Advanced decision making in sustainable city logistics projects : criteria and, risk identification and assessment

Mémoire

Farzad Jamshidi

Maîtrise en génie mécanique - avec mémoire

Maître ès sciences (M. Sc.)

Québec, Canada

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Sous la direction de :

Daoud Ait-Kadi, directeur de recherche

Résumé

Les villes sont les lieux de la plus grande concentration d'activités sociales et économiques. La logistique est l'une des plus importants éléments de la durabilité et de l'économie d'une la ville. Pour la logistique urbaine, il est nécessaire de prendre en compte les caractéristiques de la ville et les objectifs de toutes les parties prenantes (expéditeurs, destinataires, transporteurs, prestataires de services logistiques, résidents, gouvernement de la ville). Les plans de logistique urbaine durable pourraient avoir un impact significatif sur la qualité de la vie en milieu urbain. L'évaluation d'initiatives de logistique de ville durable (SCLI) telles que les centres de distribution urbains, la tarification de la congestion, le délai de livraison et les restrictions d'accès est un problème complexe, car plusieurs critères et contraintes subjectifs et objectifs doivent être pris en compte. Les administrations municipales investissent dans des initiatives de logistique urbaine durable telles que les centres de distribution urbains, la tarification de la congestion, le calendrier de livraison et les restrictions d'accès afin d'améliorer les conditions de transport de marchandises dans les villes et de réduire leurs impacts négatifs sur les citoyens et leur environnement. Cependant, il y a toujours des risques dynamiques associés à la sélection. L'analyse des risques des initiatives de logistique urbaine est une tâche complexe en raison de la multiplicité des facteurs de risque et de leurs dépendances. Bien qu'il n'y ait pas beaucoup d'études sur les risques liés à la logistique urbaine, aucune attention n'a été portée à l'analyse des risques liés à la logistique urbaine en prenant en compte les dépendances entre les facteurs de risque et leurs critères. Considérer les dépendances entre les facteurs de risque pourrait conduire à une analyse plus précise des risques et augmenter le taux de réussite de la sélection des initiatives de logistique urbaine. Méthodes: pour résoudre ce problème, nous proposons un outil avancé d'aide à la décision appelé «cartes cognitives floues» (FCM), capable de gérer les risques associés à des systèmes aussi complexes. La FCM représente avec précision le comportement de systèmes complexes et peut prendre en compte les incertitudes, les informations imprécises, les interactions entre les facteurs de risque, la rareté de l'information et les opinions de plusieurs décideurs. En outre, il pourrait être appliqué à différents problèmes de prise de décision liés aux initiatives de logistique de ville durable (SCLI). Par conséquent, l'outil proposé aiderait les praticiens à gérer les risques liés à la logistique urbaine d'une manière plus efficace et proactive et offrirait de meilleures solutions d'atténuation des risques.

Dans les études précédentes, les méthodes de décision multicritères étaient principalement utilisées pour l'évaluation, la comparaison et la sélection d'initiatives logistiques de villes en fonction des effets obtenus ou prévus résultant de leur introduction dans divers environnements urbains. Afin d'évaluer l'adéquation des solutions conceptuelles aux exigences des différentes parties prenantes et conformément aux attributs

spécifiques de l'environnement urbain, il convient de définir des solutions conceptuelles associant différentes initiatives de logistique urbaine en utilisant un processus artificiel; outils de renseignement, y compris la FCM.

Abstract

The cities are the places of the largest concentration of social activities and economic. Logistics is one of the most important for the sustainability and the economy of the city. In selecting the city logistics concept, it is necessary to consider the characteristics of the city and the goals of all the stakeholders (shippers, receivers, carriers, logistics service providers, residents, city government). Sustainable city logistics (SCL) plans could significantly affect the quality of life in the urban environment. Evaluating sustainable city logistics initiatives (SCLI) such as urban distribution centres, congestion pricing, delivery timing and access restrictions is a complex problem since several subjective and objective criteria and constraints should be considered. Municipal administrations are investing in sustainable city logistics initiatives (SCLI) such as urban distribution centres, congestion pricing, delivery timing and access restrictions in order to improve the condition of goods transport in cities and reduce their negative impacts on citizens and their environment. However, there is always some dynamic risks associated that should be selected. Risk analysis of sustainable city logistics initiatives is a complex task due to consisting of many risk factors with dependencies among them. Although there are no lots of studies on sustainable city logistics risks, no attention has been paid to the risk analysis of sustainable city logistics by considering the dependencies among risk factors and their criteria. Considering the dependencies among risk factors could lead to more precise risks analysis and increase the success rate of selecting sustainable city logistics initiatives. Methods: To address this, we are proposing an advanced decision support tool called "Fuzzy Cognitive Maps" (FCM) which can deal with risks of such complicated systems. FCM represents the behaviour of complex systems accurately and is able to consider uncertainties, imprecise information, the interactions between risk factors, information scarcity, and several decision maker's opinions. In addition, it could be applied to different decision makings problems related to sustainable city logistics initiatives (SCLI). Therefore, the proposed tool would help practitioners to manage sustainable city logistics risks in a more effective and proactive way and offer better risk mitigation solutions.

