i) a constant per establishment, (ii) a constant per establishment and a coefficient for the number of students.

Table 7.3: Descriptive statistics for the school canteens data collected

	Kg delivered / establishment	**Nb students registered at school canteens**	**Deliveries frequency / month**
Average	2223.87	196.35	7.05
Standard error	334.12	31.31	0.48
Median	1057.51	80	5
Standard deviation	3080.42	288.64	4.39
Variance of the sample	9488992.23	83314.52	19.28
Kurstosis	9.46	7.8	2.56
Coefficient of asymmetry	2.92	2.67	1.75
Number of samples	85	85	85
Min	253.21	20	2
Q1	637.84	40	4
Q2	1057.51	80	5
Q3	2336.97	220	9
Max	17238.22	1500	23
Confidence level (95%)	664.43	62.26	0.95

Table 7.4: FG model for central kitchens

Kg delivered / Central Kitchen					
a	**b**	**RMSE**	**RMSE Type**	R^2	**MAPE**
		3875.39	Average	n.a	22.00%
		4017.43	Mean	n.a	17.30%
2	10572.74	2003.96	Y = a(x) + b	0.7	11.60%
5.1		7664.2	Y = a(x)	0.61	54.60%
4820.23	123.15	2600.5	Y = a ln(x) + b	0.49	15.60%
4779.77		2600.62	Y = a ln(x)	0.86	15.60%
0.14	3.72	14426.57	ln(Y) = a ln (x) + b	0.54	99.50%
1.36		14408.04	ln(Y) = a ln (x)	0.86	99.50%

In terms of the fit of the models, the adjusted R^2 varies between -3 and 0.73, and two of them have an adjusted R^2 of 0.55, which reveals a high variability in the results across groups and an appropriate accuracy in most of the models.

Table 7.5: FG model for school canteens

Kg delivered / School Canteen					
a	**b**	**RMSE**	**RMSE Type**	R^2	**MAPE**
		3062.25	Average	n.a	170.03%
		3276.85	Mean	n.a	64.63%
10.27	207.53	833.69	Y = a(x) + b	0.92	26.80%
10.61		851.10	Y = a(x)	0.94	27.12%
5643.64	-9064.20	1652.23	Y = a ln(x) + b	0.71	81.38%
1336.56		2608.37	Y = a ln(x)	0.51	170.11%
0.86	1.39	3761.96	ln(Y) = a ln(x) + b	0.90	97.97%
1.52		3749.09	ln(Y) = a ln(x)	0.98	98.26%

In terms of the fit of the models, the adjusted R^2 varies between 0.51 and 0.98, with most of them having an adjusted R^2 higher than 0.9, which reveals a variability in the results across groups and an appropriate accuracy in most of the models.

(iii) Root mean square error (RMSE) estimation of the model selected:

Likewise, considering that the Pearson correlation coefficient measures the strength of the linear relationship between normally distributed variables, and it is the most widely used, Table 7.6 shows the Pearson correlation results for central kitchen and Table 7.7 shows the results for school canteens. Nevertheless, when the variables are not normally distributed or the relationship between the variables is not linear, it may be more appropriate to use the Spearman rank correlation method. Spearman correlation results are also presented for the same set of data.

Table 7.6: Pearson and spearman correlation results for Central kitchens

	Pearson	**Spearman**
Kg delivered per CK vs students registered	0.856	0.976
Kg delivered per CK vs delivery frequency	0.666	0.885

Analysing the Spearman and Pearson, the first one is larger than the other one but remains similar in terms of students registered. Nevertheless, it can be affirmed that the delivery frequency is a variable difficult to explain with the data obtained. Considering the results in MAPE and RMSE smaller, the model selected is the linear for both cases.

Table 7.7: Pearson and spearman correlation results for School canteens

	Pearson	**Spearman**
Kg delivered per SC vs students registered	0.962	0.998
Kg delivered per SC vs delivery frequency	0.743	0.997

Moreover, the results in Table 7.8 show the models for each category selected regarding the amount delivered per establishment, the parameters for the FG models, the RMSE, and the adjusted coefficient of determination when applicable.

Table 7.8: Selected freight generation models

Establishment	**a**	**b**	**RMSE**	**RMSE Type**	R^2
CK	2	10572.74	2003.96	Y = a(x) + b	0.70
SC	10.27	207.53	833.69	Y = a(x) + b	0.92

Indeed, the resulting models estimated a freight quantity generated for a given period of time. Moreover, knowing the supply settings (suitable vehicle types, platform location, etc.), it is possible, with the methods presented in Chapter 5, to assess a set of routes.

Supply estimation

The total daily offer per central kitchen is estimated considering the cooking capacity per facility. According to the semi-structured interviews with the municipality:

- The school canteen system produces 15000 meals/day.
- Each CK is able to produce maximal 4000 meals/day.

Then, every CK should be available to deliver at least 632kg per day considering 10 CK. Nevertheless, when it is considered fewer CK, each CK should be available to deliver at least the total demand divided into the number of CK considered.

Facilities location

CK empirical location

It can be defined from primary and secondary data collected that details the current location of 10 central kitchens (CK) (see Figure 7.4). The data collected includes the geographical position of each echelon considered.

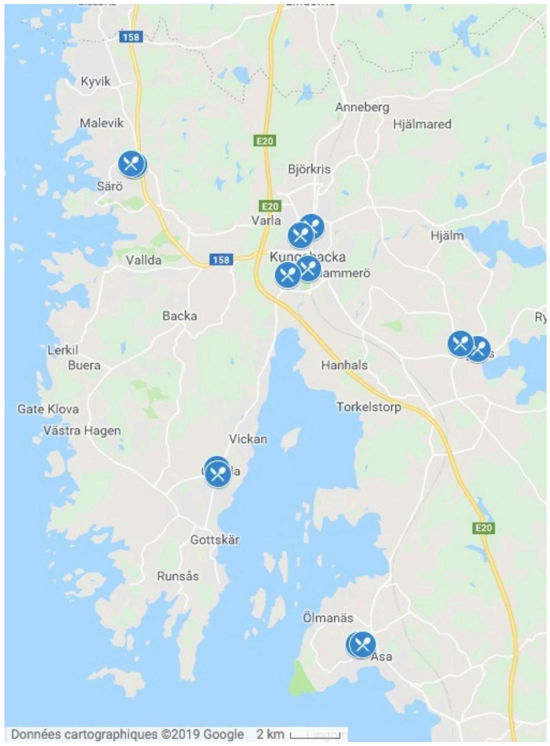


Figure 7.4: Current location of the 10 Central Kitchens. The mapping of CK is performed in Google My Maps.

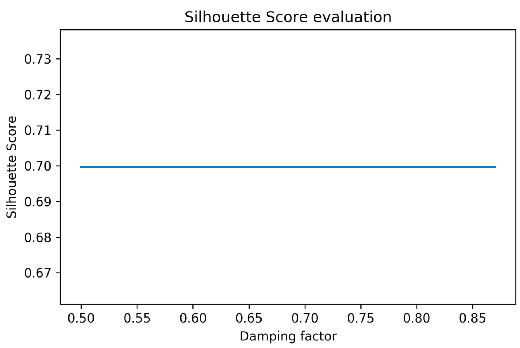
CK computational location

With the aim of integrating logistics networks for CK, the computational clusters building for CK can be analysed as an efficiency strategy for food collection, cooking and supply in the institutional catering. This strategy links the available school canteens with the current CK, enabling the food distribution collaboration by selecting a set of school canteens that will represent the school canteens that belong to one cluster, reducing the food collection and distribution complexity.

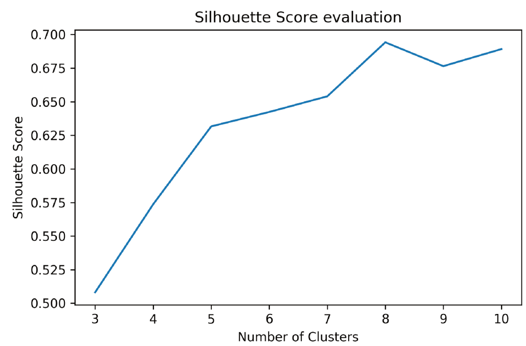
With this in mind, the clusters are used to partition the school canteens to evaluate route constructions in terms of time/distance differences between optimal vehicle routing solutions and possible re-locations of representative school canteens and CK. For this purpose, it was used the methodology for CK computational location using two types of clustering explained in subsection 5.3.

The algorithm used to cluster the school canteens for the first experiment is the Affinity Propagation proposed by Frey and Dueck (2007). The objective is to find the most representative school canteens within each cluster (the centroids). The algorithm used to cluster the school canteens for the second experiment is k-means proposed by (Lloyd, 1982). This algorithm is used to arrange the school canteens into k clusters, where the centroids are used as proposed CK in a vehicle routing problem.

Both experiments were evaluated with the same procedure. Different values of k (3-10) and λ (0.50 - 0.99) were tested to obtain the highest silhouette score. In Figure 7.5, the Silhouette values when testing values of k and λ are presented. There are two main takeaways from this. First, the partition when varying λ values does not vary in number of clusters (7) nor does it vary in silhouette scoring (0.7). The second insight is the optimal value of k to partition the central kitchens. The highest score is obtained by $k = 8$, where possible alternatives are $k = 9$ or $k = 7$. Even so, the total number of central kitchens is already 10, so having such a similar number of centroids may not reflect a significant difference in the VRP solution.



(a) Affinity Propagation Silhouette Score Evaluation



(b) K-means Silhouette Score Evaluation

Figure 7.5: Silhouette Score Evaluation for K-means and Affinity Propagation

Figure 7.6 shows the 8 clusters using k-means and 4 clusters using affinity propagation obtained for the 89 school canteens.

Summarising the findings about the CK's location based on two different methods (empirical and computational location), it is possible to compare the current CK's location and use with eight new locations for the CK and the use of only four over the ten CK that are currently used.

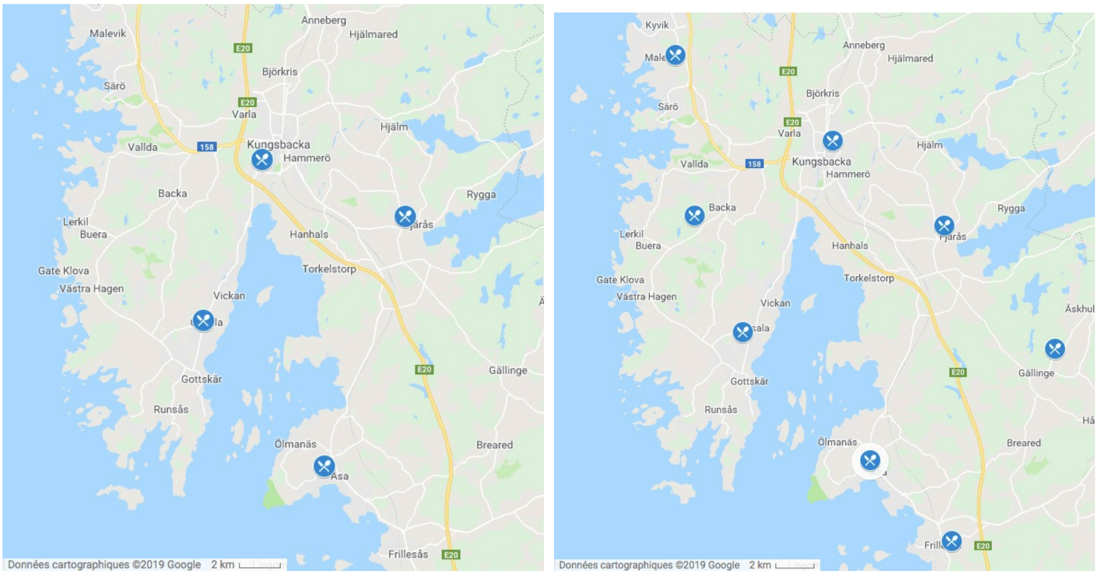
Demand and offer allocation to the facilities

Demand and offer analytical allocation

From the municipality data collected, the demand allocation is performed according to the current system considering the number of students registered per school canteen. Table 7.9 shows the number of school canteens allocated to each central kitchen.

Demand and offer mathematical modelling allocation

Following the model explained in subsection 5.3, the allocation model was constructed and adapted considering only two echelons: CK and SC.



(a) CK using Affinity Propagation (b) FH using K-means

Figure 7.6: CK clusters computational location. The mapping of CK is performed in Google My Maps.

A model that allows assigning the freight to each echelon is proposed to know which for each central kitchen (i) and for each school canteens (j). To do that, a graph with two types of nodes is defined:

- Set V_s includes school canteens (SC).
- Set V_{ck} includes the central kitchens (CK).

For the model deployment, the index values must be calculated from the previous data obtained and detailed in Table 5.2.

The parameters proposed for the model are defined as follows:

- Q_j Demand at school canteen (j) in cases.
- $C1_{i,j}$ is the transport cost in thousands of euros from CK to SC per case;
- $Cv1_{i,j}$ Fixed cost in thousands of euros per truck from CK to SC in cases;

The decision variables defined are:

- $Q1_{i,j}$ shipment quantities from CK to SC in cases;
- $T1_{i,j}$ Number of trucks from CK to SC in cases;

Table 7.9: Current demand allocation

CK	Number of school canteens	Demand allocated (kg)
CK1	5	504.3
CK2	17	877.2
CK3	18	1018.1
CK4	3	509.4
CK5	21	711.0
CK6	3	583.7
CK7	1	441.3
CK8	4	583.3
CK9	7	583.6
CK10	10	501.5
Total	***89***	***6313.5***

Finally, the linear programming model to optimize is:

$$\min \sum_{i\ \in V_{ck}; j \in V_{sc}} (C_{1_{i,j}} \times Q_{1_{i,j}}) + \sum_{i\ \in V_{ck}; j \in V_{sc}} (Cv_{1_{i,j}} \times T_{1_{i,j}}) \tag{7.2}$$

Subject to:

$$CapP \leq \sum_{j \in V_s} Q_{1_{i,j}} \forall i \in V_{ck} \tag{7.3}$$

$$\sum_{i \in V_{ck}} Q_{1_{i,j}} = \leq Q_j \forall k \in V_{ck} \tag{7.4}$$

$$T_{1_{i,j}} \leq \frac{Q_{1_{i,j}}}{Tcap_1}; i \in V_{ck}; j \in V_{sc} \tag{7.5}$$

$$Q_{1_{i,j \in real}}; T_{1_{i,j}} \in int \tag{7.6}$$

The objective function to minimize is the total logistic cost that includes handling cost at producers platforms $C_{1_{i,j}}$; and transport cost $Cv_{1_{i,j}}$.

Considering the assumption of a mono-commodity for demand constraints, the constraint (7.3) fixes the central kitchen capacity $CapP$ as the supply limit at central kitchen (i) in order to estimate the demand allocated to each CK. The constraint (7.4) establishes the demand allocated to each CK to satisfy demand at SC (j).

Constraint (7.5) limits the number of trucks between from CK to SC and establish that the shipment quantity from CK to SC $Q_{1_{i,j}}$ cannot exceed the vehicle capacity.

Taking into account the linear programming problem (LP) presented above, its complexity is of order O^3 and can be solved using a commercial tool. For this research, GAMMS software with simplex algorithm is used.

Table 7.10 details the school canteens allocation to each CK using the mathematical modelling.

Table 7.10: School canteens allocation to each CK using the mathematical modelling

CK	Number of school canteens	Demand allocated (kg)
CK1	9	632.0
CK2	6	632.0
CK3	7	629.0
CK4	15	632.0
CK5	17	632.2
CK6	9	625.5
CK7	4	632.0
CK8	13	632.0
CK9	7	632.0
CK10	11	632.0
Total	***89***	***6313.5***

It is noted that some CK share some SC. CK1 and CK7 share one SC, CK4 and CK6 share one SC, CK3 and CK5 share one SC, CK6 and CK10 share one SC, CK1 CK2 CK4 and CK8 share one SC, CK3 and CK8 share one SC, CK4 and CK9 share one SC. This means that there are seven SC that are delivered by more than one CK.

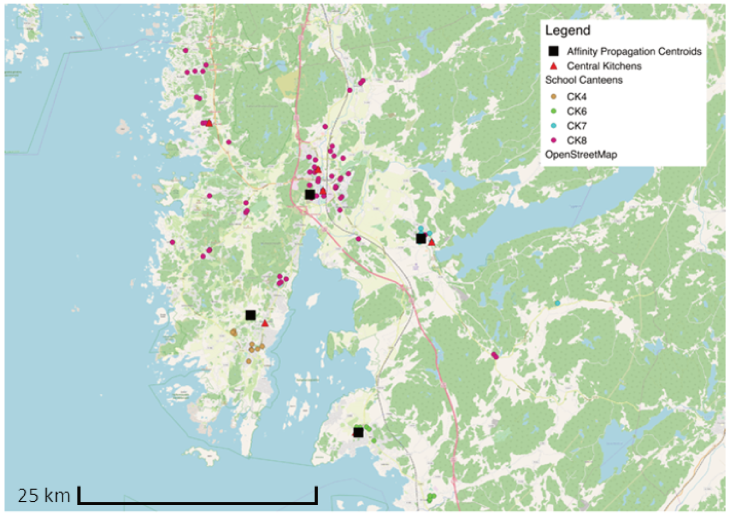
Demand and offer computational allocation

Regarding the computational allocation, Figure 7.7 shows the 89 school canteens divided into the 4 clusters obtained with Affinity propagation and 3 clusters obtained with K-means.

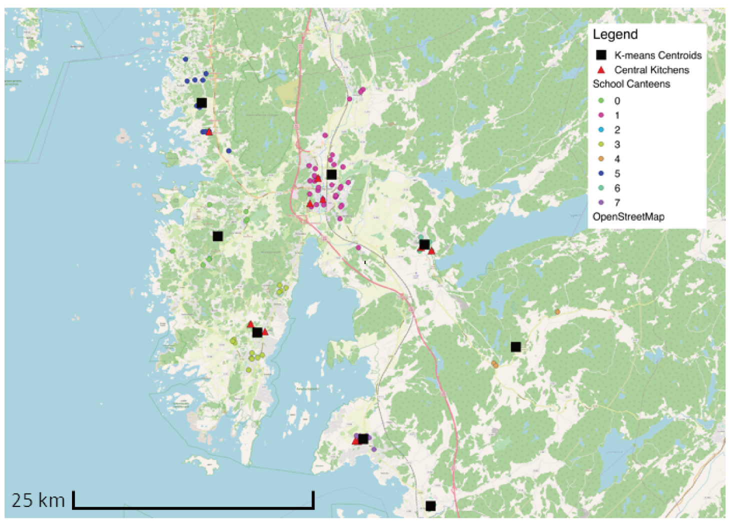
Table 7.11 details the school canteens allocation to each CK using affinity propagation.

Table 7.12 details the school canteens allocation to each CK using K-means clustering.

Summarising the findings about the demand and offer allocation based on three different methods (analytical, computational and mathematical allocation), it is possible to analyse how to allocate the demand and offer to an specific Central kitchen (CK) based on the demand of each schools canteen, the meal's production capacity of each central kitchen, and the distance between the central kitchens and the school canteens. It is noticed that the proportion of the demand allocated to each central kitchen varies according



(a) CK using Affinity Propagation



(b) CK using K-means

Figure 7.7: CK clusters computational location. The mapping of CK is performed in Open Street Maps.

the method used. The mathematical modelling shows the most proportional allocation of demand for each CK that is around 630kg per day. Nevertheless, the computational allocation using both clustering methods shows a disproportional allocation that varies between less than 10 schools canteen allocated to 60 schools canteen allocated to one central kitchen.

Table 7.11: Computational allocation using Affinity propagation

CK	**Number of school canteens**	**Demand allocated (kg)**
CK4	10	1093.0
CK6	13	1085.3
CK7	6	945.6
CK8	60	3189.6
Total	***89***	***6313.5***

Table 7.12: Computational allocation using K-means

CK	**Number of school canteens**	**Demand allocated (kg)**
CK1	6	998.6
CK2	3	96.2
CK3	34	2298.2
CK4	11	455.3
CK5	14	1199.0
CK6	8	181.0
CK7	5	374.2
CK8	8	711.1
Total	***89***	***6313.5***

Routes construction

Following the logistic decisions flow, the routes construction and impacts estimation will be presented through four different cases aiming to compare the allocation method used in each case.The cases are proposed as follows using the same demand estimation method.

- *Case 1 Based on current system*: Working with the current CK capacity, using the current CK location and using analytical allocation method considering the data obtained from the municipality.
- *Case 2 Based on mathematical modelling allocation method*: Working with a fixed CK capacity, using the current CK location and using mathematical modelling allocation method.
- *Case 3 Based on computational allocation using Affinity propagation clustering* : Working with the current CK capacity, using the 4CK locations proposed by Affinity clustering algorithm and using computational allocation method.
- *Case 4 Based on computational allocation using K-means clustering*: Working

with the current CK capacity, using the 8CK new locations proposed by K-means clustering algorithm and using computational allocation method.

Assessment

By following the methodology for the cases assessment explained in subsection 5.4, the efficiency assessment in terms of distance travelled and time spent will be presented. It is considering the service time presented in subsection 5.3.

Efficiency assessment

Cold cook efficiency assessment

With the aim of comparing the different cases presented before, Table 7.13 shows the VRP results from UCC to CK and to SC considering cold cook for all cases.

Table 7.13: Cold cook efficiency assessment

	Cold cook			
	Number of CK	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	10	3	291.9	20:36
Case 2	10	3	307.4	20:24
Case 3	4	3	286.9	19:42
Case 4	8	3	328.6	21:06

Analysing the cold cook, Case 3 (based on computational allocation using Affinity propagation clustering) shows the best results in terms of distance travelled and the time spent from the UCC to CK and SC. In fact, compared with other cases, it shows that only four central kitchens are necessary. This decision impacts the distance, this gap is about 1.7% with the current system and 12.7% compared to Case 4 (based on computational allocation using K-means clustering) using 8 new CK. Similarly, regarding the difference in terms of time, there is a difference of 4.3% with the current system, 3.3% compared to Case 2 (based on mathematical modelling allocation method) and 6.5% compared to Case 4 (based on computational allocation using K-means clustering). Nevertheless, all cases use the same number of vehicles.

Hot cook efficiency assessment

Table 7.14 shows the VRP results from CK to SC considering hot cook for all cases.

Analysing the hot cook, regarding distance travelled and the time spent from the UCC to CK and SC, Case 3 (based on computational allocation using Affinity propagation clustering) shows also the best results when comparing with others cases. It is the

Table 7.14: Hot cook efficiency assessment

	Hot cook			
	Number of CK	**Number of vehicles (3.5t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	10	3	270.5	17:12
Case 2	10	3	293.7	19:06
Case 3	4	3	224.3	16:18
Case 4	8	3	569.8	22:06

same for the number of central kitchens used, where the fact of using only four impacts on distance gains of 17.1% compared with the current system and 60.6% compared to Case 4 (based on computational allocation using K-means clustering) which uses 8 new CK. Regarding the time gains, compared with the current system, there is a gain 5.2%, compared to Case 2 (based on mathematical modelling allocation method) is 14.7% and compared to Case 4 (based on computational allocation using K-means clustering) is 26.2%. Nevertheless, all cases use the same number of vehicles.

Cold and hot cook efficiency assessment

Table 7.15 shows the VRP results from UCC to SC considering hot and cold cook for all cases.

Table 7.15: Cold and hot cook efficiency assessment

	Cold and hot cook				
	Number of CK	**Number of vehicles (3.5t)**	**Number of vehicles (14t)**	**Total distance (km)**	**Total Time (hh:mm)**
Case 1	10	3	3	562.4	37:48
Case 2	10	3	3	601.1	39:30
Case 3	4	3	3	511.2	38:00
Case 4	8	3	3	898.4	43:12

Lastly, after analysed the cold and the hot cook together from the UCC to CK and SC, Case 3 (based on computational allocation using Affinity propagation clustering) shows the best results in terms of distance travelled and the time spent, this can be explained by the use of only four central kitchens and the use of the same number of vehicles. In terms of gains compared to other cases, Case 3 has gains in:

- Distance travelled: 9.1% compared with the current system; 15% compared case 2 (based on mathematical modelling allocation method) using the same 10CK but with different demand allocated; and, 43.1% compared to Case 4 (based on computational allocation using K-means clustering) using 8 new CK.

- Time spent: 4.7% compared with the current system, 8.8% compared to Case 2 and 16.6% compared to Case 4.

Impacts assessment

By following the methodology for selecting and calculating the impacts assessment indicators explained in section 6.3, the impacts assessment considering economic and environmental issues will be presented.

Economic assessment

The transportation costs were estimated thanks to the primary and secondary information obtained. Considering the same economic indicators defined in subsection 6.4, Table 7.16 shows the indicators considered in the Swedish context.