In previous studies, multi-criteria decision-making methods are mainly used for the evaluation, comparison and selection of individual sustainable city logistics initiatives in relation to the achieved or planned effects resulting from their introduction in various urban environments. In order to assess the suitability of the conceptual solutions to the requirements of different stakeholders, and in accordance with the specific attributes of the urban environment, there is the definition of conceptual solutions that combine different sustainable city logistics initiatives by using an artificial; intelligence tools including FCM.

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List of abbreviations

CL: City Logistics

SCL: Sustainable City Logistics

FCM: Fuzzy Cognitive Maps

MCDM: Multi Criteria Decision Making

SCLI: Sustainable City Logistics Initiatives

ICT: Information and Communication Technology

ITS: Intelligent Transport Systems

GPS: Global Positioning Systems

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Thank you to my colleague and friend who have all been a source of inspiration for achieving my goals, Dr. Afshin, and also for his logistical support and his generosity for allowing me to **publish the paper which was one of the final selections of 33 best articles from around one hundred papers submitted in the International Journal of Production Research.** His guidance was instrumental in the success of this project. I also owe a debt to Mr. Garneau, who was instrumental in helping me achieve any competency in the French language.

Finally, I want to thank my wife, Masi, for his much-needed French-language support. Her love has given me the stability I needed to make the final push towards completing this level. I would also like to thank my son and daughter, Amir and Elena, who have inspired me to be an example for her and finish what I have started.

Foreword

This project was supervised by Dr. Daoud Ait-Kadi at Laval University. He completed doctoral studies at Montreal University. His research interests include the decision support system, data analysis, maintenance, industry 4.0 and many other subjects that if I want to review them, will be like a paper.

After consultation with prof. Ait Kadi, it was decided that I would pursue a study conducted previously at the sustainability of city logistics (CL). While the design, data collection and a portion of the analysis had already taken place, the synthesis and interpretation were left –the piece of my experience from my first attempt at a selected of sustainable city logistics (SCL) initiatives.

The main study outlined in Chapter five of this thesis was published in International Journal of Production Research in November of 2018 where was selected one of the final selections of 33 best articles from around one hundred papers submitted. I am listed as the author along with Daoud Ait-Kadi, Afshin Jamshidi and Amar Ramudhin respectively. Our contributions were as follows:

Conception and design: FJ
Collection and assembly of data: FJ
Analysis and interpretation of data: FJ, AJ, DA-K
Critical revision of the article for important intellectual content: FJ, AJ, DA-K Final approval of article: FJ, AJ, DA-K

Introduction

Nowadays, cities are confronted with a variety of problems including traffic jams, waiting times, noise and air pollution, raise in congestion, negative environmental impacts and energy consumption, and lack of public space from goods mobility in cities. In the other hand, the management of risk in sustainable city logistics (SCL) has emerged as one of the major research topics in the recent operations and city logistics (CL) literature (Narasimhan, 2009). Notwithstanding their significant benefits, the extended city logistics initiatives (CLI) are more vulnerable, exposing organizations to higher levels of risk.

Based on the European Commission 2014 report, more than 70% of the world's population will live in cities by 2050. It is clear that new strategies, initiatives, and sustainable solutions should be devised in the towns to improve the quality of life of citizens. Local administrations are investing in sustainable city logistics initiatives (SCLI) such as urban distribution centres, congestion pricing, delivery timing and access restrictions to improve the condition of goods transport in cities and reduce their negative impacts on citizens and their environment (Taniguchi, 2002)

Therefore, urban freight transport and logistics operations have become critical issues in sustainable urban development. According to the importance of sustainable development, city logistics initiatives (CLI) such as intelligent fleet management systems, urban consolidation centres, use of electric vehicles, and putting in place various freight regulations such as vehicle sizing, access and timing restrictions, congestion pricing (Muñuzuri, 2005) have been recognised as one of the best solutions for efficient urban freight transport and logistics with high environmental objectives.

Despite the importance of this topic and the problems associated with it, little attention has been paid to it by researchers and policy-makers. The pursuit of sustainability increasingly recognizes as an effective strategy to deal with some of the contemporary challenges facing CL. It leads to enhanced competitiveness and improved financial performance (Wang, 2013) and generates moral capital for firms to mitigate the consequences of potential business risks (Godfrey, 2009).