Table 7.16: Main economic values related to service settings

Cost type	**Cost detail**	**Value**	**Unit**
Vehicle dependent cost	Leasing vehicle 3.5t	1 650	€/month
	Leasing vehicle 14t	3 300	€/month
Time and vehicle dependent cost	Driver cost for vehicle 3.5t	4 100	€/month
	Driver cost for vehicle 14t	4 300	€/month
	Insurance cost for vehicle 3.5t	0.69	€/vehicle/h
	Insurance cost for vehicle 14t	1.48	€/vehicle/h
	Taxes for vehicle 3.5t	0.20	€/vehicle/h
	Taxes for vehicle 14t	0.77	€/vehicle/h
	Working days per year	220	days/year
	Working hours	10	h/day
Distance and vehicle dependent cost	Diesel cost	1.52	€/l
	LNG cost	1.00	€/l
	Vehicle 3.5t consumption	18	l/100km
	Vehicle 14t consumption	68.75	l/100km
	Maintenance and repairs for vehicle 3.5t	0.04	€/vehicle/km
	Maintenance and repairs for for vehicle 14t	0.12	€/vehicle/km
	Tires for each vehicle	0.04	€/vehicle/km

The diesel cost and LNG cost were consulted on a website that provides the data of historical fuel price on Sweden (Dis). The vehicle fuel consumption was directly retrieved from the technical data given by the vehicles manufacturer (Tru). The diesel consumption cost for vehicle 3.5 tons is 0.27€/km and the LNG consumption cost for vehicle 14 tons is 0.69€/km. Then the taxes, insurance, maintenance and tires cost have been retrieved from the official *Trafikverket* website, regarding the Swedish Transport Administration Annual Report of 2017 (Tra).

Besides, the costs linked to the facility are presented in Table 7.17. Moreover, these costs were discussed and established with the key stakeholders of school canteen distribution during the interviews.

Table 7.17: Main economic values related to the facility

Facility type	**Cost detail**	**Value**	**Unit**
Central kitchen	Leasing facility	24.8	€/month per m2
	Human resource	30	% Turnover
	Equipment leasing	2	% Turnover

Then, considering the previous economic indicators, the economic assessment for the Swedish case is presented in the following tables. Taking into account that cold cook has a delivery frequency of 8 days per month, the daily costs related to transport for cold cook are estimated and detailed in Table 7.18 for the four cases.

Table 7.18: Daily cost related to transport of cold cook

		Distance and vehicle dependent cost			**Time and vehicle dependent cost**		
Cases	**Leasing vehicles**	**Diesel consumption**	**Maintenance & repairs**	**Tires**	**Driver cost**	**Insurance**	**Taxes**
Case 1	540.0 €	211.3 €	36.9 €	12.3 €	703.6 €	30.2€	15.7 €
Case 2	540.0 €	211.3 €	36.9 €	12.3 €	703.6 €	30.2€	15.7 €
Case 3	540.0 €	197.2 €	34.4 €	11.5 €	703.6 €	29.2€	15.2 €
Case 4	540.0 €	225.9 €	39.4 €	13.1 €	703.6 €	31.2 €	16.2 €

Indeed, the lowest daily cost related to the transport for cold cook is Case 3 (based on computational allocation using Affinity propagation clustering). Compared with other cases, this case is between 0.4% and 2.4% less expensive. This can be explained by the cost reduction when it is necessary to use only four CK. Besides, comparing the same number of CK needed, Case 1 (based on current system) shows a lower transport cost, being 0.8% less expensive than Case 2 (based on mathematical modelling allocation method).

Taking into account that cold cook has a delivery frequency of 20 days per month, the daily costs related to transport for cold cook are estimated and detailed in Table 7.19 for the four cases.

Considering the transport for hot cook, Case 3 (based on computational allocation using Affinity propagation clustering) shows better results. Aiming to analyse the gains

Table 7.19: Daily cost related to transport of hot cook

Cases	Leasing vehicles	Distance and vehicle dependent cost			Time and vehicle dependent cost		
		Diesel consumption	**Maintenance & repairs**	**Tires**	**Driver cost**	**Insurance**	**Taxes**
Case 1	270.0 €	73.8 €	10.8 €	10.8 €	670.9 €	11.9€	3.4 €
Case 2	270.0 €	80.2 €	11.7 €	11.7 €	670.9 €	13.2 €	3.8 €
Case 3	270.0 €	61.2 €	9.0 €	9.0 €	670.9 €	11.2 €	3.3 €
Case 4	270.0 €	155.6 €	22.8 €	22.8 €	670.9 €	15.2 €	4.4 €

in transport cost, Case 3 represents between 1.6% and 10.9%. The cost reduction can be explained by the fact of using only four CK. Nevertheless, if the analyses focusses on the cases that use the same number of CK (i.e. Case 1 and 2), Case 1 (based on current system) shows a lower transport cost that represents a gain of 0.9%.

Besides, the daily cost related to CK facility are estimated and detailed in Table 7.20 for the four cases.

Table 7.20: Daily cost related to CK facility

Cases	Cost linked to the CK facility			
	Number of CK	**Facility leasing**	**Human resource**	**Equipment leasing cost**
Case 1	10	9 467.2 €	8 590.9 €	163.0 €
Case 2	10	9 467.2 €	8 590.9 €	163.0 €
Case 3	4	3 786.9 €	6 433.2 €	65.2 €
Case 4	8	7 573.7 €	7 517.0 €	130.4 €

Considering the CK facility cost, Case 3 (based on computational allocation using Affinity propagation clustering) shows the lowest cost by using only four CK. In terms of gains, Case 3 is between 32.4% and 43.5% less expensive.

The total cost related to the food distribution system is detailed in Table 7.21 for all the cases.

Table 7.21: Economic evaluation for all cases

Cases	Transport cost	Facility cost	Total daily cost	Total yearly cost
Case 1	2589.1 €	18 221.1 €	20 810.2 €	4 545 591.8 €
Case 2	2611.6 €	18 221.1 €	20 832.8 €	4 548 822.5 €
Case 3	2565.8 €	10 295.3 €	12 861.0 €	2 797 330.7 €
Case 4	2 731.3 €	15 221.2 €	17 952.5 €	3 912 799.4 €

For cold and hot cook, Case 3 (based on computational allocation using Affinity propagation clustering) is the lowest daily transportation cost. It is between 0.9% and 6.1% less expensive.Besides, comparing the cases that uses the same number of CK, Case

2 (based on mathematical modelling allocation method) shows a slightly lower transport cost compared to the Case 1 based on current system (1.8% less expensive).

Moreover, considering the total yearly cost, taking into account that the delivery frequency per month for cold cook is 8 days/ month and for hot cook is 20 days/month, the lowest cost is Case 3. In fact, compared with the other cases, Case 3 is between 28.5% and 38.5% less expensive. This can be explained by the reduced number of CK used for the distribution system that reflects less distance travelled and in consequences fewer transport and facility cost. Comparing the cases with the same number of CK used, Case 1 shows fewer total yearly cost (0.1% less expensive) compared to Case 2.

However, in all cases, the relation between distances travelled and total times on one side and transport costs on the other side, were the same (and are linear for both variables, i.e. distances and times). In that context, the estimation of unitary costs is crucial to ensure a representative assessment. In the current application, unitary costs are estimated using municipality information. It should be needed to extend it by proposing a category of vehicles, platforms and drivers in order to be able to adapt the assessment framework to other contexts.

Environmental assessment

In this work, only direct emissions related to the vehicles utilization for delivery purposes presented in subsection 6.4 are considered for the Swedish case. The vehicles used in this Swedish case were defined during the interviews. Those are:

- Light Commercial Vehicles (3.5 t): Multi-Temperature. Dimensions: 2.5m(l) x 1.9m (w)x 1.95m (h).
- Heavy-Duty Trucks (14 t): Multi-Temperature. Dimensions: 6.8m(l) x 2.5m (w)x 2.46m (h).

For the considered application, the data based extracted from COPERT V is from 2017 regarding Euro 4 for Light vehicles are considered. As COPERT V has not LNG vehicles, according to ADEME (2018), the environmental performance compared between an Iveco euro6 LNG tractor and an Iveco euro6 diesel tractor can be similar. For this reason, the heavy duty truck used for the environmental performance in cold kitchen is Euro 6. The weather conditions considered are detailed in Appendix .8.

For the environmental assessment, the average speed calculated by the VRP Spreadsheet Solver (VRP-SS) using Bing maps for each scenario is showed in Table 7.22.

The emissions factors for the environmental evaluation of the transport for hot cook is detailed in Table 7.23 for the four cases.

The emissions factors for the environmental evaluation of the transport for cold cook is detailed in Table 7.23 for the four cases.

Besides, to compare the four cases, Table 7.25 and Figure 7.8 show the results of the yearly environmental assessment for all cases.

Considering the results of all the environmental evaluation, the global warming potential (100 years) that is directly linked with fuel consumption, particulate matter

Table 7.22: Average speed used for the environmental assessment

Cases	Average speed (km/h) Hot Cook	Cold Cook
Case 1	25.6	27.7
Case 2	22.4	30.5
Case 3	21.7	31.2
Case 4	37.6	31.8

Table 7.23: Emissions factors for the environmental evaluation of the transport for hot cook

Cases	CO (g/km)	Nox (g/km)	VOC (g/km)	PM (g/km)	FC (MJ/km)	CH4 (g/km)	CO2 (g/km)
Case 1	3.994	0.062	3.085	0.034	6.322	0.018	437.9
Case 2	4.244	0.064	3.086	0.034	6.577	0.018	455.9
Case 3	4.305	0.064	3.086	0.034	6.637	0.018	460.2
Case 4	3.153	0.058	3.080	0.032	5.451	0.018	376.2

Table 7.24: Emissions factors for the environmental evaluation of the transport for cold cook

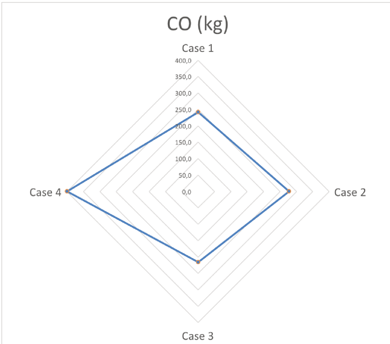
Cases	CO (g/km)	Nox (g/km)	VOC (g/km)	PM (g/km)	FC (MJ/km)	CH4 (g/km)	CO2 (g/km)
Case 1	0.143	0.385	0.030	0.075	8.154	0.002	602.4
Case 2	0.137	0.364	0.029	0.073	7.971	0.002	588.9
Case 3	0.135	0.359	0.028	0.073	7.928	0.002	585.7
Case 4	0.134	0.354	0.028	0.073	7.890	0.002	582.9

Table 7.25: Yearly environmental evaluation for the transport for hot and cold cook

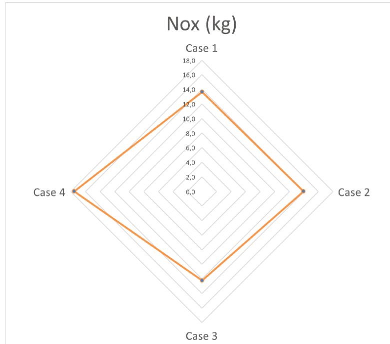
Case	CO (kg)	Nox(kg)	VOC (kg)	PM (kg)	FC (TJ)	CH4 (kg)	CO2 (kg)
Case 1	241.4	13.6	184.3	3.94	0.59	1.16	41532.6
Case 2	277.9	13.9	200.2	4.21	0.64	1.25	45387.7
Case 3	215.8	12.2	153.0	3.55	0.53	0.97	37496.2
Case 4	399.1	17.5	386.9	6.11	0.91	2.38	64016.7

emissions at exhaust (PM), Nox emissions, Volatile Organic compounds that contribute to Photochemical oxidant emissions, the case 3 (based on computational allocation using Affinity propagation clustering) shows fewer emissions factors than the others three cases.

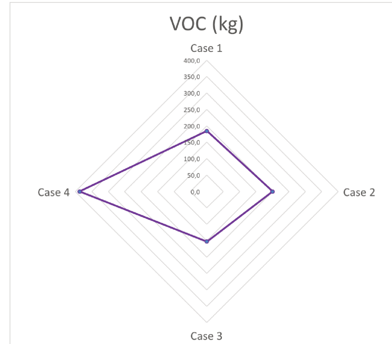
It is very interesting to note that the environmental evaluation considering the distance travelled for year by case, makes that the emissions savings change. Case 3 shows the fewer emissions compared to other cases. This can be explained by the fact that all four



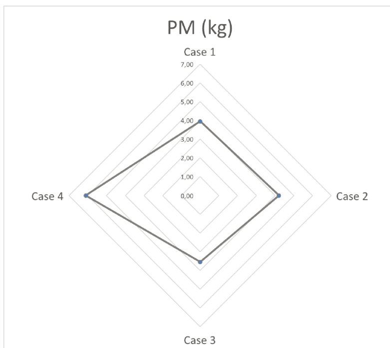
(a) CO(kg)



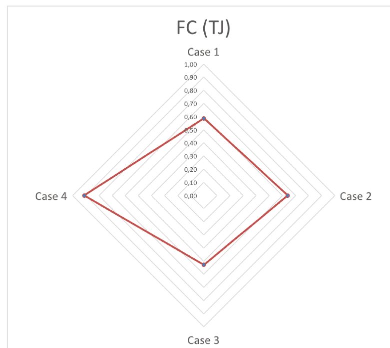
(b) Nox(kg)



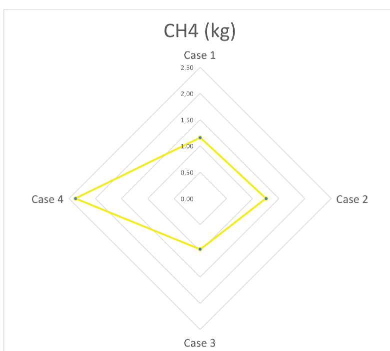
(c) VOC(kg)



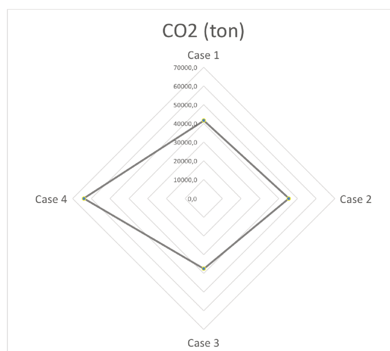
(d) PM(kg)



(e) FC(TJ)



(f) CH4(kg)



(g) CO2(ton)

Figure 7.8: Environmental assessment

CK are located in urban zones making the average speed lower compared to others. In consequence all factors emissions are greater than in the others cases. Nevertheless, as Case 3 has the lowest distance travelled, its yearly environmental evaluation is better compared others.

The emissions saving of Case 3 compared to other cases are for CO between 10.6% and 45.9%, for Nox between 10.3% and 30.3%, for VOC between 17% and 60.5%, for PM between 10.1% and 42.0%, for FC between 9.9% and 42.1%, for CH4 between 16.6% and

59.3%, and for CO2 between 9.7% and 41.4%. This can be explained by the fact of using only four CK, which means less distance travelled.

In conclusion, environmental impacts are related to both distances travelled and average speeds. Since unitary emission factors of COPERT are strongly dependent on speeds, a small speed variation can result on non-negligible gaps at unitary level, so even if distances are close, the use of different speeds and the use of fewer CK has a higher sensitivity in the environmental impact estimation. When proposing deployment impacts assessment, the definition of the most suitable speeds for assessing the cases seems to be crucial and needs to be analysed in depth.

7.3 Discussion: Framework generalisation

Generalisation issues

Considering that this framework aims to compare different scenarios in a transferability perspective; it is important that data used follows a set of standards or at least unified patterns in order to ensure the coherence of the different methods. Indeed, since while assessing scenarios that represents a reality, the choice here is that of a representation that is able to be made to any scenario in any city, and then a representation using standard models and tools, which errors and bias are known and easy to interpret and take into account in the analysis phases. It is important to note that since a model is a representation of the reality seen by the modeller, the different errors and bias are related to different elements:

- The data collection errors and bias related to data used for modelling;
- The errors and bias of input data (when using the model);
- The interpretation of the reality by the modeller;
- The hypotheses and assumptions made when developing the model (economic and environmental coefficient, for example);
- Other errors and bias related to data processing and analysis (related to aggregation; data lacks, scope of study etc.).

In this context, the validity and relevance of a model is not only related to the robustness of the calibration method or to the statistics characteristics of the data used, but also to the aim and scope of the model, the uses that will be expected (and the degree of specialization of the potential users) and the needs of accuracy related to those uses. Therefore, the choice of the data that is used and the adaptation of data aggregation should be motivated by the use that is envisioned for the models (Gonzalez-Feliu, 2017).

This framework has been developed for school canteen distribution. However, the proposed procedures may be adapted (mainly through their parameters and assumptions) to other institutional catering systems such as collective and commercial catering, and potentially to other food distribution schemes, if data inputs are available to adapt the models to the spatial and functional cases (i.e. city and distribution scheme).

Aiming to generalise the framework presented, the following analysis of each steps proposed is analysed.

I. Logistic decisions to consider

The first step of the framework considering the logistic decisions can be analysed to any reality. The different types of decisions were explained in Chapter 5, which should be considered for food distribution when considering economic and environmental issues.

II. Food system characterization

The second step aims at characterizing the food system, the estimations model can be different according to the data availability. To characterize the system, demand and transport supply, data from carrier organization is necessary. For the proposed framework, quantitative and qualitative data obtained from the stakeholders should be considered in the scenario assessment. With this aim, semi-structured interviews to shippers, receivers and transport carriers of the considered food distribution system were carried out.

- The demand estimation can be different according the social context. Regarding the demand estimation model, in the considered case (school canteens), the interviews showed that the value of coefficient K is defined from the daily average percentage of students that eat at school canteen, calculated for the entire urban zone of the scenarios to assess, is strongly related to the social local context, but is rather stable within each urban area. This coefficient K for each middle school in Paris and Lyon is similar, but it is double than that of Saint-Etienne. It has been also observed that Paris and Lyon have higher similarities in consumption and menu composition than Saint-Etienne or Valence, for example.

- The supply estimation can be different according to the distribution scheme adopted. Regarding the supply estimation model, in chapter 3 were presented different distribution schemes adopted to collect and supply food into the cities. For example, analysing the Swedish school system, there are two different food flows, cold and hot cook, that are not considered in the French school system.

III. Scenario construction

The third step of the scenario construction considers the data obtained in the previous steps, the models used for location and allocation and then for the route construction can be generalised. Nevertheless, this step will depend on the data availability and the tools used for the scenario construction. In fact, the information of how carriers are organized should be completed by assumptions to define the different scenarios to assess. Besides, as the aim of the proposed framework is to reproduce realistic routes, then, the use of VRP algorithms does not aim to find best solutions or theoretical optima but to reproduce the use of commercial transport planning and optimization tools.

IV. Scenario assessment

The last step considering the scenario assessment should be different according to the case applied.

- For the efficiency assessment, the algorithms to construct the routes can be different considering the efficiency goal. This framework aims to represent a reality neither than looking for the best solution or an optimized route that allows to assess the best solution in terms of distance and time.

- For the impacts assessment, the indicators selected should be different according to the context, because of the analysis relevance, the decisions makers should select other economic and environmental indicators to assess the system. Nevertheless, the methods used to estimate the impacts can be generalisable.

Then, considering the framework generalisations, three applicability issues should be addressed for this analysis: applicability to other school canteen systems in other cities; applicability to other catering schemes and, applicability to other distribution schemes. Considering the Swedish case explained before, the framework can be applied to other cities, but, it is necessary to analyse the data availability and the methods to apply according to the local context.

Nevertheless, the scenario construction and assessment should be used in a comparable way for the different context. In fact, since the aim is to propose a transferable framework able to be used to any city, it is important that the different modules of the proposed framework use standard databases able to be produced for any city of France. Moreover, the results of the assessment should be presented in a visual way, so a spatial approach is necessary. To deal with those needs, geographic and demographic data is needed. For the French context, since January 2017, different national and standard data sources are available at the open data website of the French government (SIR). It was used mainly the economic activity registry, the French Business Register (SIRENE) file and the open address database to geo-localize them. For spatial processing of data (and the calculation of distances and travelling times), the most suitable is to use data from existing mapping platforms: Google Maps, Bing, Open Street Maps, etc. In the proposed framework, mainly Open Street Maps was used, to follow an open data policy.

Finally, regarding the applicability to other catering schemes, such as hospitals or elderly house catering, the case study development allows to generalise the framework to those catering systems. After discussing with the institutional catering stakeholders, this framework can be applied to other sectors because the central kitchen is used also for elderly house catering in the French case and for hospital catering in the Swedish case.

Managerial implications

Managerial implications are directed toward stakeholders in food distribution systems, particularly logistic managers. It addresses four topics: the set of logistic decisions to consider, the food system characterization, the scenario construction and the scenario assessment.

The first topic is the importance of considering the relevant logistic decisions to consider when analysing a food distribution system. The results of the thesis show that according to the decisions taken by the stakeholders, the efficiency and impacts assessment could have different results. This is reflected on decisions such the choice of facility location and facility allocation at the strategic level and route construction at the tactical level. In relation to this, the thesis considers only strategic and tactical levels for the distribution decisions considered in the framework as Chapter 5.

The second topic concerns the importance of the food system characterization, where the network description, food demand and supply characteristics are decisive for the following analysis steps. The results of the thesis explain how the environmental criteria of the product can be identified and how those products criteria may influence the product demand. In consequence, by identifying these product's demand criteria, it is possible to consider the logistic requirements for the food distribution configuration (see Chapter 2). In fact, as the thesis results explained in Chapter 3, different distribution configurations that reduce external impacts on food transportation are needed to analyse by the stakeholders to improve local supply and strengthening the collaboration among the actors. Once, the food demand and supply are characterized, it is important to consider the current strategies addressed in the literature review as Chapter 4 explains. The thesis results explain how the FH can be a strategy to enable sustainable food distribution. Once the strategy is identified and analysed, it is necessary to estimate the demand and the supply. Chapter 5 shows the methods to estimate the food demand and supply according to the availability of data. This thesis presents different methods for demand and supply estimation that can be used and applied by the stakeholders according to the context.

The third topic concerns the scenario construction that can be analysed according to the previous steps considered. Chapter 5 shows different methods to locate and allocate facilities that can be used by the stakeholders to analyse different distribution cases. Once the facilities are located and the demand is allocated to those facilities, the route construction is performed. The thesis results show how considering different types of vehicles, transportation stages and vehicle utilization policies, the stakeholders can perform the routes construction using a VRP tool.

Lastly, the fourth topic concerns the scenario assessment. With this aim, the thesis proposes a methodology to select impacts indicators besides to efficiency indicators proposed in terms of distance and time (see Chapter 6). The thesis results show that by following the four steps of the proposed methodology (indicators definition, relevance analysis, indicators selection and calculation, and finally the impacts evaluation), the impacts assessment can be different according to the indicators selection by the stakeholder. Then in relation to food distribution configuration assessment, the proposed indicators methodology can present avenues to increase the analysis of economic, environmental and social impacts on food distribution.

Finally, Table 7.26 summarises the managerial implications in terms of recommendations and how the work of this thesis can support stakeholders in food distribution systems.

Table 7.26: Managerial implications for food distribution characterization and assessment

Topic	Recommendations	Support from this thesis
Logistic decisions to consider	Consider the food distribution decisions related to distribution network design, network planning and transportation planning.	Framework to define and analyse impacts of decisions on food supply chain organization.
Food system characterization	Characterize the current distribution network.	An analysis of echelons and stakeholders involved in the distribution network for food distribution
	Characterize the current food demand.	1. A conceptual model defining the product environmental criteria that impacts the product demand. 2. A set of products environmental criteria validated related to the product characteristics, to organizational strategies and to supplier selection that impact on product demand.
	Characterize the current food offer.	1. An analysis of local and organic producers in the Auvergne Rhone Alpes region 2. An analysis of current FH deployed in the Auvergne Rhone Alpes region
	Estimate the product and transport demand.	1. Model to estimate the demand in terms of number of meals and kilograms related to each echelon considered. 2. Demand generation model applied to the institutional catering sector.
	Estimate the logistic requirements for food distribution	1. A set of logistic requirements for food distribution considering the stakeholder, product type and distribution scheme adopted. 2. Distribution circuits, channels and networks characterization considering direct, short and long distribution.
Scenario construction	Locate and allocate facilities considering the strategic and tactical distribution decisions.	1. A set of methods to locate facilities that have been validated through a case study, including empirical and computational location methods. 2. A set of methods to allocate demand and offer to facilities that have been validated through a case study, including analytical computational and mathematical modelling allocation methods.
	Perform the route construction considering the location and allocation facilities as well as the vehicles characteristics.	A structure for analysing the routes construction based on type of vehicle, transportation stages and vehicle utilization policies considered.
Scenario assessment	Assess the efficiency of the proposed scenarios considering distance and time.	An analysis of how to calculate distance and time as measures of efficiency using an open Spread Sheet Solver.
	Assess the economic and environmental impacts of the food distribution system.	A methodology to identify, analyse, select, calculate and assess the environmental and economic impacts on food distribution.

Conclusion

Aiming to generalise the study, a modular framework has been proposed for assessing food-based distribution scenario that can further be adapted to different applications, but also tools that are available. Therefore, the framework combines the different steps in an integrated way, using standard or unified models to estimate the different elements needed to assess the scenarios, but in a coordinated procedure. Indeed, the fact of having a modular structure and using standard and transferable models allows to generate easily several potential scenarios and to compare each scenario with others in terms of efficiency and sustainable assessment.

Concerning the replicability of the proposed framework, it has been applied only to school canteen distribution for the conurbation of Lyon, and the city of Saint-Etienne in France, and in Kungsbacka in Sweden. However, interviews with various stakeholders of food distribution at a national level have shown that if the framework can be adapted to other context and cities. Nevertheless, the main parameters and assumptions (percentage of students who eat daily at the canteen, service settings of the carrier, menu composition in macro-categories of foods, demand requirements, etc.) need to be defined (mainly via quantitative and qualitative data collection processes) for each case. Besides, the data collection remains limited and easy to carry out, but it is not possible nowadays to define a unique food distribution scheme for different realities. Anyway, further work would explore the question of replicability to other contexts, cities, catering systems and other food distribution schemes.

Considering the representativeness and suitability of the proposed framework, different scenarios have been studied combining different location choices (including the local producers locations and Food Hubs (FH), re-location of the central kitchen or proposal of fewer central kitchens, use of different vehicles to include more environmental friendly technologies, re-location of a part of production on small local producers spread in the urban periphery with the need to define a suitable supply system to avoid a multiplication of direct transport flows from each producer to central kitchen, etc... Nowadays, the location choices and vehicle engines are in an advanced development phase since the algorithms allow to estimate the use of different platforms (and even kitchens) and the environmental assessment of vehicles includes different vehicle engines, but the economic costs of those vehicles and platforms need to be completed and the resulting databases are under construction.

However, the proposed framework presents other limits. Nowadays, there are not unified and standard databases to quantify food transport flows (only some general surveys on goods transport are available, but they are based on non-perishable goods transport mainly packaged in parcels and pallets). Moreover, food distribution data are issued in France mainly from private companies, which implies confidentiality issues and the need of reconstructing part of those data. For those reasons, it is currently difficult to define very specific demand models (for example by type of product, with a fine disaggregation for food supply frequencies, etc.). That has an impact on the route construction procedure and the representation of the resulting transport supply schemes (which degree of detail is dependent on the demand specifications). Nonetheless, further developments on the demand estimation seem to be possible, for example using time series data issued from local authorities (which are customers of distribution carriers). That data is not nowadays available, but they would be used for research purposes; therefore, further work will explore such possibilities. Consequently, with a more detailed demand model, the route construction procedure would evolve to consider such specificity.

In sum, by applying a contingency theory approach, assuming that not all stakeholders, reality specificities and products can be analysed interchangeably, the proposed framework can be adjustable to increase transferability. According to the thesis results, the framework can be applicable to different school canteen systems, other catering schemes and other food distribution schemes; however the data specificities linked to the context should be transferred with extreme caution.

Finally, the results of the case studies presented in this thesis have been integrated into the ANNONA platform in collaboration with F. Badeig from Ecole de Mines de Saint-Etienne. This thesis has been contributed to the modularity of this platform by proposing to decision-makers a "solution" approach based on the thesis findings. By using ANNONA, they could evaluate ex ante their policies to improve their food distribution systems and urban logistics activities. Appendix .9 shows screen-shots of the ANNONA platform that is available on-line in the following address: *https://territoire.emse.fr/applications/foodhub-kungsbacka*.

Conclusion

This chapter presents the conclusions of this thesis in relation to the research questions proposed by explaining its final contribution.

The objective of this research work was to enable food distribution stakeholders to analyse how eco-responsible demand impacts the urban food distribution schemes and help them to better understand how the decisions related to the configuration of school canteen distribution could have environment and economic impacts. It was necessary to clarify their possibilities for doing so, which led to the purpose of this thesis: *to analyse the relationship between product demand requirements and food distribution configurations considering environmental and economic impacts.*

Products environmental criteria

To explore ways in which eco-responsible demand impacts the urban food distribution schemes, this thesis began by identifying the product environmental criteria that impact product demand. A typology to classify the various criteria was proposed: they can be related to the product's environmental characteristics, to the organisational strategies and green practices developed by the companies, and to the supplier selection process.

The findings obtained from the semi-structured interviews and survey questionnaire show the importance of the introduction of organic labelled raw materials as one of the most influential attributes to improve the product's environmental quality. Besides, regarding the organisational strategies, the findings highlight the importance of geographical proximity with the stakeholders, which is reflected on decisions related to the facilities location such as (i) the location of distribution points close to the market and (ii) the location of production facilities close to suppliers.

That finding underscore the importance for stakeholders that belongs to food systems to consider organic and local products as environmental criteria that impacts demand and consider them as important selection criteria when choosing a supplier.

Regarding products environmental criteria that impact demand, the research makes contribution by:

- Identifying and describing twenty-nine product's environmental criteria associated with product characteristics, organisational strategies and supplier selection.

- Validating product's environmental criteria that impact product demand on the French food sector to be considered by the stakeholders to increase the product environmental quality.

Logistic requirements for food distribution

The first part of this thesis allowed to understand that the stakeholders in the food supply chain are becoming more aware of the need for the food logistic organizations improvement regarding the increasing environmental conscious demand and the importance of the agrifood production proximity. This thesis contributes in explaining the relevance of food distribution organisation due to the logistic request of food products passing more quickly from primary producers to consumers while they consider sustainability externalities.

Such a finding highlights the importance for stakeholders that belongs to food system to understand logistic requirement for food distribution configuration related to: (i) facility location (either near to the market or to the suppliers); (ii) supplier's selection (based on product characteristics and supplier's location related to a proximity relationship); and (iii) distribution optimisation due to the logistic platforms and transportation strategies development (i.e. distance travelled reduction, increasing vehicle's fill rates, decreasing sustainability externalities).

Regarding the logistic requirements for food distribution, the research makes contribution by:

- Characterising distribution configurations developed to reduce external impacts of food transportation by improving local supply and strengthening the collaboration among the local actors of the food supply chain.
- Understanding logistic requirements for food distribution configuration considering decisions linked to facility location and distribution optimisation.
- Providing information to food supply chain actors when designing the food distribution circuits aiming to consider emerging conscious demand characteristics.

Food supply chain strategies

Studying the food supply chain strategies that allow to accomplish the logistic requirements for food distribution considering the product environmental criteria, allowed this thesis to make two main contributions. The first contribution lies in describing the roles and characteristics of food hubs distribution systems created in the Auvergne-Rhône-Alpes region in France as a strategy for supplying the school canteen demands for local-organic products. The second contribution lies in assessing the producers' allocation to FH, considering geographical proximity and administrative subdivision allocation strategies.

These results allow to conclude that for strengthening the food supply, it is necessary to consider the producers' allocation regarding the geographical proximity and accessibility of the food hub, which impacts the food collection efficiency in terms of distance.

Regarding the FH as a food supply chain strategy that may allow to accomplish the logistic requirements for food distribution considering the product environmental criteria defined, the research makes contribution by:

- Describing the role of FH to enable short supply chains and allow to consider an increase in the share of local and organic products for institutional catering.
- Providing information to stakeholders of the food system when designing short supply chains with FH, as well as to policy-makers that aim at increasing their share of local and organic food in institutional catering.

Logistic decisions that impact the food distribution system efficiency

Understanding that logistics organization is an important element to deal with the increasing demand for organic and local products and reduce transportation flows, allowed this thesis to propose a framework that involves different strategic-tactical decisions to be considered for the food supply and distribution in the school canteen system.

Six cases were considering for this analysis: based on administrative subdivision allocation (Case 1), based on geographical proximity allocation (Case 2), based on mathematical modelling allocation with a producer's capacity of 21kg (Case3), based on mathematical modelling allocation with a producer's capacity of 42kg (Case 4), based on computational allocation using Affinity propagation clustering (Case 5) and based on computational allocation using K-means clustering (Case 6).

Findings based on the six cases suggest that the introduction of local products in the school canteen's menu requires to develop an efficient logistical organisation of the local producers. It has been observed that the efficient logistical organisation highly depends on the different key decisions considered.

Regarding the logistic decisions that impact the food distribution system efficiency, the research makes contribution by:

- Identifying and analysing the impacts of logistic decisions on food supply chain organization, when considering food supply strategies that enable sustainable distribution.
- Developing a framework that could support the decision maker to establish potential collaborations with the local and organic producers to improve the current food distribution systems for school canteens.

Economic and environmental impacts on food distribution assessment

Concerning the impacts of logistic decisions on food distribution configuration, the fact of modelling short food circuit distribution from independent or grouped producers (FH) and defining suitable transport schemes, impacts not only in the system efficiency but also in the economic and environmental performance.

For that reason, studying the impacts of different logistic decisions considered for food supply organisation, allowed this thesis to propose a methodology that involves the identification, calculation and validation of environment and economic indicators for assessing the food distribution system.

Regarding the economic and environmental impacts on food distribution assessment, the research makes contribution by:

- Proposing a methodology to assess economic and environmental impacts of city food logistics systems
- Applying the methodology to different distribution schemes for the school canteens supply to address its application issues, contributing to the debate on sustainable assessment of urban food systems.

Framework for food distribution characterisation and assessment

Lastly, with the aim of reducing the gap knowledge about food distribution system characterisation and assessment, this thesis has developed a framework for assessing food-based distribution configurations that can further be adapted to different applications. However the data specificities linked to the context should be transferred with extreme caution. Therefore, the framework combines different steps in an integrated way, using standard or unified models to estimate the different elements needed to assess the scenarios, but in a coordinated procedure. This framework includes four main steps: (i) logistic decisions to consider, (ii) food system characterisation, (iii) scenario construction, and, (iv) scenario assessment.

In particular the research has intended to make contribution by developing a framework for comparing different logistic decisions that impact food distribution organisation considering efficiency, economic and environmental assessment.

As a general conclusion of this thesis, the results of the proposed framework could support the decision maker to establish potential collaborations with the local and organic producers to improve the current food distribution systems for school canteens. In fact, by addressing the eco-responsible demand product and logistic requirements contribute to analysing efficiency (in terms of distance and time) economic and environmental impact on food distribution by considering key logistic decisions such as demand and offer estimation, facilities location and allocation, routes construction and distribution system assessment.

Moreover, to establish the main implications of the proposed framework in supporting decision makers in practice, some general conclusions may be drawn from the framework proposed in this thesis. By following this framework, the stakeholders of the food system will be available to: (1) be familiarized with the local and organic offer; (2) estimate its potential logistic demand; (3) assess different cases to have an idea on which logistic schema could be developed in the future; (4) consider the potential efficiency in terms of distance and time, economic and environmental impacts that the current or future distribution configuration will carry on.

Finally, the thesis findings have been integrated into the ANNONA platform in collaboration with F. Badeig from Ecole de Mines de Saint-Etienne. This thesis has been contributed to the modularity of this platform by proposing to decision-makers a “solution” approach based on the results of the case studies analysed. By using ANNONA, the decision-makers could evaluate ex ante their policies to improve their food distribution systems and urban logistics activities.

Prospectives: Further research

After over three years of working in the framework development and cases applications, many opportunities remain to further clarify how eco-responsible demand requirements impact the food supply distribution configuration. In this section, it is suggested further research based on the findings of the thesis.

For further research about the logistic decisions that must be considered for food distribution configuration, two proposed focuses for possible future studies are:

- Further analysis of how actors consider the operational decisions for food distribution configuration to understand better how consider decisions from all levels may impact the food distribution configuration.
- Development of decision making tools that consider the three levels of food logistics decisions to support the decisions-makers when configuring food distributions system considering eco-responsible products.

For further research about food distribution characterization, three proposed focuses for possible future studies are:

- Further analysis on the characterization of other food distribution networks different than institutional catering aiming to integrate this characterization to the framework generalization.
- An investigation of the potential of using the products environmental criteria proposed to improve the environmental quality of the food products in other context aiming to have a deeper understanding of the products environmental criteria impacts on product demand.
- Further analysis on the product demand and supply estimation model proposed in other food distribution channels such as food retailing, HoReCa and alternative channels.

For further research about scenario construction, one proposed focus for possible future studies is a further analysis on route construction using different VRP and seeking for best routes considering other algorithms to optimize the solution.

For further research about scenario assessment, two proposed focuses for possible future studies are:

- Consider other impacts estimations such as social and mobility for the scenario assessment.
- The development of analysis in multi-criteria methods to give a robustness in the impact assessment aiming to support the decision-makers considering its sustainability goals.
- The development of a methodology for environmental analysis based on life cycle assessment to study the potential (positive or negative) impacts of substituting thermal vehicles by other technologies such electric vehicles.

References

Air pollution from the main sources - Air emissions from road vehicles. http://ec.europa.eu/environment/air/sources/road.htm. Accessed: 2016-11-30.

Comite National Routier. http://www.cnr.fr/Outils-simulation2/Simulateurs. Accessed: 2018-01-14.

Kungsbacka Monthly Climate Averages. https://www.worldweatheronline.com/kungsbacka-weather-averages/hallands-lan/se.aspx. Accessed: 2019-02-20.

LOI-2018-938 du 30 octobre 2018 pour l'équilibre des relations commerciales dans le secteur agricole et alimentaire et une alimentation saine, durable et accessible à tous. https://www.legifrance.gouv.fr/affichLoiPreparation.do?idDocument=JORFDOLE000036562265&type=general&typeLoi=proj&legislature=15. Accessed: 2018-11-30.

Regional organic agriculture observatory. https://www.auvergnerhonealpes.bio/restaurants-collectifs/se-fournir-en-bio-locale. Accessed: 2018-01-20.

Saint-Etienne Monthly Climate Averages. https://www.worldweatheronline.com/saint-etienne-weather-averages/rhone-alpes/fr.aspx. Accessed: 2018-01-30.

SIRENE. https://www.data.gouv.fr/es/datasets/base-sirene//. Accessed: 2016-09-20.

SPAD. https://www.coheris.com/en/analytics/data-mining-software/. Accessed: 2018-05-20.

Sweden Diesel prices 2017. https://www.globalpetrolprices.com/Sweden/diesel_prices/. Accessed: 2019-02-14.

Swedish Transport Administration Annual Report of 2017. https://trafikverket.ineko.se/se/the-swedish-transport-administration-annual-report-2017. Accessed: 2019-02-14.

Technical specifications Trucks. https://www.keltruck.com/about-keltruck/news-centre/press-releases/scanias-dedicated-gas-engine-range-extended/. Accessed: 2019-02-14.

Abbasi, M. and Nilsson, F. (2016). Developing environmentally sustainable logistics: Exploring themes and challenges from a logistics service providers' perspective. *Transportation Research Part D: Transport and Environment*, 46:273–283.

Accorsi, R., Cascini, A., Cholette, S., Manzini, R., and Mora, C. (2014). Economic and environmental assessment of reusable plastic containers: A food catering supply chain case study. *International Journal of Production Economics*, 152:88–101.

Ackoff, R. L. (1977). Optimization+ objectivity= optout. *European Journal of Operational Research*, 1(1):1–7.

Ademe (2016). Alimentation et environnement: Champs d'actions pour le professionnels. Technical report, L'Agence de l'environnement et de la maitrise de l'energie (ADEME).

ADEME (2018). Les performances environnementales des poids lourds gnv destineés au transport routier de marchandises. Technical report, L'Agence de l'environnement et de la maitrise de l'energie (ADEME).

Aggarwal, C. C., Wolf, J. L., Yu, P. S., Procopiuc, C., and Park, J. S. (1999). Fast algorithms for projected clustering. In *ACM SIGMoD Record*, volume 28, pages 61–72. ACM.

Ahumada, O. and Villalobos, J. R. (2009). Application of planning models in the agri-food supply chain: A review. *European journal of Operational research*, 196(1):1–20.

Akkerman, R., Farahani, P., and Grunow, M. (2010). Quality, safety and sustainability in food distribution: a review of quantitative operations management approaches and challenges. *Or Spectrum*, 32(4):863–904.

Aljohani, K. and Thompson, R. (2019). A stakeholder-based evaluation of the most suitable and sustainable delivery fleet for freight consolidation policies in the inner-city area. *Sustainability*, 11(1):124.

Allaoui, H., Guo, Y., Choudhary, A., and Bloemhof, J. (2018). Sustainable agro-food supply chain design using two-stage hybrid multi-objective decision-making approach. *Computers & Operations Research*, 89:369–384.

Allen, J., Browne, M., Woodburn, A., and Leonardi, J. (2012). The role of urban consolidation centres in sustainable freight transport. *Transport Reviews*, 32(4):473–490.

Alwitt, L. F. and Pitts, R. E. (1996). Predicting purchase intentions for an environmentally sensitive product. *Journal of consumer psychology*, 5(1):49–64.

Ambrosini, C., Routhier, J.-L., Sonntag, H., and Meimbresse, B. (2008). Urban freight modelling: a review. *Innovations in City Logistics, Nova Science Publishers, New York*, pages 197–211.

Anderson, S., Allen, J., and Browne, M. (2005). Urban logistics—-how can it meet policy makers' sustainability objectives? *Journal of transport geography*, 13(1):71–81.

Andriankaja, D., Gondran, N., and Gonzalez-Feliu, J. (2015). Evaluation environnementale d'un centre de distribution urbaine par une approche d'ACV. *Logistique & Management*, 23(1):51–69.

ANIA (2018). Agence Nationale de l'Industrie Alimentaire nos forces, nos freins et nos chiffres clés.

Apaiah, R. K., Hendrix, E. M., Meerdink, G., and Linnemann, A. R. (2005). Qualitative methodology for efficient food chain design. *Trends in food science & technology*, 16(5):204–214.

Apaiah, R. K., Linnemann, A. R., and van der Kooi, H. J. (2006). Exergy analysis: A tool to study the sustainability of food supply chains. *Food Research International*, 39(1):1–11.

Aramyan, L., Ondersteijn, C., Kooten, O., and Oude Lansink, A. (2006). Performance indicators in agri-food production chains. *Quantifying the agri-food supply chain*, pages 49–66.

Aras, N. and Bilge, Ü. (2018). Robust supply chain network design with multi-products for a company in the food sector. *Applied Mathematical Modelling*, 60:526–539.

Aubry, C. and Kebir, L. (2013). Shortening food supply chains: A means for maintaining agriculture close to urban areas? the case of the french metropolitan area of paris. *Food Policy*, 41:85–93.

AURA, F. (2018). Rapport d'activité frab aura 2018. Technical report, Fédeération Nationale d'Agriculture Biologique (FRAB).

Baghalian, A., Rezapour, S., and Farahani, R. Z. (2013). Robust supply chain network design with service level against disruptions and demand uncertainties: A real-life case. *European Journal of Operational Research*, 227(1):199–215.

Bai, X. and Liu, Y. (2016). Robust optimization of supply chain network design in fuzzy decision system. *Journal of Intelligent Manufacturing*, 27(6):1131–1149.

Bandeira, R. A., D'Agosto, M. A., Ribeiro, S. K., Bandeira, A. P., and Goes, G. V. (2018). A fuzzy multi-criteria model for evaluating sustainable urban freight transportation operations. *Journal of cleaner production*, 184:727–739.

Banfield, J. D. and Raftery, A. E. (1993). Model-based gaussian and non-gaussian clustering. *Biometrics*, pages 803–821.

Baptiste, V. L. (2010). The logistic leverages of short food supply chains performance in terms of sustainability. In *Conference on Transport Research Society. 12th World Conference on Transport Research*.

Barham, J., Tropp, D., Enterline, K., Farbman, J., Fisk, J., Kiraly, S., et al. (2012). Regional food hub resource guide. Technical report.

Behrends, S. (2016). Recent developments in urban logistics research - a review of the proceedings of the international conference on city logistics 2009-2013. *Transportation Research Procedia*, 12:278–287.

Bell, E., Bryman, A., and Harley, B. (2018). *Business research methods*. Oxford university press.

Bezdek, J. C., Ehrlich, R., and Full, W. (1984). Fcm: The fuzzy c-means clustering algorithm. *Computers & Geosciences*, 10(2-3):191–203.

Blakey, R. C., Cole, E. H., Haygood, K., Hebert, S. L., King, P. B., McGrane, M. T., Trombly, J. W., Williams, M. I., Luce, F. D., and Wilson, R. L. (1977). Food distribution and consumption in knoxville: Exploring food-related local planning issues.

Blanquart, C., Gonçalves, A., Raton, G., and Vaillant, L. (2015). Vecteurs et freins d'une logistique plus durable dans les circuits courts: le cas du nord-pas-de-calais. In *ASRLDF*.

Blanquart, C., Gonçalves, A., Vandenbossche, L., Kebir, L., Petit, C., and Traversac, J.-B. (2010). The logistic leverages of short food supply chains performance in terms of sustainability. In *12th World Conference on Transport Research*, page 10p.

Bloemhof, J. M., van der Vorst, J. G., Bastl, M., and Allaoui, H. (2015). Sustainability assessment of food chain logistics. *International Journal of Logistics Research and Applications*, 18(2):101–117.

Bortolini, M., Faccio, M., Ferrari, E., Gamberi, M., and Pilati, F. (2016a). Fresh food sustainable distribution: cost, delivery time and carbon footprint three-objective optimization. *Journal of Food Engineering*, 174:56–67.

Bortolini, M., Faccio, M., Gamberi, M., and Pilati, F. (2016b). Multi-objective design of multi-modal fresh food distribution networks. *International Journal of Logistics Systems and Management*, 24(2):155–177.

Bortolini, M., Galizia, F. G., Mora, C., Botti, L., and Rosano, M. (2018). Bi-objective design of fresh food supply chain networks with reusable and disposable packaging containers. *Journal of cleaner production*, 184:375–388.

Bosona, T. G. and Gebresenbet, G. (2011). Cluster building and logistics network integration of local food supply chain. *Biosystems engineering*, 108(4):293–302.

Bouchery, Y., Ghaffari, A., and Jemai, Z. (2010). Key performance indicators for sustainable distribution supply chains: Set building methodology and application. *Cahiers de recherche*, 8:37–56.

Bourlakis, M., Maglaras, G., Gallear, D., and Fotopoulos, C. (2014). Examining sustainability performance in the supply chain: The case of the greek dairy sector. *Industrial Marketing Management*, 43(1):56–66.

Brécard, D. (2014). Consumer confusion over the profusion of eco-labels: Lessons from a double differentiation model. *Resource and energy economics*, 37:64–84.

Brunori, G. and Galli, F. (2016). Sustainability of local and global food chains: Introduction to the special issue.

Brunori, G., Rossi, A., and Guidi, F. (2012). On the new social relations around and beyond food. analysing consumers' role and action in gruppi di acquisto solidale (solidarity purchasing groups). *Sociologia ruralis*, 52(1):1–30.

Campbell, S., Sanchez-Diaz, I., Lawson, C. T., Jaller, M., and Holguin-Veras, J. (2012). Comparison between industrial classification systems in freight trip generation modeling. Technical report.

Cattaruzza, D., Absi, N., Feillet, D., and González-Feliu, J. (2017). Vehicle routing problems for city logistics. *EURO Journal on Transportation and Logistics*, 6(1):51–79.

Cerutti, A. K., Contu, S., Ardente, F., Donno, D., and Beccaro, G. L. (2016). Carbon footprint in green public procurement: Policy evaluation from a case study in the food sector. *Food Policy*, 58:82–93.

Chaffotte, L. and Chiffoleau, Y. (2007). Vente directe et circuits courts: évaluations, définitions et typologie. *Les Cahiers de l'Observatoire CROC, INRA, Montpellier*, 1(8).

Chaturvedi, A., Green, P. E., and Caroll, J. D. (2001). K-modes clustering. *Journal of classification*, 18(1):35–55.

Chen, C. (2001). Design for the environment: A quality-based model for green product development. *Management Science*, 47(2):250–263.

Chen, J. Y.-C. (1994). *The economic impacts of green product development*. PhD thesis, Massachusetts Institute of Technology.

Chen, W.-T. and Hsu, C.-I. (2015). Greenhouse gas emission estimation for temperature-controlled food distribution systems. *Journal of Cleaner Production*, 104:139–147.

Cirullies, J., Schwede, C., and Toth, M. (2012). Intra-simulative ecological assessment of logistics networks: benefits, concepts, and tool enhancement. In *Proceedings of the Winter Simulation Conference*, page 278. Winter Simulation Conference.

Clarke, G. and Wright, J. W. (1964). Scheduling of vehicles from a central depot to a number of delivery points. *Operations research*, 12(4):568–581.

Colicchia, C., Creazza, A., Dallari, F., and Melacini, M. (2016). Eco-efficient supply chain networks: development of a design framework and application to a real case study. *Production planning & control*, 27(3):157–168.

Colicchia, C., Marchet, G., Melacini, M., and Perotti, S. (2013). Building environmental sustainability: empirical evidence from logistics service providers. *Journal of Cleaner Production*, 59:197–209.

Combes, F. (2016). A theoretical analysis of the cost structure of urban logistics. In *Proceedings of the 6th International Conference in Informations Systems, Logistics and Supply Chain*, pages 1–4.

Comi, A. and Rosati, L. (2013). Class: A city logistics analysis and simulation support system. *Procedia-Social and Behavioral Sciences*, 87:321–337.

Conacca (2009). *Modelo A*. Centro de Logistica Alimentaria.

Cortinhal, M., Lopes, M., and Melo, M. (2015). Dynamic design and re-design of multi-echelon, multi-product logistics networks with outsourcing opportunities: A computational study. *Computers & Industrial Engineering*, 90:118–131.

Crainic, T. G. (2000). Service network design in freight transportation. *European Journal of Operational Research*, 122(2):272–288.

Crainic, T. G. and Laporte, G. (1997). Planning models for freight transportation. *European journal of operational research*, 97(3):409–438.