Sustainability can consider as the degree to which present decisions of organizations impact on the future situation of the natural environment, societies and business viability (Krysiak, 2009). With this broad definition, SCL strategies should consider the level of future uncertainty and therefore the risks that decisions may impose on the natural and social environments, in addition to the investment costs that are required to make CL more sustainable. SCL increasingly perceive as a vital source of cost reduction and indispensable for the long-term profitability of a firm (Wang, 2013).

Local administrations are responsible for taking decisions on sustainable sourcing, local content development, relationship management and asset recovery, for cutting down costs and minimize sustainability-related risks. As a result, the identification of sustainability-related CL risks, the assessment of their impact and the development of risk assessment tools are becoming critical issues for CL. Although there is a growing interest in the links between sustainable CL and risk, few studies have investigated the threat brought about by (the lack of) SCL.

Some of them focus simply on environmental risks (Cousins, 2004), and others are limited to specific sectors (Teuscher, 2006). Anderson (Anderson, D.R., 2005) and Anderson and Anderson (Anderson, 2009) generated original articles, advocating that any risk assessment strategy should incorporate sustainability-related risks. Foerstl et al. (2010) advanced the study in the field by analyzing how competitive advantage can generate with the development of appropriate SCLI and Hoffman et al. (Hoffman, 2014) investigated the processes whereby CL issues may create sustainability-related risks.

Therefore, this thesis deals with risk assessment of SCL as the most crucial phase of risk assessment and proposes an advanced decision support tool called "FCM" to overcome the shortcomings of current risk evaluation tools applied in SCL such as failure mode and effect analysis (FMEA) (Welborn, 2007). FCM is a useful artificial intelligence technique which represents and analyzes the dynamic behaviour of complex systems composed of interrelated variables (Kosko,1986, Jamshidi, 2015). Recently, this tool has been applied successfully in evaluating risks in complex and critical environments such as Enterprise Resource Planning (ERP) maintenance (Lopez, 2014, Ahmad, 2012) and IT projects, and therefore we think it has an excellent potential to be applied in complex city logistics initiatives for evaluating risks and forecasting the impact of each risk by considering interdependencies.

There is a lack of research that explores the nature of SCL-related risks in an integrated manner and develops risk assessment strategies to treat them. This thesis, the nature of sustainability-related city logistics risks distinguishes them from typical city logistics risks and develops an analytical process for their management. A literature study is conducted to generate insights about how sustainability-related risks should manage in an integrated way. A mixed method approach is adopted for criteria collection and their relation. Through an extensive literature review, the classification of risk sources adapted to CL measures, broken down into external and internal risks, has been proposed. The source of the external risk can be socio-political factors, economic factors, law regulations, infrastructure and technology innovations and civil and natural disturbances. In turn, the internal sources of risk may include management, human resources, marketing, finance and information technology.

An advanced decision support tool called "Fuzzy Cognitive Maps" (FCM) is utilized to assess the relative importance of the selected risks, to identify their potential causes and effects and test possible correlations between the identified risks. Based on the findings of the study, risk treatment strategies propose for all the identified sustainability-related city logistics risks. The results show that endogenous environmental risks are perceived to be the most important across different industries, and the interconnectedness between several sustainability-related risks is very high. This points to the need for integrated sustainability risk assessment approaches to facilitate the development of effective, sustainable strategies. We set out to address these issues by exploring two main research questions:

RQ1: What is the nature, the causes and effects of sustainability-related city logistics risks?

RQ2: How can sustainability-related risks be managed?

Following a description of the SCL risks, Chapter 1 will discuss the sustainability of city logistics planning. In Chapter 2, it presents the importance of risk assessment in the field of SCL. Chapter 3 will be shown the concept of risk assessment in CL measures' implementation. In section 4 ''The proposed risk assessment tools for sustainable city logistics'' will be presented, and finally, in chapter 5 we will have the consistency of the research article comprising this thesis in their published forms, respectively. A general conclusion closes chapter 6.

CHAPTER 1 Sustainable city logistics planning (SCLP)

1.1 Concept of city logistics (CL)

A key element of world urban mobility and logistics strategies is sustainability. Brundtland Report (Brundtland,1987) defined the three components along with sustainable development: economic growth, environmental protection and social equity (Behrends, 2008). What does city logistics mean? Taniguchi et al. (Taniguchi, 2000) explained city logistics as “the process for completely optimising the transport activities and logistics by individual companies with assistance of advanced information systems in cities regarding the traffic safety, the traffic environment, the traffic congestion and the energy savings within the framework of a market economy.” This definition highlights the total optimization of city logistics planning of private companies rather than local optimization. It also includes the congestion, social issues of the environment, and energy savings as well as economic issues relating to city logistics.