Crainic, T. G., Ricciardi, N., and Storchi, G. (2009). Models for evaluating and planning city logistics systems. *Transportation science*, 43(4):432–454.

Creswell, J. W. (2014). Creswell, qualitative inquiry and research design.

Cretella, A. and Buenger, M. S. (2016). Food as creative city politics in the city of rotterdam. *Cities*, 51:1–10.

Croom, S., Vidal, N., Spetic, W., Marshall, D., and McCarthy, L. (2018). Impact of social sustainability orientation and supply chain practices on operational performance. *International Journal of Operations & Production Management*, 38(12):2344–2366.

Čuček, L., Klemeš, J. J., and Kravanja, Z. (2012). A review of footprint analysis tools for monitoring impacts on sustainability. *Journal of Cleaner Production*, 34:9–20.

Cuda, R., Guastaroba, G., and Speranza, M. G. (2015). A survey on two-echelon routing problems. *Computers & Operations Research*, 55:185–199.

Cunha, A. E., Morgan, H. E., Moroney, M. J., and Banegas Nunez, S. A. (2015). From food bank to food hub: Challenges and opportunities.

Daganzo, C. F. (2005). *Logistics systems analysis*. Springer Science & Business Media.

Dagiliūtė, R., Liobikienė, G., and Minelgaitė, A. (2018). Sustainability at universities: Students' perceptions from green and non-green universities. *Journal of Cleaner Production*, 181:473–482.

Dangelico, R. M. and Pontrandolfo, P. (2010). From green product definitions and classifications to the green option matrix. *Journal of Cleaner Production*, 18(16-17):1608–1628.

Daoud, I. and Mellouli, R. (2015). Network design and planning with resource pooling: The context of merging two logistics entities. In *2015 IEEE International Conference on Service Operations And Logistics, And Informatics (SOLI)*, pages 24–30. IEEE.

Davis, L. B., Sengul, I., Ivy, J. S., Brock III, L. G., and Miles, L. (2014). Scheduling food bank collections and deliveries to ensure food safety and improve access. *Socio-Economic Planning Sciences*, 48(3):175–188.

de Dios Ortúzar, J. and Willumsen, L. G. (2012). Modelling transport. *IEEE intelligent transportation systems magazine*, pages 40–41.

De Fazio, M. (2016). Agriculture and sustainability of the welfare: the role of the short supply chain. *Agriculture and agricultural science procedia*, 8:461–466.

de Keizer, M., Akkerman, R., Grunow, M., Bloemhof, J. M., Haijema, R., and van der Vorst, J. G. (2017). Logistics network design for perishable products with heterogeneous quality decay. *European Journal of Operational Research*, 262(2):535–549.

de Keizer, M., Haijema, R., van der Vorst, J., and Bloemhof-Ruwaard, J. (2012). Hybrid simulation and optimization approach to design and control fresh product networks. In *Proceedings of the Winter Simulation Conference*, page 102. Winter Simulation Conference.

De Langhe, K. (2014). Analysing the role of rail in urban freight distribution. *Next Generation Supply Chains: Trends and Opportunities*, 18:223.

de Oliveira, L. K., de Albuquerque Nóbrega, R. A., Ebias, D. G., et al. (2017). Analysis of freight trip generation model for food and beverage in belo horizonte (brazil). *Region*, 4(1):17–30.

Delaître, L. and édric De Barbeyrac, C. (2012). Improving an urban distribution centre, the french case of samada monoprix. *Procedia-Social and Behavioral Sciences*, 39:753–769.

Deltas, G., Khanna, M., and Ramirez, D. T. (2004). Markets with environmentally conscious consumers. *University of Illinois, mimeo.*

Dey, P. K., Petridis, N. E., Petridis, K., Malesios, C., Nixon, J. D., and Ghosh, S. K. (2018). Environmental management and corporate social responsibility practices of small and medium-sized enterprises. *Journal of Cleaner Production*.

Dijkstra, E. W. (1959). A note on two problems in connexion with graphs. *Numerische mathematik*, 1(1):269–271.

Dong, C., Shen, B., Chow, P.-S., Yang, L., and Ng, C. T. (2016). Sustainability investment under cap-and-trade regulation. *Annals of Operations Research*, 240(2):509–531.

D'Souza, C., Taghian, M., and Lamb, P. (2006). An empirical study on the influence of environmental labels on consumers. *Corporate communications: an international journal*, 11(2):162–173.

Du, S., Tang, W., and Song, M. (2016). Low-carbon production with low-carbon premium in cap-and-trade regulation. *Journal of cleaner production*, 134:652–662.

Dunk, A. S. (2004). Product life cycle cost analysis: the impact of customer profiling, competitive advantage, and quality of is information. *Management Accounting Research*, 15(4):401–414.

Durand, B. and Gonzalez-Feliu, J. (2012). Urban logistics and e-grocery: have proximity delivery services a positive impact on shopping trips? *Procedia-Social and Behavioral Sciences*, 39:510–520.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of management review*, 14(1):57–74.

Elkington, J. (2013). Enter the triple bottom line. In *The triple bottom line*, pages 23–38. Routledge.

Erdogan, G. (2017). An open source Spreadsheet Solver for Vehicle Routing Problems. *Computers & Operations Research*, 84:62–72.

Erdoğan, G. (2017). An open source spreadsheet solver for vehicle routing problems. *Computers & Operations Research*, 84:62–72.

Erdoğan, S. and Miller-Hooks, E. (2012). A Green Vehicle Routing Problem. *Transportation Research Part E: Logistics and Transportation Review*, 48(1):100–114.

Eriksson, M., Osowski, C. P., Malefors, C., Björkman, J., and Eriksson, E. (2017). Quantification of food waste in public catering services-a case study from a swedish municipality. *Waste management*, 61:415–422.

Erokhin, V. (2018). Establishing food security and alternatives to international trade in emerging economies. *Advances in Public Policy Administration (APPA) Book Series eng*.

Esser, K. and Kurte, J. (2006). B2c e-commerce: impact on transport in urban areas. In *Recent Advances in City Logistics. The 4th International Conference on City LogisticsInstitute for City Logistics*.

Ester, M., Kriegel, H.-P., Sander, J., Xu, X., et al. (1996). A density-based algorithm for discovering clusters in large spatial databases with noise. In *Kdd*, volume 96, pages 226–231.

Etemadnia, H., Hassan, A., Goetz, S., and Abdelghany, K. (2013). Wholesale hub locations in food supply chains. *Transportation Research Record: Journal of the Transportation Research Board*, (2379):80–89.

Faccio, M. and Gamberi, M. (2015). New city logistics paradigm: From the "last mile" to the "last 50 miles" sustainable distribution. *Sustainability*, 7(11):14873–14894.

Faure, L. (2015). *Evaluation de la performance économique des Centres de Distribution Urbaine*. PhD thesis, Ecole Nationale Supérieure des Mines de Saint-Etienne.

Faure, L., Burlat, P., and Marquès, G. (2016). Evaluate the viability of urban consolidation centre with regards to urban morphology. *Transportation Research Procedia*, 12:348–356.

Faure, L., Burlat, P., Montreuil, B., and Marquès, G. (2014). A modelling approach of pooled urban consolidation centers. In *2014 gis urban modelling symposium*.

Feng, Y., Hong, Z., Cheng, J., Tian, G., Zhang, H., and Tan, J. (2017). Environmental-friendly reliability allocation for product platform based on expert measurement and icn. *Computers & Electrical Engineering*, 64:132–144.

Firoozi, Z., Ismail, N., Ariafar, S., Tang, S., Ariffin, M., and Memariani, A. (2014). Effects of integration on the cost reduction in distribution network design for perishable products. *Mathematical Problems in Engineering*, 2014.

Flick, U. (2018). *An introduction to qualitative research*. Sage Publications Limited.

Fraj, E., Martínez, E., and Matute, J. (2013). Green marketing in b2b organisations: an empirical analysis from the natural-resource-based view of the firm. *Journal of Business & Industrial Marketing*, 28(5):396–410.

François, C., Gondran, N., Nicolas, J.-P., and Parsons, D. (2017). Environmental assessment of urban mobility: Combining life cycle assessment with land-use and transport interaction modelling-Application to Lyon (France). *Ecological Indicators*, 72:597–604.

Fredriksson, A. and Liljestrand, K. (2015). Capturing food logistics: a literature review and research agenda. *International Journal of Logistics Research and Applications*, 18(1):16–34.

Frey, B. J. and Dueck, D. (2007). Clustering by passing messages between data points. *science*, 315(5814):972–976.

Galli, F., Bartolini, F., Brunori, G., Colombo, L., Gava, O., Grando, S., and Marescotti, A. (2015). Sustainability assessment of food supply chains: an application to local and global bread in italy. *Agricultural and Food Economics*, 3(1):21.

Ganti, V., Gehrke, J., and Ramakrishnan, R. (1999). Cactus-clustering categorical data using summaries. In *KDD*, volume 99, pages 73–83.

Garg, A. (2015). Green marketing for sustainable development: an industry perspective. *Sustainable Development*, 23(5):301–316.

Gebresenbet, G., Nordmark, I., Bosona, T., and Ljungberg, D. (2011). Potential for optimised food deliveries in and around uppsala city, sweden. *Journal of transport geography*, 19(6):1456–1464.

Gendron, B. and Semet, F. (2009). Formulations and relaxations for a multi-echelon capacitated location–distribution problem. *Computers & Operations Research*, 36(5):1335–1355.

Gérardin, B., Patier, D., Routhier, J.-L., and Segalou, E. (2000). *Diagnostic du transport de marchandises dans une agglomération. Document technique nÂ° 1.* PhD thesis, LET; GERARDIN CONSEIL.

Ghadimi, P., Azadnia, A. H., Heavey, C., Dolgui, A., and Can, B. (2016). A review on the buyer–supplier dyad relationships in sustainable procurement context: past, present and future. *International journal of production research*, 54(5):1443–1462.

Giancarlo, B. (2005). Matching "environmental performance" and "quality performance" a new competitive business strategy through global efficiency improvement. *The TQM Magazine*, 17(6):497–508.

Gkatzoflias, D., Kouridis, C., Ntziachristos, L., and Samaras, Z. (2007). COPERT 4: Computer programme to calculate emissions from road transport. *European Environment Agency*.

Goggins, G. and Rau, H. (2016). Beyond calorie counting: Assessing the sustainability of food provided for public consumption. *Journal of Cleaner Production*, 112:257–266.

Golden, B. L., Raghavan, S., and Wasil, E. A. (2008). *The vehicle routing problem: latest advances and new challenges*, volume 43. Springer Science & Business Media.

Gonçalves, A. (2013). *La performance des organisations logistiques des circuits courts de distribution: une analyse des déterminants et leviers d'amélioration*. PhD thesis, Université Lille 1.

Gonzalez-Calderon, C. A., Sánchez-Díaz, I., Sarmiento-Ordosgoitia, I., and Holguín-Veras, J. (2018). Characterization and analysis of metropolitan freight patterns in medellin, colombia. *European Transport Research Review*, 10(2):23.

Gonzalez-Feliu, J. (2011). Two-echelon freight transport optimisation: unifying concepts via a systematic review. *Working papers on operations management*, 2(1):18–30.

Gonzalez-Feliu, J. (2012). Cost optimisation in freight distribution with cross-docking: N-echelon location routing problem. *Promet-Traffic&Transportation*, 24(2):143–149.

Gonzalez-Feliu, J. (2013a). Multi-stage ltl transport systems in supply chain management.

Gonzalez-Feliu, J. (2013b). Vehicle routing in multi-echelon distribution systems with cross-docking: A systematic lexical-metanarrative analysis. *Computer and Information Science*, 6(3):28.

Gonzalez-Feliu, J. (2014). Costs and benefits of railway urban logistics: a prospective social cost benefit analysis.

Gonzalez-Feliu, J. (2016). Viability and potential demand capitation of urban freight tramway systemss via demand-supply modelling and cost benefit analysis. In *The International Conference on Information Systems, Logistics and Supply Chain (ILS International Conference)*, number 262. Springer International Publishing.

Gonzalez-Feliu, J. (2017). *Logistique urbaine durable: Prévision et évaluation*. ISTE Editions.

Gonzalez-Feliu, J. (2018a). Sustainability evaluation of green urban logistics systems: literature overview and proposed framework. In *Green Initiatives for Business Sustainability and Value Creation*, pages 103–134. IGI Global.

Gonzalez-Feliu, J. (2018b). *Sustainable Urban Logistics: Planning and Evaluation*. John Wiley & Sons.

González-Feliu, J., Cedillo-Campo, M. G., and García-Alcaraz, J. L. (2014). An emission model as an alternative to od matrix in urban goods transport modelling. *Dyna*, 81(187):249–256.

Gonzalez-Feliu, J., d'Arcier, B. F., Grau, J.-M. S., Hervé, T., Zubillaga, F., Jeftic, Z., Thebaud, J.-B., and Aifandopoulou, G. (2013). The deployment of urban logistics solutions from research, development and pilot results. lessons from the freilot project. In *Städtischer Wirtschaftsverkehr-Commercial/Goods Transportation in Urban Areas-Transports Commerciaux/Marchandises en Ville. Dokumentation der Internationalen Konferenz 2012 in Berlin*, pages 104–121. Deutsches Institut für Urbanistik.

Gonzalez-Feliu, J. and Morana, J. *Assessing Urban Logistics Pooling Sustainability via a Hierarchic Dashboard from a Group Decision Perspective*, chapter Chapter 5, pages 113–135.

Gonzalez-Feliu, J., Muñuzuri, J., Cedillo-Campos, M. G., Ambrosini, C., Taniguchi, E., and Chiabaut, N. (2015). Restrictions d'accès au centre-ville: à la recherche du véhicule optimal urbain. *Logistique & Management*, 23(2):31–44.

Gonzalez-Feliu, J., Osorio-Ramirez, C., Palacios-Arguello, L., and Talamantes, C. A. (2018). Local production-based dietary supplement distribution in emerging countries: Bienestarina distribution in colombia. In *Establishing Food Security and Alternatives to International Trade in Emerging Economies*, pages 297–315. IGI Global.

Gonzalez-Feliu, J. and Sánchez-Díaz, I. (2019). The influence of aggregation level and category construction on estimation quality for freight trip generation models. *Transportation Research Part E: Logistics and Transportation Review*, 121:134–148.

Gonzalez-Feliu, J., Semet, F., and Routhier, J.-L. (2014). *Sustainable urban logistics: Concepts, methods and information systems.* Springer.

Govindan, K., Rajendran, S., Sarkis, J., and Murugesan, P. (2015). Multi criteria decision making approaches for green supplier evaluation and selection: a literature review. *Journal of Cleaner Production*, 98:66–83.

Greenhalgh, T., Russell, J., and Swinglehurst, D. (2005). Narrative methods in quality improvement research. *BMJ Quality & Safety*, 14(6):443–449.

Groër, C., Golden, B., and Wasil, E. (2010). A library of local search heuristics for the vehicle routing problem. *Mathematical Programming Computation*, 2(2):79–101.

Gupta, S. and Palsule-Desai, O. D. (2011). Sustainable supply chain management: review and research opportunities. *IIMB Management Review*, 23(4):234–245.

Guyon, O., Absi, N., Boudouin, D., and Feillet, D. (2010). Plates-formes en centre ville pour la logistique urbaine: étude sur la ville de marseille. In *2ème Journée de Recherche" Mobilité, Transport et Logistique"(MTL 2010).*

Handfield, R., Walton, S. V., Sroufe, R., and Melnyk, S. A. (2002). Applying environmental criteria to supplier assessment: A study in the application of the analytical hierarchy process. *European journal of operational research*, 141(1):70–87.

Heilig, G. K. (2012). World urbanization prospects: the 2011 revision. *United Nations, Department of Economic and Social Affairs (DESA), Population Division, Population Estimates and Projections Section, New York*, page 14.

Henriot, F., Patier, D., Bossin, P., and Gérardin, B. (2008). Méthodologie d'évaluation des innovations en matière de logistique urbaine. *PREDIT-DRAST report*.

Hensher, D. A. and Button, K. J. (2007). *Handbook of transport modelling*. Emerald Group Publishing Limited.

Hinneburg, A. and Keim, D. A. (1999). Optimal grid-clustering: Towards breaking the curse of dimensionality in high-dimensional clustering.

Hinneburg, A., Keim, D. A., et al. (1998). An efficient approach to clustering in large multimedia databases with noise. In *KDD*, volume 98, pages 58–65.

Holguín-Veras, J., Jaller, M., Destro, L., Ban, X., Lawson, C., and Levinson, H. S. (2011). Freight generation, freight trip generation, and perils of using constant trip rates. *Transportation Research Record*, 2224(1):68–81.

Holguín-Veras, J. and Sánchez-Díaz, I. (2016). Freight demand management and the potential of receiver-led consolidation programs. *Transportation Research Part A: Policy and Practice*, 84:109–130.

Holguín-Veras, J., Sánchez-Díaz, I., and Browne, M. (2016). Sustainable urban freight systems and freight demand management. *Transportation Research Procedia*, 12:40–52.

Hsiao, H., Van der Vorst, J., Kemp, R., and Omta, S. (2010). Developing a decision-making framework for levels of logistics outsourcing in food supply chain networks. *International Journal of Physical Distribution & Logistics Management*, 40(5):395–414.

Huang, G. Q., Lau, J. S., and Mak, K. (2003). The impacts of sharing production information on supply chain dynamics: a review of the literature. *International journal of production research*, 41(7):1483–1517.

Igarashi, M., de Boer, L., and Fet, A. M. (2013). What is required for greener supplier selection? a literature review and conceptual model development. *Journal of Purchasing and Supply Management*, 19(4):247–263.

Igl, J. and Kellner, F. (2017). Exploring greenhouse gas reduction opportunities for retailers in fast moving consumer goods distribution networks. *Transportation Research Part D: Transport and Environment*, 50:55–69.

Ilbery, B. and Maye, D. (2005). Food supply chains and sustainability: evidence from specialist food producers in the scottish/english borders. *Land Use Policy*, 22(4):331–344.

Izumi, B. T., Alaimo, K., and Hamm, M. W. (2010). Farm-to-school programs: Perspectives of school food service professionals. *Journal of nutrition education and behavior*, 42(2):83–91.

Jabbour, A. B. L. and Jabbour, C. J. (2009). Are supplier selection criteria going green? case studies of companies in brazil. *Industrial Management & Data Systems*, 109(4):477–495.

Janjevic, M. and Ndiaye, A. (2017). Investigating the financial viability of urban consolidation centre projects. *Research in Transportation Business & Management*, 24:101–113.

Jiang, W. and Chen, X. (2016). Optimal strategies for manufacturer with strategic customer behavior under carbon emissions-sensitive random demand. *Industrial Management & Data Systems*, 116(4):759–776.

Karypis, G., Han, E.-H. S., and Kumar, V. (1999). Chameleon: Hierarchical clustering using dynamic modeling. *Computer*, (8):68–75.

Kebir, L. and Torre, A. (2012). 10 geographical proximity and new short supply food chains. In *Creative Industries and Innovation in Europe: Concepts, Measures and Comparative Case Studies*, volume 57, page 194. Routledge.

Khalili-Damghani, K., Tavana, M., and Amirkhan, M. (2014). A fuzzy bi-objective mixed-integer programming method for solving supply chain network design problems under ambiguous and vague conditions. *The International Journal of Advanced Manufacturing Technology*, 73(9-12):1567–1595.

Kin, B., Spoor, J., Verlinde, S., Macharis, C., and Van Woensel, T. (2018). Modelling alternative distribution set-ups for fragmented last mile transport: Towards more efficient and sustainable urban freight transport. *Case Studies on Transport Policy*, 6(1):125–132.

Kirwan, J., Maye, D., Bundhoo, D., Keech, D., and Brunori, G. (2014). Glamur wp2-scoping/framing general comparative report on food chain performance (deliverable 2.3). *Countryside and Community Research Institute, University of Gloucestershire, UK.*

Krejcie, R. V. and Morgan, D. W. (1970). Determining sample size for research activities. *Educational and psychological measurement*, 30(3):607–610.

Kuhmonen, T. (2017). Exposing the attractors of evolving complex adaptive systems by utilising futures images: Milestones of the food sustainability journey. *Technological Forecasting and Social Change*, 114:214–225.

Lacoste, S. (2016). Sustainable value co-creation in business networks. *Industrial Marketing Management*, 52:151–162.

Lagorio, A., Pinto, R., and Golini, R. (2016). Research in urban logistics: a systematic literature review. *International Journal of Physical Distribution & Logistics Management*, 46(10):908–931.

Lagorio, A., Pinto, R., and Golini, R. (2018). Food waste reduction in school canteens: Evidence from an italian case. *Journal of Cleaner Production*, 199:77–84.

Lambert, D. M. (2008). The supply chain management and logistics controversy. In *Handbook of logistics and supply-chain management*, pages 99–126. Emerald Group Publishing Limited.

Lambert, S., Riopel, D., and Abdul-Kader, W. (2011). A reverse logistics decisions conceptual framework. *Computers & Industrial Engineering*, 61(3):561–581.

Le Velly, R., Bottois, V., Bréchet, J.-P., Chazoule, C., Cornée, M., Emin, S., Praly, C., and Schieb-Bienfait, N. (2010). Comment se fait la rencontre entre offres et demandes locales pour la restauration collective publique? premiers enseignements. In *Colloque National Circuits Courts Alimentaires*, pages 1–10.

Lebeau, P., Macharis, C., Van Mierlo, J., and Janjevic, M. (2018). Improving policy support in city logistics: The contributions of a multi-actor multi-criteria analysis. *Case Studies on Transport Policy*, 6(4):554–563.

LeBlanc, J. R., Conner, D., McRae, G., Darby, H., et al. (2014). Building resilience in nonprofit food hubs. *Journal of Agriculture, Food Systems, and Community Development*, 4(3):1–15.

León-Bravo, V., Caniato, F., and Caridi, M. (2018). Sustainability in multiple stages of the food supply chain in italy: practices, performance and reputation. *Operations Management Research*, pages 1–22.

Leonardi, J., Browne, M., and Allen, J. (2012). Before-after assessment of a logistics trial with clean urban freight vehicles: A case study in london. *Procedia-Social and Behavioral Sciences*, 39:146–157.

Lessirard, J., Patier, C., Perret, A., and Richard, M. (2017). SociÃ©tÃ©s de restauration collective en gestion concédée, en restauration commerciale et approvisionnements de proximité. Technical report, CGAAER Conseil GÃ©nÃ©ral de l'alimentation, de l'agriculture et des espaces ruraux.

Li, D., Wang, X., Chan, H. K., and Manzini, R. (2014). Sustainable food supply chain management. *International Journal of Production Economics*, 152(0):1–8.

Li, W., Xu, L., and Schuurmans, D. (2010). Facility locations revisited: An efficient belief propagation approach. *2010 IEEE International Conference on Automation and Logistics, ICAL 2010*, pages 408–413.

Li, Y., Ye, F., Sheu, C., and Yang, Q. (2018). Linking green market orientation and performance: Antecedents and processes. *Journal of Cleaner Production*, 192:924–931.

Liljestrand, K. (2016). Improvement actions for reducing transport's impact on climate: A shipper's perspective. *Transportation Research Part D: Transport and Environment*, 48:393–407.

Lin, J., Chen, Q., and Kawamura, K. (2016). Sustainability si: logistics cost and environmental impact analyses of urban delivery consolidation strategies. *Networks and Spatial Economics*, 16(1):227–253.

Lindgreen, A., Antioco, M., Harness, D., and van der Sloot, R. (2009). Purchasing and marketing of social and environmental sustainability for high-tech medical equipment. *Journal of Business Ethics*, 85(2):445–462.

Lindholm, M. (2010). A sustainable perspective on urban freight transport: Factors affecting local authorities in the planning procedures. *Procedia-Social and Behavioral Sciences*, 2(3):6205–6216.

Lindon, D., Lendrevie, J., Lévy, J., DIONÍSIO, P., and Rodrigues, J. (2009). Mercator xxi: Teoria e prática do. *Marketing*.

Liu, Z. L., Anderson, T. D., and Cruz, J. M. (2012). Consumer environmental awareness and competition in two-stage supply chains. *European Journal of Operational Research*, 218(3):602–613.

Lloyd, S. (1982). Least squares quantization in pcm. *IEEE transactions on information theory*, 28(2):129–137.

Lopes, R. B., Santos, B. S., Dias, P., and Ferreira, C. (2010). Information visualization in facility location and vehicle routing decisions. In *2010 14th International Conference Information Visualisation*, pages 110–115. IEEE.

Macharis, C. and Melo, S. (2011). *City distribution and urban freight transport: multiple perspectives*. Edward Elgar Publishing.

MacQueen, J. et al. (1967). Some methods for classification and analysis of multivariate observations. In *Proceedings of the fifth Berkeley symposium on mathematical statistics and probability*, volume 1, pages 281–297. Oakland, CA, USA.

Mancini, S., Gonzalez-Feliu, J., and Crainic, T. G. (2014). Planning and optimization methods for advanced urban logistics systems at tactical level. In *Sustainable Urban Logistics: Concepts, Methods and Information Systems*, pages 145–164. Springer.

Mantovani, A., Tarola, O., and Vergari, C. (2016). Hedonic and environmental quality: a hybrid model of product differentiation. *Resource and Energy Economics*, 45:99–123.

Mantovani, A. and Vergari, C. (2017). Environmental vs hedonic quality: which policy can help in lowering pollution emissions? *Environment and Development Economics*, 22(3):274–304.

Manzini, R. and Accorsi, R. (2013). The new conceptual framework for food supply chain assessment. *Journal of food engineering*, 115(2):251–263.

Marshall, C. and Rossman, G. B. (2014). *Designing qualitative research*. Sage publications.

Matson, J. and Thayer, J. (2016). The role of food hubs in food supply chains. *Journal of Agriculture, Food Systems, and Community Development*, 3(4):43–47.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach*, volume 41. Sage publications.

McKinnon, A. (2000). Sustainable distribution: opportunities to improve vehicle loading. *Industry and environment*, 23(4):26–27.

Melo, S. and Costa, A. (2011). Definition of a Set of Indicators to Evaluate the Performance of Urban Goods Distribution Initiatives. In *City Distribution and Urban Freight Transport*. Edward Elgar Publishing.

Melo, S. M. d. B. M. et al. (2010). Evaluation of urban goods distribution initiatives towards mobility and sustainability: indicadors, stakeholders and assessment tools.

Meyer, R., Benetto, E., Igos, E., and Lavandier, C. (2017). Analysis of the different techniques to include noise damage in life cycle assessment. a case study for car tires. *The International Journal of Life Cycle Assessment*, 22(5):744–757.

Meynard, J.-M., Jeuffroy, M.-H., Le Bail, M., Lefèvre, A., Magrini, M.-B., and Michon, C. (2017). Designing coupled innovations for the sustainability transition of agrifood systems. *Agricultural Systems*, 157:330–339.

Michelsen, O. and de Boer, L. (2009). Green procurement in norway; a survey of practices at the municipal and county level. *Journal of Environmental Management*, 91(1):160–167.

Migliore, G., Schifani, G., and Cembalo, L. (2015). Opening the black box of food quality in the short supply chain: Effects of conventions of quality on consumer choice. *Food Quality and Preference*, 39:141–146.

Miles, M. B. and Huberman, A. M. (1984). Qualitative data analysis: A sourcebook of new methods. In *Qualitative data analysis: a sourcebook of new methods*. Sage publications.

Miranda, P. A., Garrido, R. A., and Ceroni, J. A. (2009). e-work based collaborative optimization approach for strategic logistic network design problem. *Computers & Industrial Engineering*, 57(1):3–13.

Moazzam, M., Akhtar, P., Garnevska, E., and Marr, N. E. (2018). Measuring agri-food supply chain performance and risk through a new analytical framework: a case study of new zealand dairy. *Production Planning & Control*, 29(15):1258–1274.

Moldan, B., Janoušková, S., and Hák, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, 17:4–13.

Morana, J. and Gonzalez-Feliu, J. (2015a). Le tableau de bord durable d'un système mutualisé des livraisons à l'aune des préoccupations du xxième siècle. *Revue française de gestion industrielle*, 34(1):pp–45.

Morana, J. and Gonzalez-Feliu, J. (2015b). A sustainable urban logistics dashboard from the perspective of a group of operational managers. *Management Research Review*, 38(10):1068–1085.

Morganti, E. (2018). Food logistics and urban 09. *Urban Logistics: Management, Policy and Innovation in a Rapidly Changing Environment*, page 196.

Morganti, E. and Gonzalez-Feliu, J. (2013). Pôles logistiques alimentaires: un nouveau concept pour l'approvisionnement des villes. *Nutripolis*, pages En–ligne.

Morganti, E. and Gonzalez-Feliu, J. (2015a). City logistics for perishable products. the case of the parma's food hub. *Case Studies on Transport Policy*, 3(2):120–128.

Morganti, E. and Gonzalez-Feliu, J. (2015b). The last food mile concept as a city logistics solution for perishable products. *Enterprise Interoperability: Interoperability for Agility, Resilience and Plasticity of Collaborations (I-ESA 14 Proceedings)*, page 202.

Morganti, M. E. (2011). *Urban food planning, city logistics and sustainability: the role of the wholesale produce market. The cases of Parma and Bologna food hubs.* PhD thesis, alma.

Morley, A. S., Morgan, S. L., and Morgan, K. J. (2008). Food hubs: the 'missing middle' of the local food infrastructure?

Mundler, P. and Laughrea, S. (2016). The contributions of short food supply chains to territorial development: A study of three quebec territories. *Journal of Rural Studies*, 45:218–229.

Muñuzuri, J., Van Duin, J., and Escudero, A. (2010). How efficient is city logistics? estimating ecological footprints for urban freight deliveries. *Procedia-Social and Behavioral Sciences*, 2(3):6165–6176.

Murtagh, F. (1983). A survey of recent advances in hierarchical clustering algorithms. *The Computer Journal*, 26(4):354–359.

Nichols, K. et al. (2006). Alternative urban futures: Planning for sustainable development in cities throughout the world. *Ecological Economics*, 59(1):182–183.

Nicholson, C. F., Gómez, M. I., and Gao, O. H. (2011). The costs of increased localization for a multiple-product food supply chain: Dairy in the united states. *Food Policy*, 36(2):300–310.

Nordmark, I., Ljungberg, D., Gebresenbet, G., Bosona, T., and Jüriado, R. (2012). Integrated logistics network for the supply chain of locally produced food, part ii: Assessment of e-trade, economic benefit and environmental impact. *Journal of Service Science and Management*, 5(03):249.

Nouira, I. (2013). *Sur la prise en compte de la qualité environnementale des produits dans la conception des chaines logistiques vertes*. PhD thesis, Université de Grenoble.

Nouira, I., Frein, Y., and Hadj-Alouane, A. B. (2014). Optimization of manufacturing systems under environmental considerations for a greenness-dependent demand. *International Journal of Production Economics*, 150:188–198.

Nouira, I., Hammami, R., Frein, Y., and Temponi, C. (2016). Design of forward supply chains: Impact of a carbon emissions-sensitive demand. *International Journal of Production Economics*, 173:80–98.

Nsamzinshuti, A., Janjevic, M., Rigo, N., and Ndiaye, A. (2018). Short supply chains as a viable alternative for the distribution of food in urban areas? investigation of the performance of several distribution schemes. In *Sustainable Freight Transport*, pages 99–119. Springer.

Oglethorpe, D. and Heron, G. (2010). Sensible operational choices for the climate change agenda. *The International Journal of Logistics Management*, 21(3):538–557.

Ollagnon, H. (1987). Une nécessaire rencontre des approches théoriques et pragmatiques de la gestion de la nature: l'audit patrimonial de type système-acteurs. *Paris, Ministère de l'Agriculture-DAFE*.

Ottman, J., Stafford, E., and Hartman, C. (2006). Avoiding green marketing myopia. issue of environment, 48 (5) 22-36.

Otto, A., Schoppengerd, F. J., and Shariatmadari, R. (2009). *Direct store delivery: concepts, applications and instruments*. Springer Science & Business Media.

Palacios-Argüello, L., Girard, M.-A., Gondran, N., Gonzalez-Feliu, J., and Laforest, V. (2018a). Product's environmental criteria definition related to supply chain management. In *Proceedings of the 7th International Conference on Information Systems, Logistics and Supply Chain, ILS*, pages 465–474.

Palacios-Argüello, L. and Gonzalez-Feliu, J. (2016a). Assessing the sustainability of urban food systems for collective uses: case study of a french city. In *VREF Conference on Urban Freight 2016: Plan for the future-sharing urban space*, page F26.

Palacios-Argüello, L. and Gonzalez-Feliu, J. (2016b). Food hub as an efficient alternative to sustainably feed the cities. In *RIODD 2016*.

Palacios-Argüello, L., Gonzalez-Feliu, J., Gondran, N., and Badeig, F. (2018b). Assessing the economic and environmental impacts of urban food systems for public school canteens: case study of great lyon region. *European Transport Research Review*, 10(2):37.

Palacios-Argüello, L., Morganti, E., and Gonzalez-Feliu, J. (2017). Food hub: Una alternativa para alimentar las ciudades de manera sostenible. *Revista Transporte y Territorio*, (17):10–33.

Palacios-Argüello, L., Sanchez, I., Gonzalez-Feliu, J., and Gondran, N. (2018c). Towards a logistic organization for organic-local product supply case of study: School canteen distribution system. In *Proceedings of the 7th International Conference on Information Systems, Logistics and Supply Chain, ILS*, pages 552–561.

Palacios-Argüello, L., Sanchez, I., Gonzalez-Feliu, J., Gondran, N., and Carlsson, J. (2018d). A joint demand and supply chain characterization for school canteen urban distribution in sweden. In *VREF Conference on Urban Freight 2018: Current issues influencing urban freight research*, page P92.

Pan, S. (2010). *Contribution à la définition et à l'évaluation de la mutualisation de chaînes logistiques pour réduire les émissions de CO2 du transport: application au cas de la grande distribution*. PhD thesis, École Nationale Supérieure des Mines de Paris.

Parra-Herrera, J. E., Palacios-Argüello, L. V., Gonzalez-Feliu, J., and Adarme-Jaimes, W. (2017). Decision support system design requirements, information management, and urban logistics efficiency: Case study of bogotá, colombia. In *Handbook of Research on Information Management for Effective Logistics and Supply Chains*, pages 223–238. IGI Global.

Partyka, J. and Hall, R. (2010). On the road to connectivity. *OR/MS Today*, 37(1):42–49.

Patier, D. and Browne, M. (2010). A methodology for the evaluation of urban logistics innovations. *Procedia-Social and Behavioral Sciences*, 2(3):6229–6241.

Pisano, U., Lepuschitz, K., and Berger, G. (2014). Framing urban sustainable development: Features, challenges and potentials of urban sd from a multi-level governance perspective. *ESDN Quarterly Report*, (31):30.

Pope, J., Annandale, D., and Morrison-Saunders, A. (2004). Conceptualising sustainability assessment. *Environmental impact assessment review*, 24(6):595–616.

Portnov, B. A., Trop, T., Svechkina, A., Ofek, S., Akron, S., and Ghermandi, A. (2018). Factors affecting homebuyers' willingness to pay green building price premium: Evidence from a nationwide survey in israel. *Building and Environment*, 137:280–291.

Praly, C., Chazoule, C., Delfosse, C., Bon, N., and Cornée, M. (2009). La notion de" proximité" pour analyser les circuits courts. In *XLVIe colloque de l'ASRDLF*.

Prosperi, P., Moragues-Faus, A., Sonnino, R., and Devereux, C. (2015). Measuring progress towards sustainable food cities: sustainability and food security indicators. *Report of the ESRC financed Project "Enhancing the Impact of Sustainable Urban Food Strategies"*.

Raton, G., Gonçalves, A., Vaillant, L., Blanquart, C., Loeuilleux, P., and Tellier, C. (2015). Allocirco–alternatives logistiques pour les circuits courts en nord-pas-de-calais. *Rapport final, 275p*.

Renting, H., Marsden, T. K., and Banks, J. (2003). Understanding alternative food networks: exploring the role of short food supply chains in rural development. *Environment and planning A*, 35(3):393–411.

Riopel, D., Langevin, A., and Campbell, J. F. (2005). The network of logistics decisions. In *Logistics Systems: Design and Optimization*, pages 1–38. Springer.

Rodríguez-Reyes, M. (2009). La función de los mercados mayoristas en los centros urbanos de colombia. *Bogotá: FAO-Organización de las Naciones Unidas para la Agricultura y la Alimentación*.

Rousseeuw, P. J. (1987). Silhouettes: a graphical aid to the interpretation and validation of cluster analysis. *Journal of computational and applied mathematics*, 20:53–65.

Sánchez-Díaz, I. (2018). Potential of implementing urban freight strategies in the accommodation and food services sector. *Transportation Research Record*, page 0361198118796926.

Sarkis, J. (2003). A strategic decision framework for green supply chain management. *Journal of cleaner production*, 11(4):397–409.

Sawik, B., Faulin, J., and Pérez-Bernabeu, E. (2017). A multicriteria analysis for the green vrp: A case discussion for the distribution problem of a spanish retailer. *Transportation research procedia*, 22:305–313.

Ségalou, E. (1999). Preparation du bilan environnemental du tmv sur la ville de bordeaux. note relative au calcul de la distribution des flux de véhicules pour motif achat zone à zone. *Report LET-ADEME-DTT, Lyon, France.*

Segalou, E., Ambrosini, C., and Routhier, J.-L. (2004). The environmental assessment of urban goods movement. In *Logistics Systems for Sustainable Cities: Proceedings of the 3rd International Conference on City Logistics (Madeira, Portugal, 25–27 June, 2003)*, pages 207–220. Emerald Group Publishing Limited.

Semini, M., Fauske, H., and Strandhagen, J. O. (2008). Which manufacturing logistics decisions are supported by operational research? a literature survey. In *Lean Business Systems and Beyond*, pages 231–238. Springer.

Severson, R. M. and Schmit, T. M. (2015). *Building success of food hubs through the cooperative experience: A case study perspective.* Charles H. Dyson School of Applied Economics and Management, College of Agriculture and Life Sciences, Cornell University.

Sgarbossa, F. and Russo, I. (2017). A proactive model in sustainable food supply chain: Insight from a case study. *International Journal of Production Economics*, 183:596–606.

Sharma, A., Iyer, G. R., Mehrotra, A., and Krishnan, R. (2010). Sustainability and business-to-business marketing: A framework and implications. *Industrial Marketing Management*, 39(2):330–341.

Simula, H., Lehtimäki, T., and Salo, J. (2009). Managing greenness in technology marketing. *Journal of systems and Information Technology*, 11(4):331–346.

Skilton, P. F. and Robinson, J. L. (2009). Traceability and normal accident theory: how does supply network complexity influence the traceability of adverse events? *Journal of Supply Chain Management*, 45(3):40–53.

Smith, J., Andersson, G., Gourlay, R., Karner, S., Mikkelsen, B. E., Sonnino, R., and Barling, D. (2016). Balancing competing policy demands: the case of sustainable public sector food procurement. *Journal of Cleaner Production*, 112:249–256.

Soylu, K. and Dumville, J. (2011). Design for environment: The greening of product and supply chain. *Maritime Economics & Logistics*, 13(1):29–43.

Sprenger, R. and Mönch, L. (2012). A methodology to solve large-scale cooperative transportation planning problems. *European Journal of Operational Research*, 223(3):626–636.

Stroink, M. L. and Nelson, C. H. (2013). Complexity and food hubs: five case studies from northern ontario. *Local Environment*, 18(5):620–635.

Tan, L. P., Johnstone, M.-L., and Yang, L. (2016). Barriers to green consumption behaviours: The roles of consumers' green perceptions. *Australasian Marketing Journal (AMJ)*, 24(4):288–299.

Taniguchi, E., Thompson, R., Yamada, T., and Van Duin, R. (2001). City Logistics-Network modelling and Intelligent Transport System, Amsterdam. *Elsevier*.

Thron, T., Nagy, G., and Wassan, N. (2007). Evaluating alternative supply chain structures for perishable products. *The international journal of logistics Management*, 18(3):364–384.

Torre, A. and Wallet, F. (2014). The role of proximity relations in regional and territorial development processes.

Toth, P. and Vigo, D. (2014). *Vehicle routing: problems, methods, and applications*. SIAM.

Tozzi, M., Corazza, M. V., and Musso, A. (2014). Urban goods movements in a sensitive context: The case of parma. *Research in Transportation Business & Management*, 11:134–141.

Union, E. (2011). Buying green a handbook on green public procurement. Technical report, Publications Office of the European Union, Luxembourg.

Vaccaro, V. L. (2009). B2b green marketing and innovation theory for competitive advantage. *Journal of systems and Information Technology*, 11(4):315–330.

Vaghi, C. and Percoco, M. (2011a). City logistics in Italy: success factors and environmental performance. *City Distribution and Urban Freight Transport: Multiple Perspectives. Edward Elgar, Northampton*, pages 151–175.

Vaghi, C. and Percoco, M. (2011b). City logistics in italy: success factors and environmental performance. *City Distribution and Urban Freight Transport: Multiple Perspectives. Edward Elgar, Northampton*, pages 151–175.

Vaillant, L., Gonçalves, A., Raton, G., and Blanquart, C. (2017). Transport et logistique des circuits courts alimentaires de proximité: la diversité des trajectoires d'innovation. *Innovations*, (3):123–147.

Validi, S., Bhattacharya, A., and Byrne, P. (2014). A case analysis of a sustainable food supply chain distribution system -a multi-objective approach. *International Journal of Production Economics*, 152:71–87.

Van Duin, R., Quak, H., and Munuzuri, J. (2008). Revival of cost benefit analysis for evaluating the city distribution centre concept. *Innovations in city logistics, Nova Science, New York*, pages 97–114.

Villanueva-Ponce, R., Garcia-Alcaraz, J. L., Cortes-Robles, G., Romero-Gonzalez, J., Jiménez-Macías, E., and Blanco-Fernández, J. (2015). Impact of suppliers' green attributes in corporate image and financial profit: case maquiladora industry. *The International Journal of Advanced Manufacturing Technology*, 80(5-8):1277–1296.

Vollebregt, H., Scheer, F., van der Vorst, J., and Pauls-Worm, K. (2010). . florilog regie: logistics orchestration in the pot plant supply chain network. *P ubli*, page 47.

Wang, W., Yang, J., Muntz, R., et al. (1997). Sting: A statistical information grid approach to spatial data mining. In *VLDB*, volume 97, pages 186–195.

Wang, Z., Wang, Q., Zhang, S., and Zhao, X. (2018). Effects of customer and cost drivers on green supply chain management practices and environmental performance. *Journal of Cleaner Production*, 189:673–682.

Wanke, P. F. and Zinn, W. (2004). Strategic logistics decision making. *International journal of physical distribution & logistics management*, 34(6):466–478.

Wieberneit, N. (2008). Service network design for freight transportation: a review. *OR spectrum*, 30(1):77–112.

Wolff, A., Gondran, N., and Brodhag, C. (2017). Detecting unsustainable pressures exerted on biodiversity by a company. application to the food portfolio of a retailer. *Journal of Cleaner Production*, 166:784–797.

Xiong, Y., Yang, J., and Li, Y. (2016). Price and carbon emission decisions under pressures of consumer, regulator and competition. *International Journal of Manufacturing Technology and Management*, 30(1-2):87–115.

Xu, X., He, P., Xu, H., and Zhang, Q. (2017). Supply chain coordination with green technology under cap-and-trade regulation. *International Journal of Production Economics*, 183:433–442.

Yalabik, B. and Fairchild, R. J. (2011). Customer, regulatory, and competitive pressure as drivers of environmental innovation. *International Journal of Production Economics*, 131(2):519–527.

Yang, D., Lu, Y., Zhu, W., and Su, C. (2015). Going green: How different advertising appeals impact green consumption behavior. *Journal of business research*, 68(12):2663–2675.

Yang, Y., Lu, G.-H., Guo, X., and Yamamoto, R. (2003). Greenness assessment of products in plca by dea approach. *Materials Transactions*, 44(4):645–648.

Yenipazarli, A. (2016). Managing new and remanufactured products to mitigate environmental damage under emissions regulation. *European Journal of Operational Research*, 249(1):117–130.

Yenipazarli, A. and Vakharia, A. J. (2017). Green, greener or brown: choosing the right color of the product. *Annals of Operations Research*, 250(2):537–567.

Yin, R. K. (2009). Case study research: Design and methods (applied social research methods). *London and Singapore: Sage*.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. Sage publications.

Zanoni, S. and Zavanella, L. (2012). Chilled or frozen? decision strategies for sustainable food supply chains. *International Journal of Production Economics*, 140(2):731–736.

Zhang, H. and Sheng, W. (2010). Application of dijkstra-based n-shortest-paths algorithm to catering logistics transportation. In *ICLEM 2010: Logistics For Sustained Economic Development: Infrastructure, Information, Integration*, pages 3317–3323.

Zhang, L., Li, D., Cao, C., and Huang, S. (2018). The influence of greenwashing perception on green purchasing intentions: The mediating role of green word-of-mouth and moderating role of green concern. *Journal of Cleaner Production*, 187:740–750.

Zhao, X. and Lv, Q. (2011). Optimal design of agri-food chain network: an improved particle swarm optimization approach. In *2011 International Conference on Management and Service Science*, pages 1–5. IEEE.

Zheng, Y., Liao, H., and Yang, X. (2016). Stochastic pricing and order model with transportation mode selection for low-carbon retailers. *Sustainability*, 8(1):48.

Zissis, D., Aktas, E., and Bourlakis, M. (2017). A new process model for urban transport of food in the uk. *Transportation research procedia*, 22:588–597.

Part IV

Appendices

.1 Appendix A. Summary of the recent literature on the product's environmental criteria regarding product characteristics

Table 27: Criteria related to raw materials characteristics

P1. Raw materials characteristics		
P 1.1	Energy efficient raw materia. Ex. thermal insulating materials	Dangelico et al (2010)
P 1.2	Raw materia allowing to extend lifecycle of other product. Ex. Use of recycled material.	Dangelico et al (2010)
P 1.3	Raw materia with extended lifecycle/high durability.	Dangelico et al (2010)
P 1.4	Environmentally certified raw materials	Dangelico et al (2010)
P 1.5	Renewable raw materials: Ex. - Organic material - Raw material from reforestation - Biodegradable materials.	Simon (1992); Dangelico et al (2010)
P 1.6	Raw materials not derived from threatened species or from threatened environments.	Elkington and Hailes (1988); Simon (1992); Peattie (1995); Ljungberg (2007); Dangelico et al (2010)
P 1.7	Less or non-polluting/toxic materials. Ex. - Materials not containing harmful or toxic substances for product	Dangelico et al (2010), De Medeiros et al (2017), EPA (2017)

Table 28: Criteria related to products components characteristics

P2. Products components characteristics		
P 2.1	Eco-designed products: Product with extended lifecycle/high durability by using reduced amount of toxic substances, using less or non-polluting/toxic materials Ex: - Products avoiding/reducing pollution/release of toxic substances of other products. - Products not causing unnecessary waste, either because of overpackaging or because of an unduly short useful life. - Reduction of solid wastes. - Products with reduced emissions. - Products without impact on protected species. - Products that reduce the pollution in the environment wherein disposed.	Elkington and Hailes (1988); Schmidheiny (1992); Simon (1992); Shrivastava and Hart (1995); Peattie (1995), Schvaneveldt (2003); Rao and Holt (2005); Luttropp and Lagerstedt (2006); Chen et al. (2006); Hu and Hsu (2006), Vachon (2007), Zhu et al. (2007); Zhu et al. (2008a,b), Chen (2008); Gonzalez et al. (2008), Holt and Ghobadian (2009), Routroy (2009); Paulraj (2009), Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); Chiou et al. (2011); Morana J. (2014); (Aung and Chang, 2014); Ahi, P., & Searcy, C. (2015); Chander et al (2015); (Chan, Yee, Dai, & Lim, 2016); EPA (2017); De Medeiros et al (2017).
P 2.2	Energy efficient products : Products requiring less energy to be produced or installed. Ex: - Products working through energy coming from renewable sources by themselves generated. - Products increasing energy generation efficiency. - Thermal insulating products. - Products with low energy and resource consumption during use.	Elkington and Hailes (1988), Simon (1992), Shrivastava and Hart (1995), Robert (1995), Luttropp and Lagerstedt (2006), Ljungberg (2007), Dangelico et al (2010)
P 2.3	Environmentally certified product: - Product using label: label from environmental quality of the product or from green practices. - Carbon footprint evaluation defined as ecological quality of the product.	Rao and Holt (2005), Chen et al. (2006); Chen (2008), Gonzalez et al. (2008), Holt and Ghobadian (2009), Dangelico et al (2010), Chiou et al. (2011), (Azevedo, Carvalho, & Cruz Machado, 2011), (Brecard, 2014), (Chan, Yee, Dai, & Lim, 2016), (Brecard, 2017), De Medeiros et al (2017)

Table 29: Criteria related to product's packaging

P3. Packaging		
P 3.1	Environmentally friendly packaging : - Packaging partly made of recyclable or biodegradable materials. - Packaging that can be recycled with high-energy efficient processes. - Packaging's size reducted and weight, more compact packaging. - Packaging completely reusable, remanufacturable or recyclable.	Simon (1992), Schmidheiny (1992), Roy et al. (1996), Rao and Holt (2005), Chen et al. (2006); Chen (2008); Zhu et al. (2008a,b), Routroy (2009), Dangelico et al (2010), Chiou et al. (2011), (Azevedo, Carvalho, & Cruz Machado, 2011), Morana J. (2014), (Aung and Chang, 2014), (Chan, Yee, Dai, & Lim, 2016).
P 3.2	Environmental information on product available to customer.	Roy et al. (1996), Dangelico et al (2010)

.2 Appendix B. Summary of the recent literature on the product's environmental criteria regarding organisational practices