City logistics planning identify the sustainability aspect by viewing freight together with its surrounding environment. Altogether, the defined freight plans protect all three sustainability components; however, environmental can considered as the main criteria comparing across countries. Only two methods are defined by Dundee and London, as sustainable city logistics planning (Transport for London, 2007, Dundee City Council, 2014). Stakeholders in city logistics planning classified into four groups: administrators, shippers, freight carriers, and residents who are involved in city logistics. Since stakeholders’ aim and standpoint are distinct on city logistics planning, coordination amongst the stakeholders is required to improve the condition of goods transport in cities and reduce their negative impacts on citizens and their environment. Local administrations are investing in SCLI such as urban distribution centers, congestion pricing, delivery timing and access restrictions to improve the condition of goods transport in cities and reduce their negative impacts on citizens and their environment (Anderson, 2005).

Therefore, urban freight transport and logistics operations have become critical issues in sustainable urban development. According to the importance of sustainable development, city logistics initiatives such as intelligent fleet management systems, urban consolidation centers, use of electric vehicles, and putting in place various freight regulations such as vehicle sizing, access and timing restrictions, congestion pricing (Taniguchi, 2001) have been recognized as one of the best solutions for efficient urban freight transport and logistics with high environmental objectives. The essential components of city logistics classified into three categories:

(a) Application of innovative technologies of Information and Communication Technology (ICT) and Intelligent Transport Systems (ITS)

(b) Change in mindsets of logistics managers

(c) Public-private partnerships.

One of the most critical roles of the application of innovative technologies of ICT and ITS in urban transport is the collection of accurate data of pickup-delivery truck movements on city road networks with lower costs. Digital data can be fully used to optimize vehicle routing and scheduling planning in a dynamic and stochastic manner (Taniguchi, 2006). This kind of optimization of vehicle operations can chip in towards alleviating CO2, NOx and SPM emissions as well as decreasing traffic congestion and reducing logistics costs. Hence, both private companies and society at large can profit from the application of innovative ICT and ITS technologies in terms of the efficiency of logistics as well as the decline of adverse environmental impacts. The second critical element for city logistics is a change in the mindset of logistics administrator, for logistics managers are playing an important role in city logistics planning. Thirdly, public-private partnerships are a core element for sustainable city logistics (Browne, 2004).

In traditional city logistics planning, administrators mainly extend city logistics plans based on their surveys and information and then sometimes listen to the public authority and habitats. However, public/private partnerships allow all stakeholders to participate in improving city logistics plans from the initial phase. For understanding, the situation of goods distribution and related problems need to contribute data between private companies and the public sector. Based on the European Commission 2014 report, more than 70% of the world's population will live in cities by 2050. It is clear that new strategies, initiatives, and sustainable solutions should be devised in cities in order to improve the quality of life of citizens. Despite the importance of this topic and the problems associated with it, little attention has been paid to it by researchers and policymakers.

There is a need to identify the most common and suitable criteria and factors for evaluating the SCLI and more importantly, advanced decision-support systems (DSS) which could be applied for selecting the best initiatives in different cities. This requires defining a large number of criteria in order to be applicable in all cities by taking into account all the requirements of stakeholders and the factors that cover different aspects of city characteristics.

1.2 Challenges and tendency for sustainable city logistics

The most important subject in our thesis is just focus on city logistics, sustainability and its risks. There are many different challenges and opportunities; however, Pelletier et al. (Pelletier, 2016) discuss many of them related to the use of vehicles for goods distribution in cities. Another relevant stream investigates routing problems in which one of its objectives is decreasing negative impact (Bektas 2011), (A. Campbell, 2016) and (Campbell, 2016). One of the challenges confronted is that emissions depend on the weight and the speed of the vehicle.

However, importance ensuring the environmental, social, and economic sustainability of our cities goes beyond greenhouse gas emissions. A comprehensive summary of relevant models for these externalities within freight transportation can be observed in Demir et al. (Demir, 2015). How to consolidate the management of these externalities in optimization models and decisions support systems is an important issue and has to involve other scientific disciplines (e.g., social science or urban science). The most critical challenges and tendency for SCL that identified are the following:

Trends and Advances in technology

In this section, most of our focus is on a few trends and advances in technology which are driving changes in urban logistics. In the trends, we discuss an increase in the intricacy of city logistics that it can lead to an increase in the negative impacts on congestion, safety, and the environment. Specifically, the recent data provide on the growing importance of e-commerce, the desire for speed in supply chains, city population growth, and the increased attention to sustainability. This information is supplemented with views on the impact of these trends on city logistics. On the other hand, we discuss the new and emerging technologies that can lead city logistics innovation that finally can potentially decrease the negative effects on congestion, safety, and environments. (Such as Digital connectivity, big data, and automation.)