Table 30: Criteria related to purchasing practices

O1. Purchasing practices		
O 1.1	Suppliers location - Give thought to keeping the circuits between the producer as short as possible. - Group the purchases with those suppliers who are closest - Seek out the closest competitive suppliers.	Hu and Hsu (2006), Zhu et al. (2008a), and Holt and Ghobadian (2009), (Azevedo, Carvalho, & Cruz Machado, 2011)
O 1.2	Environmental impact of purchased materials (raw materials and packaging) Ex. - Buy renewable materials for product and minimize the use of nonrenewable materials. - Increase the amount of recyclable materials. - Buy environmentally certified raw materials for product. - Buy of materials not containing harmful or toxic substances for product or packaging. - Do not buy materials derived from threatened species or from threatened environments.	Simon (1992), Schmidheiny (1992), Roy et al. (1996), Lippmann (1999), Schvaneveldt (2003), Rao and Holt (2005), Hu and Hsu (2006), Chen et al. (2006), Luttropp and Lagerstedt (2006), Zhu et al. (2007), Ljungberg (2007), Vachon (2007), Zhu et al. (2008a,b), Chen (2008), Holt and Ghobadian (2009), Paulraj (2009), Routroy (2009), Dangelico et al (2010), (Azevedo, Carvalho, & Cruz Machado, 2011), (Azevedo, Carvalho, & Cruz Machado, 2011), Chiou et al. (2011), Morana J. (2014), (Aung and Chang, 2014), Ahi, P., & Searcy, C. (2015), (Chan, Yee, Dai, & Lim, 2016).
O 1.3	Environmental practices performed by the supplier: - Supplier green image: Green marketing strategies are comunicated to the business customer. - Green certification because of the suppliers' environmentally friendly practices. - ISO certification of suppliers.	Hu and Hsu (2006), Vachon (2007), Zhu et al. (2008a), Zhu et al. (2008b), Holt and Ghobadian (2009), Paulraj (2009), Holt and Ghobadian (2009), Routroy (2009), Paulraj (2009), (Azevedo, Carvalho, & Cruz Machado, 2011), Morana J. (2014), Ahi, P., & Searcy, C. (2015)
O 1.4	Using green purchasing guideline: - Greening procurement/ sourcing, substitute environmentally preferred buying processes. - Increase the size of your orders and your lots (group together and consolidate flows) - Communicating to third-suppliers environmental criteria for goods and services. - Providing design specification to suppliers that include environmental requirements for purchased item.	Schmidheiny (1992), Hu and Hsu (2006), Vachon (2007), Zhu et al. (2008a,b), Holt and Ghobadian (2009), Paulraj (2009), Routroy (2009), Dangelico et al (2010), (Azevedo, Carvalho, & Cruz Machado, 2011), (Aung and Chang, 2014), Morana J. (2014)
O 1.5	Environmental partnership with suppliers: - Arranging for funds to help suppliers to purchase equipment for pollution prevention, waste water recycling, etc. - Encouraging suppliers to take back packaging. - Working with suppliers to reduce and eliminate product environmental impact.	Lippmann (1999), Rao and Holt (2005), Hu and Hsu (2006), Zhu et al. (2007), Zhu et al. (2008a,b), Paulraj (2009), Holt and Ghobadian (2009), (Azevedo, Carvalho, & Cruz Machado, 2011), Ahi, P., & Searcy, C. (2015)

Table 31: Criteria related to manufacturing practices

O 2. Manufacturing practices		
O 2.1	Location decision on manufacturing and warehouse : - Localized production near to the consumption bases and supplier bases. - Relocate distant production sites to closer sites. - Take account of all the cost variables of long distance supply and production (prolonged transport times, increased stock inventories, delays, less predictability, more difficult monitoring and poorer quality, increased spending on business travel, more frequent use of transport or of breakdown repairers, etc.).	Roy et al. (1996); Dangelico et al (2010); Morana J. (2014).
O 2.2	Energy efficiency of production: - Use of renewable energy sources in production processes. - Use of co-generation plants to provide electricityheatingand cooling in production processes. - Generating energy from exhaust hot gas/waste in production processes. - Use of more efficient energy generation systems in production processes. - Minimize energy and resource consumption in the production phase and transport.	Ellkington and Hailes (1988); Schmidheiny (1992); Simon (1992); Peattie (1995); Roy et al. (1996); Rao and Holt (2005); Luttropp and Lagerstedt (2006); Gonzalez et al. (2008); Holt and Ghobadian (2009); Paulraj (2009), Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); Ahi, P., & Searcy, C. (2015); EPA (2017).
O 2.3	Eco-efficiency of production: Causing no significant damage to the environment during manufacture. Ex: - Proper waste disposal (ex. transforming production waste in fuel). - Using standardized components to facilitate their reuse. - Internal recycling of materials within the production phase. - Formal policy on green warehouse, lend favor to new high environmental quality (HQE) platforms. - Water use efficiency: To assess water consumption and water use during the manufacturing phase. - Reduction of emissions due in production process (1) Air emissions control: To assess Air emissions and Greenhouse gas emissions, global warming contribution per unit of net value added. Using filters and controls for emissions and discharges. (2) Pollution control: Non-polluting manufacture.	Elkington and Hailes (1988); Simon (1992); Schmidheiny (1992); Peattie (1995); Shrivastava and Hart (1995); Roy et al. (1996); Schvaneveldt (2003); (Rao and Holt (2005); Vachon (2007); Ljungberg (2007); Gonzalez et al. (2008); Zhu et al. (2008b); Holt and Ghobadian (2009); Paulraj (2009); Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); (Brecard, 2013); Morana J. (2014); (Aung and Chang, 2014); Ahi, P., & Searcy, C. (2015); Chander et al (2015); Ahmadi, A., & Bouri, A. (2017), EPA (2017); De Medeiros et al (2017).
O 2.4	Greener production technology : Use of cleaner technology processes. Ex. - Invest in green technologies required for production of green products and that allow to make some savings in the ressources. - Training the employees to use environmental technologies in an efficiency way	Amacher et al. (2004); (N. W. Chan & Kotchen, 2014), Ahi, P., & Searcy, C. (2015); De Medeiros et al (2017).

Table 32: Criteria related to distribution practices

O 3. Distribution practices		
O 3.1	Location decision on distribution points: - Avoid a proliferation of hubs, platforms, shops and depots which increase the dispersity of cargos and detours on delivery rounds; or, conversely, too centralized platforms (national or continental) which increase delays and delivery times. - Use shared logistical platforms, use river ports and railway depots to consolidate incoming flows. - Create relay points to limit the number of vehicles and the mileage covered.	Dangelico et al (2010); Morana J. (2014); De Medeiros et al (2017)
O 3.2	Energy efficiency of distribution: To perform the distribution by using environmentally friendly transportation. Ex. - Formal policy on the use of green vehicles: Support research and innovation in terms of clear CO2 and clean vehicles, favor newer vehicles, which are green and clean, which consume less or use renewable energies. - Use ”soft” modes of transport (electric vehicles, electrically-assisted bicycles, etc.) for small urban distances. - Bio fuels use: The possibility of using biofuels, features that reduce CO2 emissions and also hybrid engine technology. - Use of flex-fuel technology (i.e. automobiles that run both on gasoline and ethanol). - Improve the vehicles in technical terms (restriction of engines, aerodynamic accessories, tires, automatic gearboxes, self-cooling engines, etc.).	Roy et al. (1996); Rao and Holt (2005), Rao and Holt (2005), Gonzalez et al. (2008), Holt and Ghobadian (2009), Paulraj (2009); Holt and Ghobadian (2009); Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); Morana J. (2014), Ahi, P., & Searcy, C. (2015);De Medeiros et al (2017); EPA (2017).
O 3.3	Eco-efficiency of distribution: - Pollution control: Use modes of transport which are slower but more consolidated, more economic and less heavy emitters of CO2 (rail, river, sea) the opportunities of multimodal transport. - Reduction of emissions due to transportation : (1) Air emissions control: To assess Air emissions and Greenhouse gas emissions, global warming contribution per unit of net value added. Using filters and controls for emissions and discharges. (2) Train drivers in eco-driving and in behavior (switching off engines when stopped, use of air conditioning, etc.). (3) Planning vehicle routes for reduced environmental impacts (Avoid multiple deliveries to the same customer, weed out miles covered by empty vehicles. (4) Assess your itineraries as closely as possible (reduce the miles covered, avoid backlogs, equip your fleets with tracking devices). Give thought to keeping the circuits between the consumer as short as possible. (5) Increase the capacity of the transport units (e.g. layers one on top of another in a truck, or higher palettes). - Organize pooling (filling of trucks by multiple orders), multidrop (combination of small deliveries to nearby customers), multipick (concentration of deliveries from multiple suppliers), etc. to reduce the number of vehicles in circulation and with whom you can work to concentrate flows using shared means (transport, platforms).	Peattie (1995); Roy et al. (1996); Ljungberg (2007); Gonzalez et al. (2008); Zhu et al. (2008a), Holt and Ghobadian (2009); Paulraj (2009), Holt and Ghobadian (2009); Dangelico et al (2010); Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); (Brécard, 2013); Morana J. (2014); Ahi, P., & Searcy, C. (2015); Chander et al (2015); Ahmadi, A., & Bouri, A. (2017).

Table 33: Criteria related to reverse logistics practices

O 4. Reverse logistics practices		
O 4.1	Formal policy on reverse logistics: Post-consumer collection/disassembly system. - Recovery of company's end-of-life products and recycling. - Organize your reverse logistics (packaging, old products, repairs, exchanges, unsold stock, etc.).	Simon (1992); Schmidheiny (1992); Roy et al. (1996); Lippmann (1999); Rao and Holt (2005); Hu and Hsu (2006); Luttropp and Lagerstedt (2006); Chen et al. (2006); Zhu et al. (2007); Vachon (2007); Gonzalez et al. (2008); Zhu et al. (2008a); Chen (2008); Routroy (2009); Ljungberg (2007); Gonzalez et al. (2008); Holt and Ghobadian (2009); Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); Chiou et al. (2011); Morana J. (2014); (Chan, Yee, Dai, & Lim, 2016); De Medeiros et al (2017).

Table 34: Criteria related to collaboration practices

O5. Transversal: Stakeholder collaboration practices		
O 5.1	Customer management practices: Cooperation with customer in the product eco-design. Ex - Working with customers to change product specifications. - Cooperation with customers for green packaging. - Customers return original packaging or pallet systems. - To asess the retention of green consumers	Lippmand (1999); Zhu et al. (2008a,b); Gonzalez et al. (2008); Holt and Ghobadian (2009); (Azevedo, Carvalho, & Cruz Machado, 2011); Ahi, P., & Searcy, C. (2015).
O 5.2	The green network efficiency: - Green strategies influence prices, qualities and market shares differently. - Collaborating with other companies and organisations for environmental initiatives. - Improving opportunities for reducing waste through cooperation with other actors. - Improve the quality of products so as to limit after-sales flows.	(Brécard, 2013); Morana J. (2014); Ahi, P., & Searcy, C. (2015).
O 5.3	Product's environmental performance assessment: A practice to improve the environmental performance of products is taking into account the energy efficiency of the product. - To assess the environmental cost. - Develop Life cycle assessment (LCA) for every product . - To assess Revenues from "green" products. - To perform and environmental performance measurement according to the organizational processes (environmental accounting, audits, environmental reports). - To perform and environmental performance measurement according to the regulatory compliance (compliance with ISO, number of audits.). - Evaluating environmental disclosure in annual report with the material capital expenditures to reduce the hazardous emissions. - A nonfinancial ratio based on the level of pollution emissions released by the organization or the relative quantity of hazardous waste recycled, and they feel that it is important to qualify the measure of environmental disclosure and distinguish it from its more generic connotation. - To assess number of regulatory violations by type.	Schvaneveldt (2003), Ahi, P., & Searcy, C. (2015), Ahmadi, A., & Bouri, A. (2017)
O 5.4	Implementing environmental management system (EMS): Integrating total quality environmental management (TQEM) into planning and operation processes. - To prepare and to obtain ISO 14000 certification (environmental management). - Environmental reporting should be reports on emissions trading schemes and include reporting greenhouse gas direct and indirect emissions, recycling or disposal waste and fuel combustion in boilers. - The environmental reporting must reflect to the emissions trading schemes and include reporting greenhouse gas direct and indirect emissions, recycling or disposal waste and fuel combustion in boilers. - Environmental compliance and auditing programs. - To apply Environmental policies and audits.	Schmidheiny (1992); Simon (1992); Rao and Holt (2005); Hu and Hsu (2006); Luttropp and Lagerstedt (2006); Ljungberg (2007); Zhu et al. (2007); Vachon (2007); Zhu et al. (2008a); Zhu et al. (2008a,b); Gonzalez et al. (2008); Routroy (2009); Holt and Ghobadian (2009); Dangelico et al (2010); (Azevedo, Carvalho, & Cruz Machado, 2011); Morana J. (2014); Ahi, P., & Searcy, C. (2015); Ahmadi, A., & Bouri, A. (2017).

.3 Appendix C: Semi-structured interview guide applied in french to extract product environmental criteria perception

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation

- Pourriez-vous décrire votre entreprise ou établisement?
  - Quelle est la position de l'entreprise dans le secteur (Leader ?)
  - Quel est l'ordre de grandeur du volume de marché que représente votre entreprise?
  - Dans ce volume, quelle part de votre marché représente votre offre/demande de produits écoresponsables - verts?
  - Qui sont vos partenaires (privé/public)?

Diagnostic

- Comment est géré l'approvisionnement des produits écoresponsables/verts chez-vous ?
  - Combien avez-vous de fournisseurs ?
    * Quel sont vos principaux critères de sélection des fournisseurs ? (En général et plus particulièrement sur l'environnement ?
  - Selon vous quelles sont les principales modifications apportées par le fait de privilégier les produits écoresponsables/verts? Quels ont été les principaux freins? Préciser les principaux risques ?
- Comment est géré la vente et distribution des produits écoresponsables/verts chez-vous ?
  - Qui sont vos principaux clients ?
  - Certains de vos clients vous ont-ils déjà fait part de leurs préoccupations environnementales ? (cahiers de charges demandant emballages recyclables, produits ne nuisant pas à l'environnement, mise en place de SME, etc.)
  - Selon vous quelles sont les principales modifications apportées par le fait de privilégier une offre de produits écoresponsables/verts?

  * Qu'est-ce qu'a motivé ou favorisé ces choix ?
  * Quels ont été les principaux freins?
  * Préciser les principaux risques ?

Prospective

- Comment voyez-vous l'évolution de la demande des produits écoresponsables/vertes dans un futur proche ?
  - Est-ce-que vous envisagez d'augmenter le nombre des fournisseurs (verts) et votre offre des produits verts ? et spécifiquement avec la restauration collective ?
  - Comment voyez-vous l'adoption des stratégies vertes afin d'augmenter votre part de marché dans la restauration collective ?

Proposition d'actions

- Selon vous, quelles pourraient être les autres démarches qui pourront impacter la qualité environnementale de vos produits afin d'augmenter votre part de marché dans la restauration collective ?
  - Motivations réglementaires : Certification environnement (ISO 14000, SMEA)
  - Motivations stratégiques: Avantage de compétitivité
  - Motivations économiques : Augmentation des prix à cause de l'introduction des produits écoresponsables/verts

.4 Appendix D: On-line survey applied in french

Industrie Agro-Alimentaire : Attractivité de la Qualité et de la Performance environnementale

CONCLUDE

<u>CON</u>ception des <u>C</u>haînes <u>L</u>ogistiques avec <u>U</u>ne <u>D</u>emande sensible à la performance <u>E</u>nvironnementale

https://conclude.mines-stetienne.fr/

Information préliminaire sur l'enquête

En collaboration avec Rennes School of Business et l'Institut Polytechnique de Grenoble, le département Génie de l'Environnement et des Organisations de l'école des Mines de Saint-Etienne développe le projet CONCLUDE qui est soutenu par l'ANR (Agence Nationale de la Recherche).

Dans ce cadre nous cherchons à recueillir l'opinion des professionnels et capitaliser sur leurs pratiques dans le domaine. Nous avons retenu deux secteurs cibles en particulier : l'industrie automobile d'une part, l'industrie agro-alimentaire d'autre part.

Pour ce faire, nous avons choisi de mettre en œuvre une enquête en ligne et quelques interviews.

Enquête sur les facteurs environnementaux susceptibles d'affecter le niveau de la demande

Formulaire concernant l'industrie agro-alimentaire

Il comporte 4 parties :

A. Informations générales du répondant et de votre entreprise
B. Concernant la qualité environnementale de vos produits
C. Concernant vos pratiques visant à satisfaire et développer la qualité environnementale de vos produits et la performance de vos processus
D. Concernant la qualité environnementale de vos fournisseurs

Il y a 57 questions dans ce questionnaire

Rappel des conventions

1 []" le questionnaire porte sur un produit spécifique auquel vous pouvez penser, sur lequel une stratégie de prise en compte de l'environnement dans la conception du produit et la gestion de la chaîne logistique a été mise en place"

Parlant de la qualité environnementale, nous entendons les propriétés intrinsèques du produit qui fait l'objet des transactions (achat aux fournisseurs comme vente aux clients).

Un certain nombre de pratiques, si elles ne contribuent pas directement à la construction de ces propriétés du produit lui-même, peuvent néanmoins participer à une évaluation plus favorable des impacts environnementaux de l'activité (par ex, certains choix de transport), et ainsi améliorer la perception des partenaires et l'attractivité de vos activités.

Etudiant les facteurs environnementaux susceptibles d'influencer la demande, il nous a paru logique de les intégrer au questionnement.

Le questionnaire prévoit des questions optionnelles, en fonction des réponses fournies et notamment en fonction des responsabilités de la personne qui remplit le questionnaire

Selon le choix du service	Partie B	Partie C	Partie D
	Produit	Pratiques	Fournisseurs
Direction	10→14	15 → 26	27 → 32
RSE	10→14	15 → 26	27 → 32
Qualité	10→14	15 → 26	27 → 32
Achats		15→17, 24 →26	27 → 32
Production		18, 24 →26	
Logistique - Recyclage		19→22, 24 →26	
Commercial - Ventes	10→14	23→ 26	
Communication / Marketing	10→14	23 → 26	

Veuillez écrire votre réponse ici :

A - Informations générales sur les activités de l'entreprise

2 []Quel est le nom de l'établissement ?

Veuillez écrire votre réponse ici :

3 []Quel est l'effectif des emplois sur le site ? *

Veuillez sélectionner une seule des propositions suivantes :

- 5 personnes ou moins
- 5 à 50 personnes
- 50 à 500 personnes
- Plus de 500 personnes
- Réponse inconnue
- Non réponse

4 []Votre entreprise fait elle partie d'un groupe ? *

Veuillez sélectionner une seule des propositions suivantes :

- OUI
- NON

5 []Quel est le nom de ce groupe ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'OUI' à la question '4 [Dans un groupe]' (Votre entreprise fait elle partie d'un groupe ?)

Veuillez écrire votre réponse ici :

6 []Quel est l'effectif du groupe ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'OUI' à la question '4 [Dans un groupe]' (Votre entreprise fait elle partie d'un groupe ?)

Veuillez sélectionner une seule des propositions suivantes :

- moins de 10 personnes
- 10 à 250 personnes
- 250 à 2000 personnes
- Plus de 2000 personnes
- Réponse inconnue
- Non réponse

7 []De quel type d'industrie agroalimentaire votre entreprise se rapproche t'elle le plus ? *

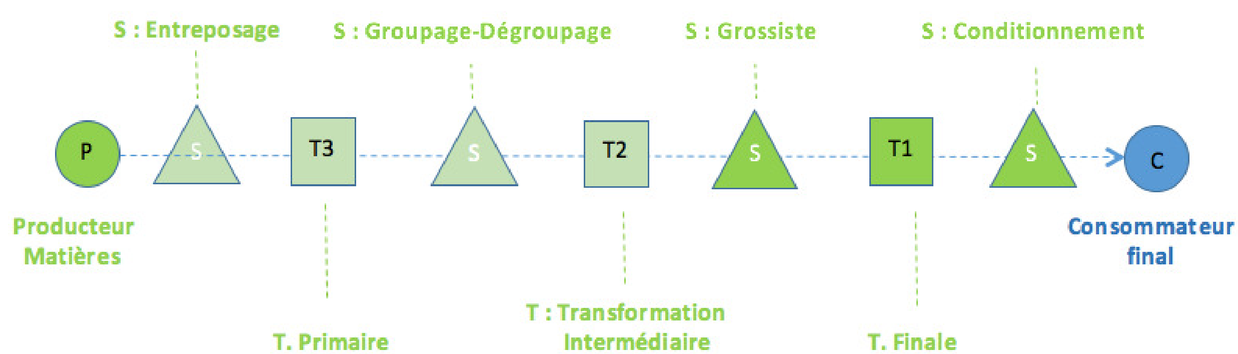
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Filière Maraichage
- ◯ Filière Viandes
- ◯ Filière Poissons
- ◯ Filière grains
- ◯ Filière Lait
- ◯ Industrie des boissons
- ◯ Industrie des pâtes alimentaires et boulagerie
- ◯ Fabrication d'aliments pour animaux
- ◯ Autres, préciser en commentaire

Faites le commentaire de votre choix ici :

8 []

Sur la chaîne logistique globale, entre matières premières et consommateurs finaux,



vous estimez qu'il y a environ : *

Veuillez sélectionner une seule des propositions suivantes :

- ◯ 1 seul échelon de transformation (ex T1)
- ◯ 2 échelons de tranformation (ex T3 et T1)
- ◯ 3 échelons de transformation (ex T3 - T2 - T1)
- ◯ Plus de 3 échelons échelons de transformation entre producteur des matières premières et consommateur final
- ◯ Ne sait pas
- ◯ Non réponse

9 []Les activités de votre entreprise se situent principalement au niveau : *

Veuillez sélectionner une seule des propositions suivantes :

- ○ des services (codes en S, par ex : Entreposage, Groupage/dégroupage, Transport, Conditionnement...)
- ○ de la transformation (codes en T, par ex : Fabrication (élevage - culture, Collecte, Préparation, Cuisine ...)

10 []

Par rapport à la chaine complète, à quel stade d'évolution du produit situeriez vous les activités de votre site

Entre AMONT (0 : Production des matières premières) et AVAL (100 : Livraison au Consommateur final) : *

Veuillez écrire votre(vos) réponse(s) ici :

11 []

Quant à la position de la personne qui répond à ce questionnaire.

Quelle est votre fonction ? *

Veuillez sélectionner une seule des propositions suivantes :

- ○ Cadre dirigeant
- ○ Ingénieur
- ○ Technicien
- ○ Autre

12 []Préciser votre fonction

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Autre' à la question '11 [QuiRepond]' (Quant à la position de la personne qui répond à ce questionnaire. Quelle est votre fonction ?)

Veuillez écrire votre réponse ici :

13 []Quelle est votre expérience dans cette fonction ?

Veuillez sélectionner une seule des propositions suivantes :

- ○ Moins de deux ans
- ○ 2 à 5 ans
- ○ 5 à 10 ans
- ○ plus de 10 ans

14 []Votre fonction actuelle vous amène à traiter principalement de questions *

Veuillez choisir toutes les réponses qui conviennent :

- ☐ RSE - Qualité
- ☐ Achats - Approvisionnements
- ☐ Production
- ☐ Logistique
- ☐ Commercialisation - Distribution
- ☐ Marketing - Communication
- ☐ Direction

B - Concernant la qualité environnementale de vos produits

15 []

MATIERES PREMIERES :

Parmi les critères ci-dessous, quels sont ceux qui permettent le mieux de définir la qualité environnementale de <u>votre produit</u> *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner au moins une réponse

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Utilisation de produits non toxiques dans le process (nettoyage, adjuvants...)
- ☐ Préférence pour des matières de provenance locale ou nationale
- ☐ Utilisation d'ingrédients issus du commerce équitable
- ☐ Utilisation d'ingrédients ayant une tracabilité garantie
- ☐ Utilisation d'ingrédients labellisés AB (agriculture bio)
- ☐ Ingredients labellisés avec d'autres normes (ex UTZ ...)
- ☐ Autre caractéristique : préciser en commentaire
- ☐ Aucun critère

16 []Quel autre critère souhaitez vous mentionner ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '15 [B Matières]' (MATIERES PREMIERES : Parmi les critères ci-dessous, quels sont ceux qui permettent le mieux de définir la qualité environnementale de votre produit)

Veuillez écrire votre(vos) réponse(s) ici :

Critère 1 ________________

Critère 2 ________________

17 []

EMBALLAGES :

Parmi les critères ci-dessous, quels sont ceux qui permettent le mieux de définir la qualité environnementale de votre produit *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner au moins une réponse

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Préférence pour des emballages non toxiques
- ☐ Préférence pour des emballages recyclables
- ☐ Préférence pour des emballages biodégradables
- ☐ Utilisation d'emballages affichant les informations environnementales
- ☐ Autre caractéristique : préciser en commentaire
- ☐ Aucun critère

18 []Quel autre critère souhaitez vous mentionner ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Autre caractéristique : préciser en commentaire' à la question '17 [B Emball]' (EMBALLAGES : Parmi les critères ci-dessous, quels sont ceux qui permettent le mieux de définir la qualité environnementale de votre produit)

Veuillez écrire votre réponse ici :

19 []Vos produits sont ils labellisés par rapport à l'environnement ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- ○ OUI
- ○ NON
- ○ ne sait pas ou non réponse

20 []

Quels sont ces labels ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI' à la question '19 [Label]' (Vos produits sont ils labellisés par rapport à l'environnement ?)

Veuillez écrire votre(vos) réponse(s) ici :

Label 1	
Label 2	
Label 3	

21 []

La <u>qualité environnementale</u> <u>intrinsèque</u> de votre produit peut-elle modifier le niveau de la demande de vos clients *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- ○ OUI
- ○ NON
- ○ ne sait pas ou non réponse

22 []Avec l'augmentation de la qualité environnementale, vous pensez qu'il peut se produire *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI' à la question '21 [Lien Qualite Demande]' (La qualité environnementale intrinsèque de votre produit peut-elle modifier le niveau de la demande de vos clients)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Une croissance de la demande
- ☐ Une diminuation de la demande
- ☐ Un changement de clientèle
- ☐ Autre changement

23 []Quelle pourrait être l'amplitude de l'augmentation de demande ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI' à la question '21 [Lien Qualite Demande]' (La qualité environnementale intrinsèque de votre produit peut-elle modifier le niveau de la demande de vos clients) *et* La réponse était à la question '22 [Quelle incidence]' (Avec l'augmentation de la qualité environnementale, vous pensez qu'il peut se produire)

Veuillez sélectionner une seule des propositions suivantes :

- ○ Moins de 3%
- ○ de 3 à 5%
- ○ 5 à 10%
- ○ 10 à 25%
- ○ plus de 25%
- ○ ne sait pas ou non réponse

24 []

Pensez-vous que la demande n'a pas augmenté à cause de : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI' à la question '21 [Lien Qualite Demande]' (La qualité environnementale intrinsèque de votre produit peut-elle modifier le niveau de la demande de vos clients) *et* La réponse était à la question '22 [Quelle incidence]' (Avec l'augmentation de la qualité environnementale, vous pensez qu'il peut se produire)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Le prix est trop élevé
- ☐ Autre: ____________

25 []Quel autre changement ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '22 [Quelle incidence]' (Avec l'augmentation de la qualité environnementale, vous pensez qu'il peut se produire)

Veuillez écrire votre réponse ici :

26 []

Sur marché qui est le vôtre, comment percevez-vous le positionnement des clients directs vis-à-vis de la qualité environnementale des produits (en fréquence des clients), aujourd’hui

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

	Indifférent	Faible	Sensible	Fort
à quel niveau actuel se situent les "opinions", en % des clients	☐	☐	☐	☐

27 []Quelle évolution de tendance percevez vous pour ces opinions, à l'horizon de 3 ans

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Choisissez la réponse appropriée pour chaque élément :

	Augmenter	Sans changement	Diminuer
Clients Indifférents	○	○	○
à Sensibilité faible	○	○	○
à Sensibilité moyenne	○	○	○
à Sensibilité forte	○	○	○

C- Les pratiques pour satisfaire et développer la performance environnementale

Cette partie aborde différents éléments liés à la maîtrise des impacts environnementaux de vos activités. Les questions sont sélectionnées selon le cadre de responsabilités que vous avez déclaré plus haut.

28 []Cette partie aborde différents éléments liés à la maîtrise des impacts environnementaux de vos activités. Les questions sont sélectionnées selon le cadre de responsabilités que vous avez déclaré plus haut.

Veuillez écrire votre réponse ici :

Pratiques ACHATS-APPROVISIONNEMENTS

Cette partie aborde différents éléments liés à la maîtrise des impacts environnementaux de vos activités. Les questions sont sélectionnées selon le cadre de responsabilités que vous avez déclaré plus haut.

29 []Quelle part (en % du volume total) des quantités achetées à une origine : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

	moins de 50kms	moins de 200 kms	Nationalement	International
en %				

30 []Votre entreprise est elle associée à un groupement d'achats ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- OUI partiellement
- OUI, l'entreprise est un groupement d'achats
- NON
- ne sait ou non réponse

31 []

Ce groupement a-t-il des actions spécifiques en faveur de l'amélioration des performances environnementales ? Lesquelles

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI partiellement' *ou* 'OUI, l'entreprise est un groupement d'achats' à la question '30 [GroupeAchats]' (Votre entreprise est elle associée à un groupement d'achats ?) *et* La réponse était 'OUI partiellement' *ou* 'OUI, l'entreprise est un groupement d'achats' à la question '30 [GroupeAchats]' (Votre entreprise est elle associée à un groupement d'achats ?)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1

Action 2

32 []

Quelles pratiques d’achat, votre entreprise a-t-elle mises en place afin d’augmenter la qualité environnementale de ses produits et process: *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Sélection de fournisseurs de proximité (ex. producteurs de la région)
- ☐ Prise en compte des impacts environnementaux dans le choix des matières premières achetées
- ☐ Mise en place d’une politique d’achats responsables
- ☐ Commerce équitable
- ☐ Collaborations avec les fournisseurs (ex. développement de produits BIO dans la région, achats de saison, etc..)
- ☐ Accords sur la gestion des conditionnements, emballages
- ☐ Accords sur les modalités de stockage et transports
- ☐ Respect pour la terre (ex. choix des semences adaptées au climat et au terrain, interdiction d’utiliser des produits chimiques de synthèse)
- ☐ Respect pour les animaux (ex. choix de races du terroir, une alimentation issue de l’agriculture biologique et interdiction d’utiliser certains médicaments)
- ☐ Autres (à préciser)
- ☐ Aucune

33 []Préciser

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Achats - Approvisionnements' *ou* 'RSE - Qualité' *ou* 'Direction' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '32 [ActionsAchats]' (Quelles pratiques d’achat, votre entreprise a-t-elle mises en place afin d’augmenter la qualité environnementale de ses produits et process:)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 ______________________

Action 2 ______________________

Pratiques PRODUCTION

34 []Selon vous, quelles pratiques dans le process de production ont été mises en place par votre entreprise afin d'augmenter la qualité environnementale de votre produit / du process ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Efficacité énergétique des équipements
- ☐ Utilisation de meilleures technologies disponibles pour la production
- ☐ Limitation au maximum les additifs alimentaires, colorants et autres
- ☐ Prévention des déchets
- ☐ Valorisation des déchets de production
- ☐ Réduction des nuisances sonores, olfactives et des pollutions atmosphériques
- ☐ Réduction des émissions en production
- ☐ Choix de gestion des stocks (type de stockage, niveaux de stocks...)
- ☐ Maîtrise des consommations d'eau
- ☐ Limitation du volume et de la toxicité des rejets polluants dans l'eau
- ☐ Formation et information des personnels aux bonnes pratiques
- ☐ Autres actions (à préciser)
- ☐ Aucune action ou non réponse

35 []Lequelles :

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Production' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '34 [ActionsProd]' (Selon vous, quelles pratiques dans le process de production ont été mises en place par votre entreprise afin d'augmenter la qualité environnementale de votre produit / du process ?)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 ____________________

Action 2 ____________________

Pratiques DISTRIBUTION

36 []Répartition de vos principaux clients : ils se trouvent (en % des volumes traités) *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

	moins de 50 kms	moins de 200 kms	Nationalement	International
en %	☐	☐	☐	☐

37 []Votre entreprise est elle associée à un groupement de distribution *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- ○ OUI partiellement
- ○ OUI, l'entreprise est un groupement de distribution
- ○ NON
- ○ ne sait ou non réponse

38 []Votre entreprise utilse de la sous-traitance pour distribuer vos produits. Quels part de volume celà concerne t'il *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'OUI partiellement' à la question '37 [GroupeDistri]' (Votre entreprise est elle associée à un groupement de distribution)

Veuillez sélectionner une seule des propositions suivantes :

- ○ moins de 10%
- ○ entre 10 et 35%
- ○ entre 35 et 65 %
- ○ entre 65 et 90%
- ○ plus de 90%

39 []Selon vous, quelles pratiques de distribution ont été mises en place par votre entreprise afin d’augmenter sa performance environnementale : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Localisation des points de distribution proches du marché
- ☐ Localisation des sites de production proche du marché et des fournisseurs
- ☐ Optimisation des kilomètres parcourus pour le transport
- ☐ Utilisation des technologies moins émettrices pour le transport routier (ex camions électriques, camions GNV, Euro 6)
- ☐ Utilisation de modes alternatifs au transport routier (ex. frêt ferroviaire ou fluvial
- ☐ Mutualisation logistique
- ☐ Choix des conditionnements de transport
- ☐ Autres actions (à préciser)
- ☐ Aucune

40 []Lequelles ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '39 [Actions Distri]' (Selon vous, quelles pratiques de distribution ont été mises en place par votre entreprise afin d’augmenter sa performance environnementale :)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 ____________________

Action 2 ____________________

41 []Selon vous, quelles pratiques ont été mises en place par votre entreprise pour la gestion de fin vie de l’emballage de votre produit, afin d’augmenter la qualité environnementale de votre produit : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Emballage compostable ou biodegradable
- ☐ Emballage mangeable
- ☐ Emballage le plus léger possible
- ☐ Emballage recyclable
- ☐ Inscription de consignes de tri sur l’emballage
- ☐ Autres actions (à préciser)
- ☐ Aucune action

42 []

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Logistique' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '41 [FindevieEmb]' (Selon vous, quelles pratiques ont été mises en place par votre entreprise pour la gestion de fin vie de l'emballage de votre produit, afin d'augmenter la qualité environnementale de votre produit :)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 ______________________

Action 2 ______________________

Pratiques COMMERCIALES

43 []

Selon vous, quelles pratiques de marketing sur la qualité environnementale ont été mises en place par votre entreprise ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Communication sur les pratiques environnementales (rapport d'activité RSE)
- ☐ Label BIO
- ☐ Autres labels (à préciser)
- ☐ Information sur les emballages (ex.consignes de tri)
- ☐ Choix de supports de com « sobres »
- ☐ Autres actions (à préciser)
- ☐ Aucune

44 []

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '43 [Marketing]' (Selon vous, quelles pratiques de marketing sur la qualité environnementale ont été mises en place par votre entreprise ?)

Veuillez écrire votre(vos) réponse(s) ici :

Label 1 __________

Label 2 __________

45 []

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Marketing - Communication' *ou* 'Commercialisation - Distribution' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '43 [Marketing]' (Selon vous, quelles pratiques de marketing sur la qualité environnementale ont été mises en place par votre entreprise ?)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 __________

Action 2 __________

Pratiques COLLABORATIVES

46 []Selon vous, quelles pratiques de de collaboration avec les parties prenantes de la chaîne logistique ont été mises en place par votre entreprise afin d'augmenter la qualité environnementale de votre produit / process: *

Veuillez choisir toutes les réponses qui conviennent :

- ☐ Coopération avec le client pour l'eco-conception du produit
- ☐ Collaboration pour la mise en place des stratégies environnementales
- ☐ Collaboration pour avoir une certification environnementale (ISO 14000)
- ☐ Implémentation du système de gestion environnementale
- ☐ Suivi de la performance environnementale du produit tout au long de la chaîne logistique
- ☐ Implémentation du système de gestion environnementale
- ☐ Actions collaboratives pour gérer et limiter le gaspillage
- ☐ Veille collective des partenaires
- ☐ Gestion partagée de l'info sur les stocks
- ☐ Gestion partagée de ressources (matériel, emplois ...)
- ☐ Autres actions (à préciser)
- ☐ Aucune

47 []Lesquelles ?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était à la question '46 [Collabo]' (Selon vous, quelles pratiques de de collaboration avec les parties prenantes de la chaîne logistique ont été mises en place par votre entreprise afin d'augmenter la qualité environnementale de votre produit / process:)

Veuillez écrire votre(vos) réponse(s) ici :

Action 1 ________

Action 2 ________

Bilan Pratiques - impacts

48 []

Selon vous quelles sont les pratiques, ayant trait à l'environnement, qui ont le plus d'influence sur la demande (0 : n'influence pas – 3 : influence maximale): *

Choisissez la réponse appropriée pour chaque élément :

	0 (sans influence)	1 (faible)	2 (sensible)	3 (forte)	ne sait pas
Eco-Conception	○	○	○	○	○
Achats - Approvisionnements	○	○	○	○	○
Production et Qualité	○	○	○	○	○
Distribution et Logistique	○	○	○	○	○
Gestion des conditionnements	○	○	○	○	○
Marketing et communication	○	○	○	○	○
Pratiques collaboratives : technologies et méthodes	○	○	○	○	○
Pratiques collaboratives : veille, partenariats	○	○	○	○	○
Autres	○	○	○	○	○

49 []

Grâce aux pratiques de votre entreprise avec les parties prenantes de la chaîne logistique, la performance environnementale de vos produits et process est elle à même d'accroître votre demande ? *

Veuillez sélectionner une seule des propositions suivantes :

- ○ OUI
- ○ NON
- ○ ne sait pas ou non reponse

50 []

Si OUI, pourriez-vous la quantifier ? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'OUI' à la question '49 [EffetPratEnv]' (Grâce aux pratiques de votre entreprise avec les parties prenantes de la chaîne logistique, la performance environnementale de vos produits et process est elle à même d'accroître votre demande ?)

Veuillez sélectionner une seule des propositions suivantes :

- ○ moins de 3%
- ○ entre 3 et 5%
- ○ entre 5 et 10%
- ○ entre 10 et 25%
- ○ plus de 25%
- ○ ne sait pas ou non réponse

D- Concernant la performance environnementale de vos fournisseurs

51 []Dans la sélection de vos fournisseurs, combien environ pèsent les critères suivants *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

	Prix	Conditions de service (délais, lots, livraisons, proximité...)	Qualité et spécifications techniques du composant	Qualité environnementale du composant	Réputation du fournisseur et étendue de sa gamme	Autre
en %	☐	☐	☐	☐	☐	☐

52 []Globalement, vous estimez que votre entreprise est attentive aux qualités et performances environnementales de vos approvisionnements *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- ○ Pas du tout
- ○ Un peu
- ○ Assez
- ○ Beaucoup

53 []

L'offre des produits qui vous sont nécessaires et <u>possédant des qualités environnementales adaptées à vos besoins</u>, <u>est à votre avis</u> *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez choisir toutes les réponses qui conviennent :

- ☐ est rare ou n'existe pas
- ☐ Est disponible facilement
- ☐ Est disponible à proximité
- ☐ Est disponible mais éloignée ou irrégulière
- ☐ Est disponible mais mal calibrée (hors gabarits, défauts d'aspect…)
- ☐ Est disponible mais un peu chère
- ☐ Est disponible mais très chère
- ☐ Autre opinion (à préciser)
- ☐ ne sait pas ou non réponse

54 []Autres difficultés d'approvisionnement

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était à la question '53 [OffreQE]' (L'offre des produits qui vous sont nécessaires et possédant des qualités environnementales adaptées à vos besoins, est à votre avis)

Veuillez écrire votre(vos) réponse(s) ici :

Opinion 1 [ ]

Opinion 2 [ ]

55 []

Comment jugez-vous la sensibilité à la qualité environnementale de vos fournisseurs (en fréquence chez les fournisseurs) *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

	Nulle ou très faible	Légère à moyenne	Plutôt forte
en %	[ ]	[ ]	[ ]

56 []

Pour définir la qualité environnementale des composants que vous utilisez, quel poids donneriez-vous aux critères et pratiques suivants chez votre fournisseur *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Choisissez la réponse appropriée pour chaque élément :

	Aucun	Faible	Moyen	Fort	ne sait pas
Coopération sur les spécifications des composants, des emballages…	○	○	○	○	○
Composants d'origine sécurisée : Fabrication locale ou nationale de ses produits (« made in France »)	○	○	○	○	○
Proximité régionale (terroir) et culturelle (valeurs)	○	○	○	○	○
Image environnementale, réputation du fournisseur	○	○	○	○	○
Labels	○	○	○	○	○
Process fournisseur économe en eau et énergie	○	○	○	○	○
Process fournisseur économe en engrais/effluents	○	○	○	○	○
Transport à moindre émissions atmosphériques	○	○	○	○	○
Transparence sur les pratiques environnementales	○	○	○	○	○
Echange de bonnes pratiques (actions concertées, formations…)	○	○	○	○	○
Coopérations sur les démarches commerciales et communication	○	○	○	○	○
Autres	○	○	○	○	○

57 []

Pour améliorer la qualité environnementale de vos produits, sur la composante achats, vous seriez prêt ou prête à payer ceux ci : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions) *et* La réponse était 'Direction' *ou* 'Achats - Approvisionnements' *ou* 'RSE - Qualité' à la question '14 [Service]' (Votre fonction actuelle vous amène à traiter principalement de questions)

Veuillez sélectionner une seule des propositions suivantes :

- ○ Pas plus cher
- ○ jusqu'à 5% plus cher
- ○ jusqu'à 15% plus cher
- ○ plus de 15% plus cher

Envoyer votre questionnaire.
Merci d'avoir complété ce questionnaire.

.5 Appendix E: Semi-structured interview guide applied in french to extract the logistic requirements perception

Semi-structured interview guide for producers, industrial producers and wholesalers

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation
Description du groupe / entreprise:

- Pourriez-vous faire une description de votre entreprise?
  - Dans quel département êtes-vous situé ?
  - Quel est votre chiffre d'Affaires? ou quel est votre effectif ?
- Pourriez-vous faire une description de votre offre et canaux de distribution?
  - Quels sont vos principaux produits (légumes, fruits) ?
  - Quel est votre tonnage annuel ?
  - Quels sont vos différents circuits de commercialisation ?
  - Quel pourcentage de votre chiffre d'affaires représente chacun de vos circuits de vente ?
- Pourriez-vous faire une description de vos clients?
  - Parmi vos différents circuits de commercialisation, avez-vous la restauration collective ?
  - Quel pourcentage de votre chiffre d'affaires représente la restauration collective ?
  - Quel type de restauration collective, ex. gestion directe (marché public; gestion concédée (marché privé avec une cuisine centrale)) ?
  - Pouvez-vous nous indiquer quelles sont vos différentes catégories de clients dans la restauration collective?

Diagnostic

- Pourriez-vous nous parler sur votre organisation logistique ?
  - Avec quelle fréquence, livrez-vous la restauration collective ?
  - Pensez-vous qu'il serait pertinent de coopérer avec d'autres producteurs pour avoir une offre plus robuste (en volume et variété) ?
  - Assurez-vous la livraison/distribution de vos produits par vous-même ? ou bien délégué à un transporteur ? ou bien collecté par un grossiste ?
  - Quelle est la distance moyenne parcourue pour la livraison de vos produits (par tournée journalière kms)?
  - Quel type de flote avez-vous ?
  - Comment vous optimisez vos déplacements ?

Prospective

- Pourriez-vous mentionner quelles sont les particularités de livrer la restauration collective ?
  - Concernant la politique des produits locaux (donc la mise en place des circuits courts), avez-vous remarqué de changements dans l'organisation votre distribution? Pourriez-vous mentionner lesquels ?

Proposition d'actions

- Selon vous, quelles pratiques dans le transport, votre entreprise a-t-elle mises ou va mettre en place suite aux exigences de la restauration collective ?

Semi-structured interview guide for carriers

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation

- Pourriez-vous faire une description de votre entreprise?
  - Dans quel département êtes-vous situé ?
  - Quel est votre Chiffre d'Affaires? ou quel est votre effectif ?
- Pourriez-vous faire une description de votre services de distribution?
  - Quels sont les principaux produits que vous transportez (légumes, fruits) ?
  - Quel est votre tonnage annuel ?
- Pourriez-vous faire une description de vos clients?
  - Parmi vos différents clients, avez-vous travailllé avec la restauration collective ?
  - Quel pourcentage de votre chiffre d'affaires représente la restauration collective ?
  - Quel type de restauration collective, ex. gestion directe (marché public; gestion concédée (marché privé avec une cuisine centrale)) ?
  - Pouvez-vous nous indiquer quelles sont vos différentes catégories de clients dans la restauration collective?

Diagnostic

- Pourriez-vous nous parler sur votre organisation logistique ?
  - Avec quelle fréquence, livrez-vous la restauration collective ?
  - Quelle est la distance moyenne parcourue pour la livraison des produits (par tournée journalière kms)?
  - Quel type de flote avez-vous ?
  - Comment vous optimisez vos déplacements ?

Prospective

- Pourriez-vous mentionner quelles sont les particularités de livrer la restauration collective et quels sont ses exigents ?
  - Concernant la politique des produits locaux (donc la mise en place des circuits courts), avez-vous remarqué de changements dans l'organisation votre distribution? Pourriez-vous mentionner lesquels ?

Proposition d'actions

- Selon vous, quelles pratiques dans le transport, votre entreprise a-t-elle mises ou va mettre en place suite aux exigences de la restauration collective ?

Semi-structured interview guide for public agents and receivers

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation: Information générales de la restauration de la ville

- Quels types des restaurants sont gères par la mairie de Saint-Etienne (ex : restaurants scolaires, administratives, hôpitaux, maisons de retraite) ?
- Comment est manage la restauration scolaire de Saint Etienne aujourd'hui ?
  - Combien des restaurants scolaires sont gères par la mairie de Saint-Etienne parmi les écoles publiques ?
  - Combien des repas sont servis par année ?
  - Qui est le prestataire qui gère la restauration scolaire ?
    - Comment a été le processus de sélection du prestataire ? Quels ont été les éléments requis pour la sélection ?
    - Quels sont les conditions d'engagement avec ce prestataire ?
    - Quelle est la genèse des relations entre le prestataire et cuisine Centrale de St Etienne ?

Diagnostic: Projet Cantines Bio et local

- Dans quel contexte a émergé le projet cantine bio et local de St Etienne ?
- Depuis combien temps le projet des cantines bio et local a été mis en place ?
- Quels ont été les initiatives pour passer vers l'offre de bio et local dans les restaurants scolaires ?
- Préciser les conditions nécessaires pour la réalisation du projet ? Comment a été fait les démarches pour l'organisation du projet :
  - Qui a gère l'organisation du projet ? Il a été consulté un bureau d'étude ? Sinon comment a été fait l'organisation du projet ?
  - PartenairesÂ : Qui et depuis quandÂ participe dans le démarche du projet ?
  - Quels ont été les indicateurs de suiviÂ qu'ont été pris en compte ?
  - Quels ont été les principaux freins à la réalisation de ce projet ?

  - Préciser les principaux risques ?

- Combien d'écoles sont couverts par restaurant ?
  - Combien des écoles maternelles ?
  - Combien des collèges ?
  - Combien des lycées ?
  - Combien des universitésÂ ou des établissements d'éducation supérieure ?

- Comment est l'organisation entre la cuisine centrale et les restaurants ?
  - Combien d'employés il y a par restaurant que sont directement embouchées par la Mairie de Saint-Etienne ?

Prospectives et propositions d'actions

- Quels sont les perspectives d'implémentation du projet cantines Bio el local dans l'avenir ?
- Le projet Cantines Bio el local envisage tout type de restauration et non seulement que la restauration scolaire ?
- La Mairie de Saint-Etienne a déjà commencé des démarches pour travailler directement avec les producteurs locaux et bio ? Quels sont les principaux freins, avantages ou risques ?
- La Mairie de Saint Etienne préconise promouvoir des démarches pour tout type de restauration afin d'approvisionner la ville de manière durable ? Il y a des autres initiatives que la mairie voudrait mettre en place ?
- Quels ont été les principales expériences pour la capitalisation des connaissances dans le projet bio et local que pourront être partages avec des autres villes ?

.6 Appendix F: Semi-structured interview guide applied in french to characterise the regional FH

Semi-structured interview guide for FH

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation

- Pourriez-vous faire une description de votre société?
  - Quand et comment a été crée votre entreprise (ex. groupement des producteurs, initiative publique?)?
  - Dans quel département êtes-vous situé ?
  - Quel est votre chiffre d'affaires? ou quel est votre effectif ?
  - Quelle est votre raison sociale (avec un but lucratif ou pas) ?
  - Quel est l'intérêt de travailler directement avec les producteurs ?
- Pourriez-vous faire une description de vos producteurs et type de produit que vous g'erez ?
  - Quels sont les principaux produits que vous avez (légumes, fruits, frais) ?
  - Quel pourcentage de vos produits sont BIO ?
  - Avec quel type de producteurs travaillez-vous (bio 100% en conversion) ? Combien de chaque type ?
  - Pourriez-vous nous dire o'u se trouvent vos principaux producteurs?
- Pourriez-vous faire une description de vos clients?
  - Parmi vos différents clients, avez-vous travailllé avec la restauration collective ?
  - Quel pourcentage de votre chiffre d'affaires représente la restauration collective ?
  - Quel type de restauration collective, ex. gestion directe (marché public; gestion concédée (marché privé avec une cuisine centrale)) ?
  - Pouvez-vous nous indiquer quelles sont vos différentes catégories de clients dans la restauration collective?

- Pourriez-vous nous dire o'u se trouvent vos principaux clients?

- Pourriez-vous faire une description de votre organisation logistique ?
  - Quels sont les caractéristiques de votre plateforme (surface, chambres froides)?
  - Afin d'ajouter de la valeur au produit, quel type d'activit'es sont développes dans la plateforme?
  - Est-ce que tous les produits passent par la plateforme ? ou bien il y a des produits que sont livrés directement par les producteurs ? Quels sont les conditions pour choisir un ou l'autre ?
  - Assurez-vous la livraison/distribution des produits par vous-même ? Si oui, quel type de flotte avez-vous ?
  - Assurez-vous la collecte ou ramassage des produits par vous-même ? ou bien c'est chaque producteur qui est en charge de livrer la plateforme ?
- Pourriez-vous faire une description de votre organisation commerciale?
  - Quels sont les caractéristiques de votre accompagnement aux producteurs dans la commercialisation de ses produits ?
  - Quels sont les activités commerciales que votre société développe (marketing des produits, fixation de prix, négociation des prix)?