- E-commerce:

Today, in the city logistics and services, E-commerce, social media and mobile devices play an essential role. Steadily, in freight transport, individual orders such as courier, express mail is rising. Individualization of production and trade are crucial elements for the future, and it will entail a further increase in the number of flows. Today, in the city logistics and services, E-commerce, social media and mobile devices play an essential role, and it has become more popular. Steadily, in freight transport, individual orders such as courier, express mail is rising. Individualization of production and trade are a vital element for the future, and it will entail a further increase in the number of flows. The development of Internet shopping Business to Consumer (B2C) affects urban city logistics.

Taniguchi and Kakimoto (Taniguchi, 2004) studied the effects of e-commerce by using vehicle routing and scheduling problem model on urban freight transport. They declared that the influence of B2C e-commerce could develop the truck flows for home delivery with time windows, but this can reduce by introducing joint delivery systems and pickup points where customers visit to pick up their commodities. Hong et al. (Hong, 2013) investigated the scheduling and optimization of vehicle routing for B2C e-commerce city logistics distribution systems.

- Climate change & sustainability

One of the main results in traffic accidents, air and noise pollution, traffic congestion, and greenhouse gas emissions is the increased freight activity in urban areas (Demir, 2015). Concentrating on the environmental, social, and economic sustainability of cities should not impact on the quality of life and attractiveness of urban areas, and on impact urban citizens' health too. Finally, it needs to ensure that with increasing the city freight transport does not eventually lower the quality of life and attractiveness of urban areas.

However, on the other hand, it needs to support the urban lifestyles, maintain industrial and trading activities (Macharis, 2015, Browne, 2012). It is clear that the need for urban freight transport is developing and will continue. Reducing the impact of the distribution of goods and service has a direct effect on living conditions in urban areas. Given the importance of freight transport in Europ, "transport is the most source of emitting sector, with upward emission trends" (European Environment Agency, 2009). Improving air quality is another essential contemporary challenge in city living. Between 1990 and 2007, in Europe, the amount of CO2 emissions from transport, increased by 29 %. In 2000 (Demir, 2000) for road transportation, the CO2 emissions were nearly 73%. In related to road transport CO2 emissions, the contribution of urban traffic accounts is 40 %, and other air pollutants are 70%.

It should be noted that in terms of traffic congestion in Europe, as a result of this phenomenon assigns every year nearly 100 billion Euros or 1% of the European Union's (EU's) GDP to the European economy. According to the European norms for NOx, cities should be improved the air quality considerably. Because of this concentration have a negative impact on the residents' health. According to the reports of the Commission of the European Communities 2007, in the largest European cities over 41 million Europeans expose to extreme noise from road traffic.

- Big data and analysis

To the grace of the development and deployment of Information and Communication Technology (ICT) and Intelligent Transport Systems (ITS), it quickly collects "big data" of transportation of truck movements. One of the crucial devices that typically install in trucks and allowing the location of vehicles to precisely measured every second is named global Positioning Systems (GPS). To gain insights into the behaviour of drivers, the analysis of big data of truck movements in urban areas could be helped us in the management of city logistics planning. Lin et al. (Lin, 2013) applied data mining technique to find routing patterns from the past cases of urban freight. Ehmke and Mattfeld (2010) mentioned the data provision of time-dependent travel times for city logistics planning. They considered a smart routing system on mobile, which install on the drivers' smartphone. It demonstrates that the proposed method was successful in the case of studies in reducing travel times on congested urban logistics networks. Xu et al. (2014) studied on a set of data that was utilized to design a high-efficient flow path using Petri-Nets and offered a city logistics model based on a cloud-based platform.

- Road pricing

Traffic congestion is one of the most reason for economical costs and environmental impacts. For solving this problem, road pricing could be a demand management tool for decreasing the economic and ecological costs of freight transport in CL planning sector. Nowadays, trucks and passenger vehicle compete for road space in city areas, while the public transport systems exist and it could be a good alternative instead of private transport. It seems that the need to develop improved models is vital to predicting the change in transportation as well as the reduction of passenger-related costs. To this end, many suppliers in the vast metropolitan area rent multiple warehouses or distribution centres to provide better customer service and decrease the environmental and economic costs.