Diagnostic

- Pourriez-vous parler sur la relation contractuelle que vous avez avec les producteurs que travaillent avec vous ?
  - Comment est la fixation de prix du produits ?
  - Quel type de contrat est établis avec les producteurs (quelle est la politique de payement)?
  - Est-ce que avez-vous une politique d'exclusivité avec les producteurs?
  - Est-ce que les producteurs ont accès aux informations relatifs au coût logistique des produits ?
- Pourriez-vous parler sur la genèse de la relation que vous avez avec les producteurs que travaillent avec vous ?
  - Est-ce que vous formez les producteurs ? Si oui, dans quelle type des pratiques ?
- Pourriez-vous parler sur vos démarches de responsabilité environnementale ?
  - Est-ce que vous accompagnez les producteurs dans la conversion BIO ?
  - Comment vous optimisez vos déplacements afin de diminuer vos émissions ?

Prospective

- En tentant en compte un scénario où il y aura une future politique d'achat de 50% plus de produits BIO et locaux par la restauration colllective :
  - Quels seront les critères à prendre en compte lors de la sélection des producteurs?
  - Vos producteurs actuels, sont-ils capables de fournir ce volume?
  - Devriez-vous faire une consultation en dehors du département et donc de changer le pourcentage de produits locaux?
  - Quelles sont les limites du changement?
  - Vous devriez changer la configuration d'approvisionnement ? Pourriez-vous mentionner lesquels ?

Proposition d'actions

- Selon vous, quelles pratiques votre entreprise a-t-elle mises ou va mettre en place suite aux exigences de la restauration collective afin de diminuer les externalités liès à la collecte et distribution des produits bio et locaux?

Semi-structured interview guide for Public authority

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation

- Pourriez-vous faire une description de votre société?
  - Quand et comment a été crée votre entreprise (ex. groupement des producteurs, initiative publique?)?
  - Quel est l'intérêt de travailler directement avec les producteurs ?
- Pourriez-vous faire une description des producteurs qui existent en la région Auvergne-Rhône-Alpes ?
  - Quels sont les principaux produits que sont produits (légumes, fruits, frais) ?
  - Quel pourcentage des producteurs sont BIO ou en conversion BIO ?

Diagnostic

- Pourriez-vous parler sur la relation entre les producteurs et la restauration collective ?
  - Quel pourcentage des producteurs BIO livrent la restauration collective ?
  - Quels sont les principaux limites de travailler avec la restauration collective que sont considérés par les producteurs ?

Prospective

- En tentant en compte un scénario où il y aura une future politique d'achat de 50% plus de produits BIO et locaux par la restauration colllective :
  - Quels seront les critères à prendre en compte lors de la sélection des producteurs?
  - Est-ce que les producteurs BIO et en conversion existants, sont-ils capables de fournir ce volume?
  - Pensez vous que la restauration collective devra faire une consultation en dehors de la région et donc de changer le pourcentage de produits locaux?
  - Quelles sont les limites du changement?

Proposition d'actions

- Selon vous, quelles pratiques votre société a-t-elle mises ou va mettre en place suite aux exigences de la restauration collective afin de diminuer les externalités liès à la collecte et distribution des produits bio et locaux?

Semi-structured interview guide for meal contractor

Introduction

- Présentation des intervenants.
- Description de l'objectif de l'entretien.
- Description de déroulement de l'entretien.

Identification de la situation

- Pourriez-vous faire une description de votre société?
  - Quand et comment a été crée votre entreprise ?
  - Quel est votre chiffre d'affaires? ou quel est votre effectif ?
- Pourriez-vous faire une description de votre offre pour la restauration collective ?
  - Quel pourcentage des produits offerts dans le repas sont BIO ?
  - Avec quel type de producteurs travaillez-vous (producteur, coopérative des producteurs) ? Combien de chaque type ?
  - Pourriez-vous nous dire d'o'u vient vos principaux produits bio?
- Pourriez-vous faire une description de vos clients?
  - Quel pourcentage de votre chiffre d'affaires représente la restauration collective ?
  - Pouvez-vous nous indiquer quelles sont vos différentes catégories de clients dans la restauration collective?
  - Pourriez-vous nous dire o'u se trouvent vos principaux clients?

Diagnostic

- Pourriez-vous parler sur la relation contractuelle que vous avez avec les producteurs ou coopératives de producteurs que travaillent avec vous ?
  - Quel type de contrat est établis avec les producteurs ?
- Quels sont les perspectives d'implémentation du projet cantines Bio el local dans l'avenir en tenant en compte le haut pourcentage qui est demandé par la municipalité?
- Quels sont les principaux freins, avantages ou risques de travailler directement avec les producteurs locaux et bio ?

Prospective

- En tentant en compte un scénario où il y aura une future politique d'achat de 50% plus de produits BIO et locaux par la restauration colllective :
  - Quels seront les critères à prendre en compte lors de la sélection des fournisseurs?
  - Vos fournisseurs actuels, sont-ils capables de fournir ce volume?
  - Devriez-vous faire une consultation en dehors du département et donc de changer le pourcentage de produits locaux?
  - Quelles sont les limites du changement?
  - Vous devriez changer la configuration d'approvisionnement ? Pourriez-vous mentionner lesquels ?

Proposition d'actions

- Selon vous, quelles pratiques votre entreprise a-t-elle mises ou va mettre en place suite aux exigences de la restauration collective afin de diminuer les externalités liès à la collecte et distribution des produits bio et locaux?

.7 Appendix G: Semi-structured interview guide for Kungsbacka municipality

My name is Laura Palacios, I am a PhD student at Ecole de Mines de Saint-Etienne in France. My research field is Urban food distribution and in particularly I work in assessing the potential of urban food systems for collective uses. I have been working in a test case on the middle school restaurant distribution in French cities.

The objective of this work in Sweden is to develop a methodology to build a model that enable municipalities to assess the consequences of food logistics flow centralization on an urban consolidation centre (UCC) based on the notion of food hub (i.e.the centralization of logistics, commercial and decision flows concerning food distribution, mainly addressed to local producers).

The aim of this interview is to discuss about the food policy of Kungsbacka municipality regarding the school canteens. It is necessary to remind you of the confidentiality of this interview, in particular anonymity and double validation of what will be written and reported, as well as the possibility of modifying or adding elements even after the end of the interview. The interview will take around 1 hour with six main topics that will be discussed.

Could you please introduce yourself: (Name, position, background)?

General Information about Kungsbacka Municipality

- General Description about Kungsbacka: Could you please in a few words describe the Kungsbacka municipality? (Nb inhabitants, Nb cities, Nb schools per level)

School Canteen Food policy

- How is the food policy of Kungsbacka municipality regarding the school canteens?
  - How the school canteen is managed? (outsourced or non)
  - How many school canteens are in Kungsbacka municipality?
  - How many meals are served per year in the school canteens?
  - How is served the meal in the canteen? (self-service, buffet, table service?) It depends on the type of school (kindergarten, middle school, high school)
  - How many days per year the school canteen is open?

School canteen demand estimation

- How is the food forecast managed for the school canteens?
- How many students eat in the school canteen every day? (rate)
- In average, how could be the weight of a meal? (kg)

- What are the factors that may influence the numbers of meals served per canteen?
  - Nb students that eat in the canteen vs Nb student registered at the school?
  - Age of students (Nutritional requirement)?
  - Type of service? (self-service, buffet, table service?)
  - Reservation system?

School canteen purchasing system

- How is the purchasing policy, centralized or decentralized (per restaurant, per city)?
- How is the purchasing frequency (daily, per week, per month?)
  - Does it depend on the product family?
  - Does it depend on the supplier?
- How is managed the selection of the suppliers?
  - How many suppliers do you have?
  - Where is the food comes from?
  - Do you have organic products / organic suppliers? What is the percentage of this kind of products?
  - Do you consider local producers as suppliers? What is the percentage over all the suppliers? (local means city level? region level? municipalityÂ level? countryÂ level? Number of km?)

School canteen distribution system

- How is managed the distribution system from the suppliers to the school canteens?
  - There is a Consolidation Centre in Kungsbacka for the school canteens? or the supplies deliver directly the food to the school canteen?
    * If there is managed by the supplier, do you have any request in terms of vehicles, time window to deliver every canteen?
    * If it is managed by the municipality:
      · Do you have any 3PL? or own vehicles?
      · How many vehicles are necessary for the distribution system?
      · What is the vehicles capacity?
      · What is the energy technology used by these vehicles?
  - Do you have any indicators to measure the efficiency of the distribution system?

School Canteen technical characteristics

- Has every school canteen a storage capacity? If yes, how much is it?
  - Area in square metres?
  - Number of cold-rooms?
  - How many employees has each canteen?
    - Direct employees or outsourced?
  - How the food waste is managed by the school canteen?

.8 Appendix H: Temperature and humidity considered for environmental assessment

Table 35 shows the temperature and humidity considered for environmental assessment in Auvergne-Rhône-Alpes. The period of time considered is 2017 and it was extracted from Wea (b).

Table 35: Temperature and Humidity considered for the French case

	Min °C	Max °C	Humidity (%)
Jan	-3.5	3.5	74
Feb	2.4	12.7	73
Mar	4.3	15.4	64
Apr	2.4	16.4	62
May	8.1	21.8	63
Jun	15.2	27.7	66
Jul	15.8	28.3	49
Aug	15.1	28.9	66
Sept	9.2	20.8	72
Oct	6.6	19.7	66
Nov	2	10.3	76
Dec	1.3	7.3	78

Table 36 shows the temperature and humidity considered for environmental assessment in Kungsbacka, Sweden. The period of time considered is 2017 and it was extracted from Wea (a).

Table 36: Temperature and Humidity considered for the Swedish case

	Min °C	Max °C	Humidity (%)
Jan	0	3	85
Feb	0	2	83
Mar	2	5	85
Apr	3	8	76
May	8	14	76
Jun	12	16	80
Jul	12	18	77
Aug	14	18	79
Sept	11	16	83
Oct	8	12	79
Nov	4	7	79
Dec	3	5	84

.9 Appendix I. Annona Platform

Annona platform is a modular decision support system for urban logistics tactical planning in a multi-stakeholder and multi-criteria context.

Figure 9 shows the school canteens locations visualised in Annona Platform.

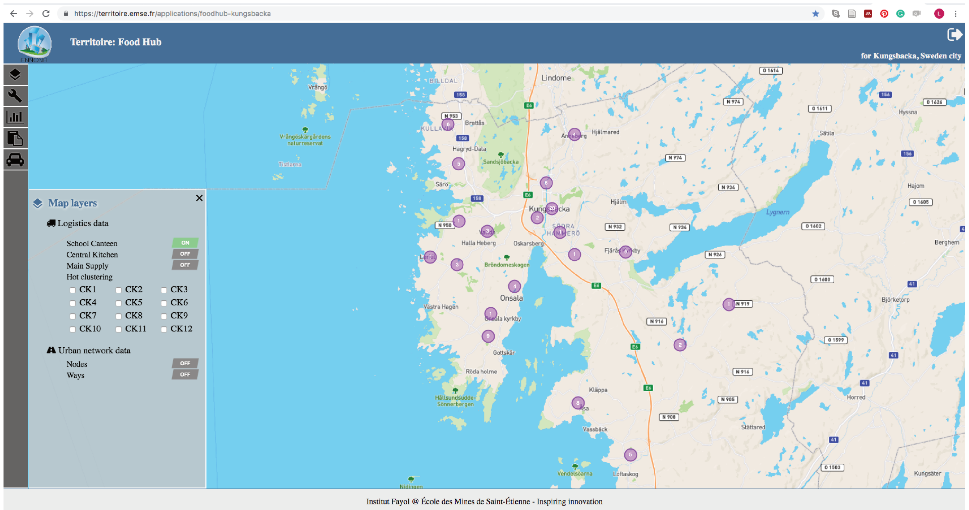


Figure 9: The school canteens locations in Annona Platform

Figure 10 shows the central kitchens locations visualised in Annona Platform.

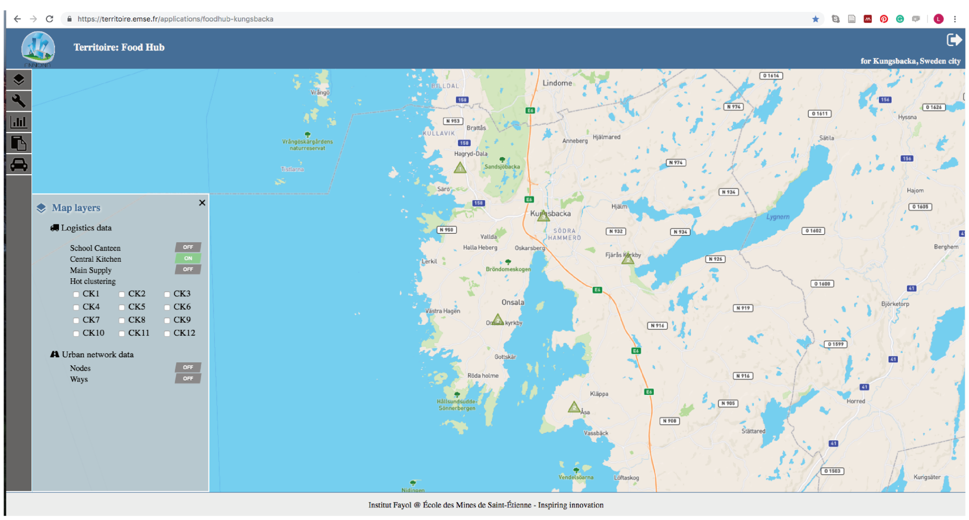


Figure 10: The central kitchens locations in Annona Platform

Figure 11 shows the UCC location visualised in Annona Platform.

Figure 12 shows the scenario parameters that can be analysed in Annona Platform.

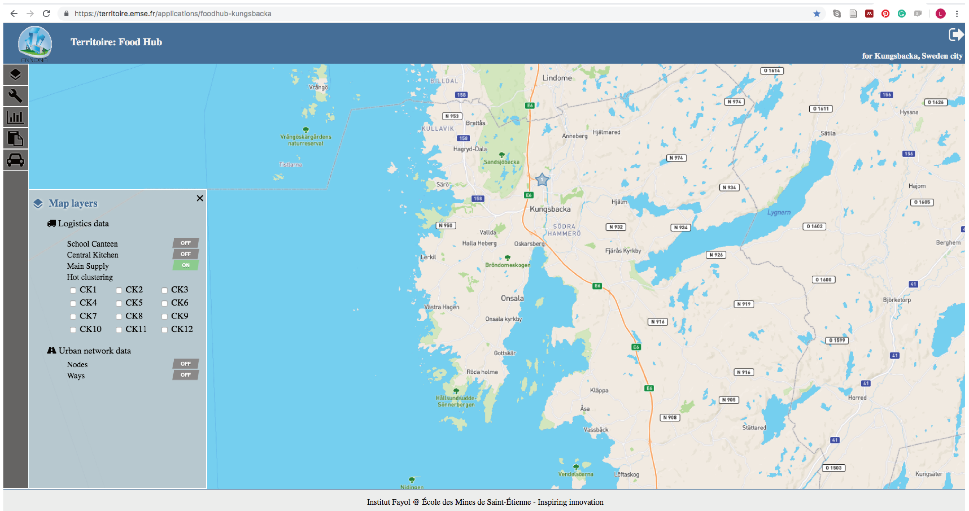


Figure 11: The UCC's location in Annona Platform

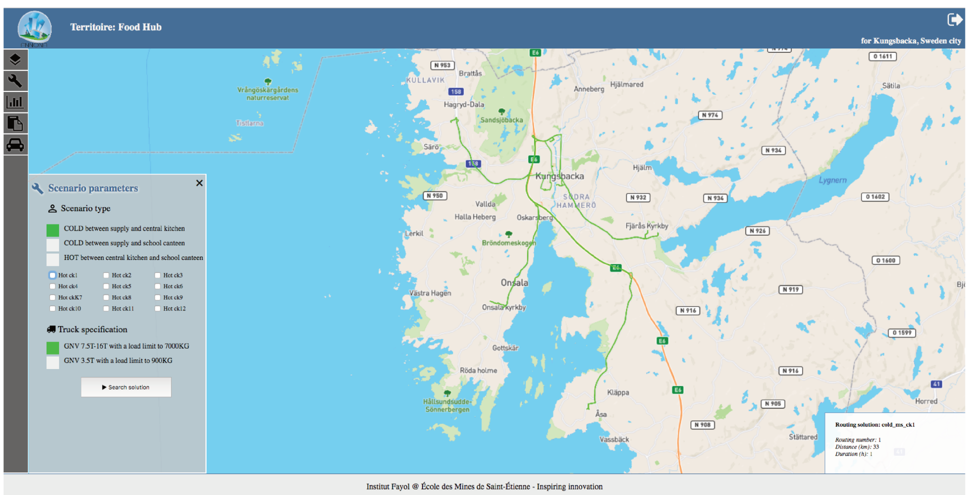


Figure 12: Scenario parameters in Annona Platform

Figure 13 shows the scenario results in terms of economic and environmental assessment that can be analysed in Annona Platform.

Figure 14 shows the scenario assessment that compares different scenarios that can be analysed in Annona Platform.

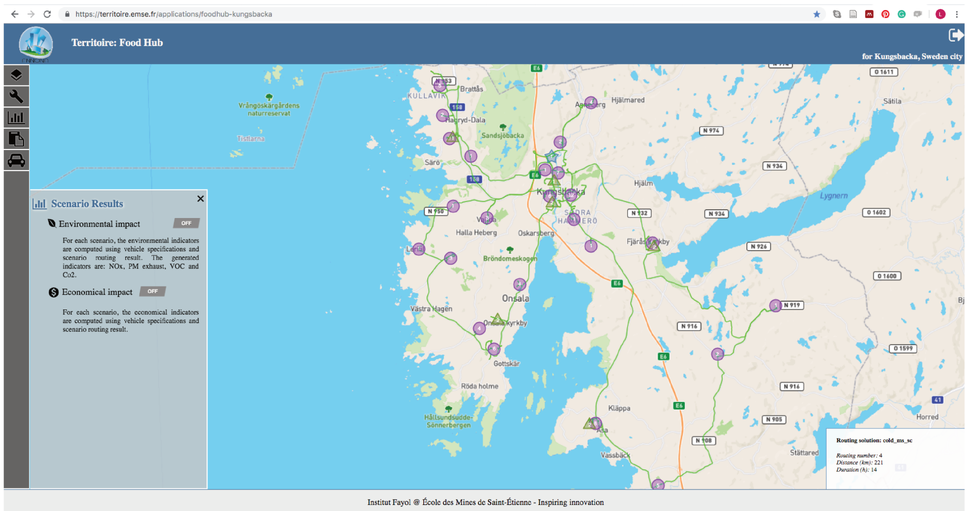


Figure 13: Economic and environmental assessment in Annona Platform

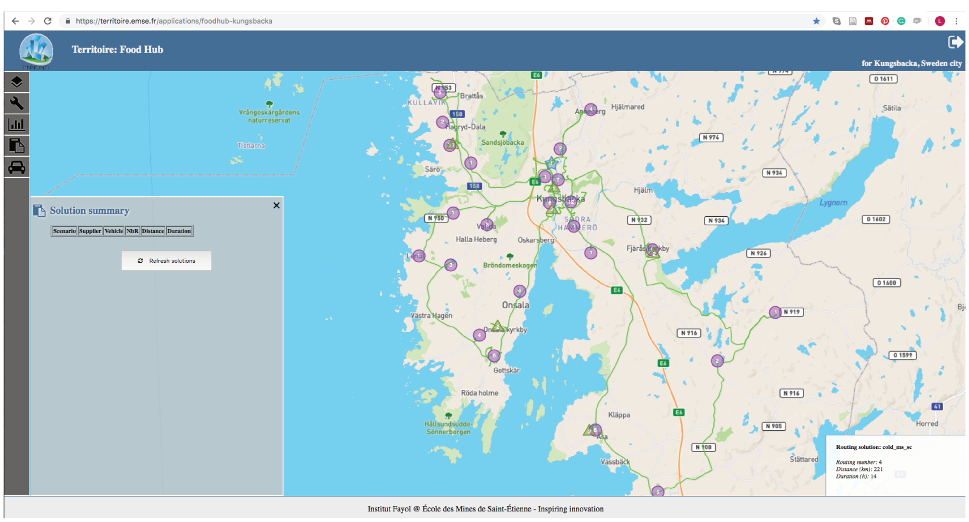


Figure 14: Scenario assessment in Annona Platform

École Nationale Supérieure des Mines
de Saint-Étienne

NNT : *Communiqué le jour de la soutenance*

Laura PALACIOS-ARGÜELLO

CHARACTERIZATION AND ASSESSMENT OF DISTRIBUTION SCHEMES FOR FOOD SUPPLY AND DISTRIBUTION SYSTEMS CONSIDERING ENVIRONMENTALLY SENSITIVE DEMAND

Speciality : Industrial Engineering - Logistics

Keywords : Food supply chains, Eco-responsible demand, Urban food distribution, Organic and local product, Institutional catering, Economic and environmental impacts.

Abstract :

This thesis addresses the research question of how demand requirements for eco-responsible and local products may impact the food supply distribution configuration. In other words, how to configure urban food systems to satisfy a demand for eco-responsible food products. Therefore, the purpose of this research is to explore how to estimate the relationship between a demand for eco-responsible and food distribution configuration considering economic and environmental issues.

The thesis is a compilation of three phases:

- Eco-responsible food demand: It seeks to identify the product's environmental quality criteria that impact product demand and how these demand's characteristics can be used to describe the requirements of logistic schemes for sustainable distribution.
- Food supply chain configuration: Considering these new requirements, this phase aims to describe the food supply chain strategies that achieve a sustainable food distribution addressed in the literature, and to analyse how these strategies identified impact logistic decisions in the supply chain.
- Food supply chain assessment: It attempts to analyse the estimation of economic and environmental indicators that may represent the impacts generated in the configuration of the different food distribution schemes proposed.

The results highlight a framework proposal, aiming to understand how changes in a current food distribution system can be identified and quantified (in a logic of before-after scenario assessment). This framework includes: (i) Logistic decisions to be considered in the distribution system at strategic and tactical level. (ii) Food system characterization to define an initial situation (stakeholders, demand and supply characterization), and the demand and supply estimation; (iii) Scenario construction to analyse scenarios to be tested; and (iv) Scenario assessment to identify and assess economic and environmental impacts of the food distribution system, including tests and expert feedback to validate the scenarios proposed.

École Nationale Supérieure des Mines
de Saint-Étienne

NNT : *Communiqué le jour de la soutenance*

Laura PALACIOS-ARGÜELLO

CARACTÉRISATION ET ÉVALUATION DES SCHÉMAS DE DISTRIBUTION POUR LES SYSTÈMES D'APPROVISIONNEMENT ET DE DISTRIBUTION ALIMENTAIRE EN TENANT COMPTE DE LA DEMANDE SENSIBLE À L'ENVIRONNEMENT

Spécialité : Génie Industriel - Logistique

Mots clefs : Chaînes d'approvisionnement alimentaire, Demande écoresponsable, Distribution alimentaire urbaine, Produits biologiques et locaux, Restauration collective, Impacts économiques et environnementaux.

Résumé :
Cette thèse questionne la façon dont les exigences de la demande de produits écoresponsables peuvent influencer la configuration de la distribution de l'approvisionnement alimentaire. En d'autres termes, elle interroge la configuration des systèmes alimentaires urbains pour satisfaire une demande de produits alimentaires écoresponsables. Par conséquent, son objectif est d'explorer comment estimer la relation entre une demande écoresponsable et une configuration de distribution alimentaire en tenant compte des enjeux économiques et environnementaux.

La thèse compile trois phases : ***(1)*** *demande alimentaire écoresponsable :* identifier les critères de qualité environnementale du produit qui ont un impact sur sa demande et comment les caractéristiques de cette demande peuvent être utilisées pour décrire les exigences des systèmes logistiques pour une distribution durable. ***(2)*** *Configuration de la chaîne d'approvisionnement alimentaire* : compte tenu de ces nouvelles exigences, cette phase vise à décrire, à partir de la littérature, les stratégies de la chaîne d'approvisionnement alimentaire qui permettent d'atteindre une distribution durable, et analyser l'impact de ces stratégies sur les décisions logistiques dans la chaîne d'approvisionnement. ***(3)*** *évaluation de la chaîne d'approvisionnement alimentaire :* Identifier et construire des indicateurs économiques et environnementaux que représentent les impacts générés dans la configuration des systèmes de distribution alimentaire proposés.

Les résultats permettent de formuler une proposition de cadre afin d'identifier et quantifier les changements dans le système actuel de distribution alimentaire (dans une logique d'évaluation de scénario avant-après). Ce cadre comprend : i) les décisions logistiques à prendre en compte dans le système de distribution aux niveaux stratégique et tactique. ii) la caractérisation du système alimentaire pour définir une situation initiale (parties prenantes, caractérisation de l'offre et de la demande) et l'estimation de l'offre et de la demande ; iii) l'élaboration de scénarios pour réaliser des tests ; et iv) l'évaluation de scénarios pour identifier et évaluer les impacts économiques et environnementaux du système de distribution alimentaire.