On the other hand, direct road charges such as tolls are one of the most important reasons to avoid the need for additional warehouses and more efficient utilization of vehicles. If we decrease the trip time for freight vehicles, then it will steer to more stope route as well as fewer routes that finally it will lead to reducing the number of the car needed and labour costs. The reason for leading to higher operating costs for city logistics carriers as well as augmented environmental costs from freight vehicles could be more prolonged periods of congestion. Holguin-Veras et al. (2006) in their study about the assessment of the impacts of the Port Authority of New York of day pricing initiative discovered that carriers had multiple responses including productivity increases, cost transfers as well as changing the use of facilities.

CHAPTER 2 The importance of risk assessment in the field of sustainable city logistics

2.1 Risk assessment

Risk assessment is an indispensable part of an occupational health and safety management plan. It is very important as that could help to create awareness of risk, identify who may be at risk, prioritize risk and control measures and Prevent injuries. We use the throughout processes to describe the risk assessment which could be included identify risk factors, evaluate the risk, establish the appropriate ways to reduce the risk or to control it. They play an important role in various industries to identify conditions, processes, methods, etc. If you do not manage it, that may cause harm. Next step after identification is, analyze and evaluate step. Finally, when the determination is performed, you can decide what measures could be caused in place to effectively reduce or control the harm from happening. As clear from the name the risk assessment process, its goal is to evaluate hazards to remove or minimize the level of risk by analyzing control measures. There could be many reasons a risk assessment is needed. We do a risk assessment before new processes or activities and changes are introduced.

2.2 The risk assessment process

If the organizations enter in the critical and unknown area, it could lead to catastrophic defeats; therefore, risk assessment not only prevents its entering but also secure the improvement and growth of the business. Two elements that are critical for risk assessment and have to consider are including the depth and clarity with which risk defined. When the risk is classified and is documented in particular; afterward, the concerned stakeholders engage potential risk assessment and solving problems. In decision-making method need to requires threats identified, its influence and reaction on the business. To changes in the organizational policies and structures, it needs a thorough review of the position and critical feedback; especially in the status of a larger project. Nowadays, the best management method is a systematic approach to managing risk. By doing a thorough analysis, organizations will have fewer surprises and therefore, consume scarcer time recovering from the losses that may be inevitable at times. The risk assessment process divide as follows (Fig.1):

Figure 1. The risk assessment process

If you plan to implement the risk assessment process in your projects, be aware that you must separate it into specific steps so that everything happens as expected.

- Establish goals and context

Once the context is established, the first critical step is a definition of risk and establish context and define a goal. After the goal defined, there is a need to identify the scope of the context. Also, it is important to know what is the restriction of the risk strategy proposed. Importance Role of the effective risk assessment team is in the understands the needs of the organization and the procedure it utilizes. Generally, the needs of the organization could be categorized into operational and strategic risks. We can classify operational risk assessment into technological, human resource, financial, reputation and other relevant strategic issues, while strategic risk assessment includes risk assessment economic, social, environmental, political, legal and public issues.

The process of risk assessment needs to be accurate, useful and simple. If the organization would like to be effective, should be considered strength, weakness, opportunities and threats (SWOT) type analysis of the situation. The management by conducting the SWOT analysis can analyze identity in different condition (IRM, AIRMIC, ALARM, 2002). After the identification of threats, the management with appropriate measures and decisions could take to convert the threat into an opportunity. The organizational context helps us to understand the organization, Its aims and strategies and also its capacity and goals. The identification of stakeholders is the first and critical step to establishing the organizational context. Stakeholders are individuals who may be affected by decisions made by the risk assessment team.

- Identification of risks

There are various sources of risk. For risk identification, it should review the technical ability, key performance parameters, performance challenges, stakeholders expectations vs. current plan, external and internal dependencies, implementation challenges, combination, interoperability, supportability, supply-chain vulnerabilities, ability to handle threats, cost deviations, safety, security, and more. Risk identification is including an orderly process of analyzing situations and gaining solutions that achieve by group meeting and brainstorming gatherings to create a variety of ideas. While all the plans or objectives created may or may not remain critical, it is necessary to document all problems, possible results and solutions identified. Risks can identify by analyzing reports of previous activities or events. Other methods that can help us to identify risks are results from past events (individual, local or abroad) (Hillson, 2002) within conduction conversations of stakeholders (Susilawati, 2004).

- Analyse risks

The first step of analyzing risk, one decides on the relationship among the possibility of a risk happening and the consequences of the risk classified. Then the level of risk is determined and following that its management investigate. The levels of risks can be categorized into four steps.

a) Extreme: It needs urgent action since this level of risk could be disastrous to the organizations;
b) High: A high level of risk needs immediate action because it has the potential to be breaking to the business;
c) Moderate: Moderate level indicates specific ability to implement monitoring or acknowledgment methods; and
d) Low: This level can maintain a low level of risk with conventional methods.

The tools that usually applied to measure risks include qualitative techniques. The risk matrix usually applied as a tool to illustrate various risks after they have investigated. This tool is a qualitative technique that could provide better insight into the nature of risk. The questions that could become important in related to each of the recognized risks:

1. What is the level of the risk?
2. What are the consequences if the risk should occur?
3. What is the probability of the risk occurring? and
4. Are there any controls to manage the risk?

- Evaluate and Treatments of risks

In the evaluation step, the tolerance of the risk specifies is acceptable or unacceptable. The evaluation steps are the following:

- potential and genuine damages that could occur from the risk;
- opportunities and advantages proffered by the risk;
- probable results of a risky activity and importance of risk assessment; and
- control level of one has over the risk.

Acceptable risk

It is a kind of risk that an organization could bear (for example- the risk does not have a major impact on the business). This type of risk because of its importance that should be regularly observed, reviewed and documented so that it remains sustainable.

Unacceptable risk

This kind of risk happens when an organization falls the losses of experience significant that such damages cannot be endured. In this type of event, it needs to address and treat the risk in a suitable way. In the most decision-making methods to hit a balance between the cost and effect, opinions are considered and calculations are made. In treatment level, Risks could solve in different ways. It could decrease, avoided, distributed or saved. If the appropriate decisions are taken to resolve all possible pitfalls and consequently prevent the situation from occurring, we say that risk avoided. In the most decision-making methods for a balance between the cost and effect, calculations did and opinions considered. In such conditions, the risks that calculated accepted and risks with a high level could be reduced by:

- Identifying opportunities to manage the risk;
- Picking the best treatment possibility;
- Providing a risk assessment plan; and
- Executing a risk assessment plan.

➢ Monitor and controlling

Risk assessment teams play an essential role in identifying and addressing risks and attempts to decrease the risks. In this process, information retrieval and reporting could contribute valuable insights into the risk assessment method. To reduce risks, this process enables an organization to undertake suitable and timely measures to avert risks. It is important to regularly monitor and assess the procedures that are applied to manage risks. Because the risks do not remain the same and new risks are created, may be reduced or raised and some risks may no longer exist and prior or existing risk control policies may no longer be effective.

2.3 The importance of risk assessment in SCL

The word "risk" comes from the early Italian word, ''risicare", which means "to dare". In this sense, risk is a choice rather than a fate" (Bernstein, 1996). For many years, risk was associated only with gambling. In the early nineteenth century the term was adopted by the insurance industry in England and in the 50s and 60s of the last century industries became interested in the concept of risk. This was due to the rise in competition in the market and the need to consider in decision making the possibility of the occurrence of various kinds of interference. Traditionally, risk was considered through the financial and insurance prism. Nowadays a holistic approach to risk as an integral part of business strategy can be seen (Ciesielski, 2009).

In the literature many definitions of risk can be found (Hutchins, 2003, Project Management Institute, 2000). According to the ISO/IEC Guide 73 risk “can be defined as the combination of the probability of an event and its consequences”. while Hutchins defines risk as “the probability that an event or action may adversely affect the organization”.

In turn, according to Australian standard of risk assessment, definition of risk is understood as “the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood”. A somewhat different definition of risk was proposed by Project Management Institute in PMBOK Guide (Project Management Institute, 2000), were risk was defined as an uncertain event or condition that, if it occurs, has a positive or a negative effect on a project objective”.

According to Hillson and Hulett (2004), despite the heterogeneous approaches to defining risk it can be observed, that in all these definitions risk has two dimensions: uncertainty and the impact on objectives. Therefore, risk assessment comprises the development of guidelines in order to determine the significance of risk on the basis of the probability of occurrence and the impact on the implementation of the project. The problem of risk in the area of urban freight transport equated by many authors with city logistics (Benjelloun, 2009, Taniguchi, (2000), Würdemann, 1992), concerns on the one hand individual measures implemented in this area, and on the other the entire freight transport system in the city.

In this project, the risk in the area of SCL will be considered from the perspective of SCL measures’ implementation. Based on the above considerations it can be assumed that risk assessment in SCL measures’ implementation consists of an uncertain event or condition that, if it occurs, has a positive or a negative effect on SCL measures’ objectives. For the purposes of this project risk will be considered from the perspective of threats that impede the realisation of SCL measures. The risk associated with the implementation of SCL measures apparent in particular from the involvement of various stakeholders, such as: shippers, receivers, freight carriers, administrators and residents, each of which has different expectations and objectives. Therefore, sources of risk may originate from the interior - from individual stakeholders (lack of cooperation, poor coordination, lack of liquidity), and externally (earthquakes, fires, floods, changing regulations at national/EU level, etc.).

According to Taniguchi et al. (2010) in many cities risk is still not considered in the modelling of CL. And yet implemented in cities, SCL measures are directly related to public welfare and public health. In particular, local governments should be interested in reduction or elimination of risk factors as a result of activities related to SCL to ensure a high quality of life in the city. Risk assessment in the area of SCL is difficult and complex, requiring effective risk assessment of processes throughout the lifecycle of UFT measures and in collaboration with all stakeholders. Therefore, appropriate risk assessment can significantly increase the effectiveness of the implemented projects and reduce or completely eliminate the potential risks. According to Latham risk can be “minimized, shared, transferred or accepted but cannot be ignored”.

CHAPTER 3 Risk assessment in SCL

3.1 The procedure of risk assessment in the field of SCL

Originally, the word "risk" comes from Italy “risicare”. Initially, the term was chosen by the insurance industry in England and from the 50’s and 60’s became in the concept of risk. In many industries, risk assessment is constantly growing. In the literature, we have found many definitions such as Australian/New Zealand Standard AS/NZS4360:1999, COSO (Curtis, 2012) ISO/IEC Guide 73; Hutchins, 2003; Risk assessment Standard FERMA (http://www.ferma.eu/risk-management/standards/risk-management-standard), A Risk assessment Standard, Institute of Risk assessment in UK (The Institute of Risk assessment, 2002). The mentioned standards represent different approaches to risk assessment. For example, the European standards for risk assessment FERMA includes five main steps:

- Stablish context
- Assessment (which includes identification, analysis and evaluation)
- Treatment
- Monitoring /review
- Communication / consultation

The defined standards describe the various approaches to risk assessment. As explained before, seven significant areas that were developed by IRM includes: “the organization’s strategic aims, risk assessment, risk reporting, decision, risk treatment, remaining risk reporting and monitoring. It may occur modification and formal audit during the whole process; however, Project Management Institute (Project Management Institute, 2000) explained a slightly different risk assessment process which classified in six groups: “risk assessment planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control".

In the case of SCL logistics and freight transport, there is a lack of tools and standards that enable stakeholders to perform efficient and effective risk assessment in this area. Risk assessment in the process of SCL measures requires firstly selection of appropriate solutions, which in the right order, should be implemented. Therefore, the proposed risk analysis process should be selected by the municipal administration of CL measures. In the beginning, the responsible for SCL should be indicated in a local authority. This person should be responsible for the analyses of CL problems and stakeholders’ requirements in this field.

Risk evaluation of SCL is a complex and critical task since several tangible and intangible risk factors should be considered in this process. Besides, there are always some dependencies among risks that can influence each other mutually, and these dependencies make the evaluation process more complex and challenging. Therefore, an effective method for evaluating the risks is fundamental and essential. However, research about the risk assessment of SCL by considering the interrelationships among risks factors and forecasting the impact of each risk on the other risks is lacking in the literature, and further research in this field is required. Considering the interdependencies among risks could lead to more accurate risk assessment to organizations.

To carry out these analyses, many methods in the field of marketing research can be applied. Among other things: observations, survey, focus groups, Delphi method, FMEA, FCM, etc. In the next stage, in cooperation with SCL stakeholders, a comparison of the city strategic objectives with the problems in the area of SCL and the expectations of CL stakeholders should be carried out. As a result of these studies and meetings consensus among stakeholders in selecting measures of SCL risk, which can be implemented in a city should be obtained. Finally, the chosen measures should be prioritized according to their importance and the order in which they will be implemented. (Fig.2).

As you can see in Fig 2, The risk assessment process for selected sustainable city logistics planning could be classified into five steps.

- Risk assessment planning
- Identification of risk factors in relations to each measure
- Risk factor assessment
- Identification of the corrective actions;
- Continuous monitoring.

Continuous monitoring step refers to the evaluation of the effectiveness of the implementation of each level of the risk assessment process, from controlling risk factors, through identifying the new one and finishing with implementation of reduction plans for each risk factor. In the risk assessment planning step, it should be defined as a structure and methods by which risk analysis will be carried out in relation to SCL measures. the person responsible for the risk management process and the team which will participate is selected in this step.

As a result of the meetings between the person responsible and members of the team, a risk plan covering is defined such following:

- Method of analysis
- Task descriptions

- Size of the budget
- Time and frequency of risk analysis throughout the life cycle of SCL measures
- Way of scaling for quantitative and qualitative analyses

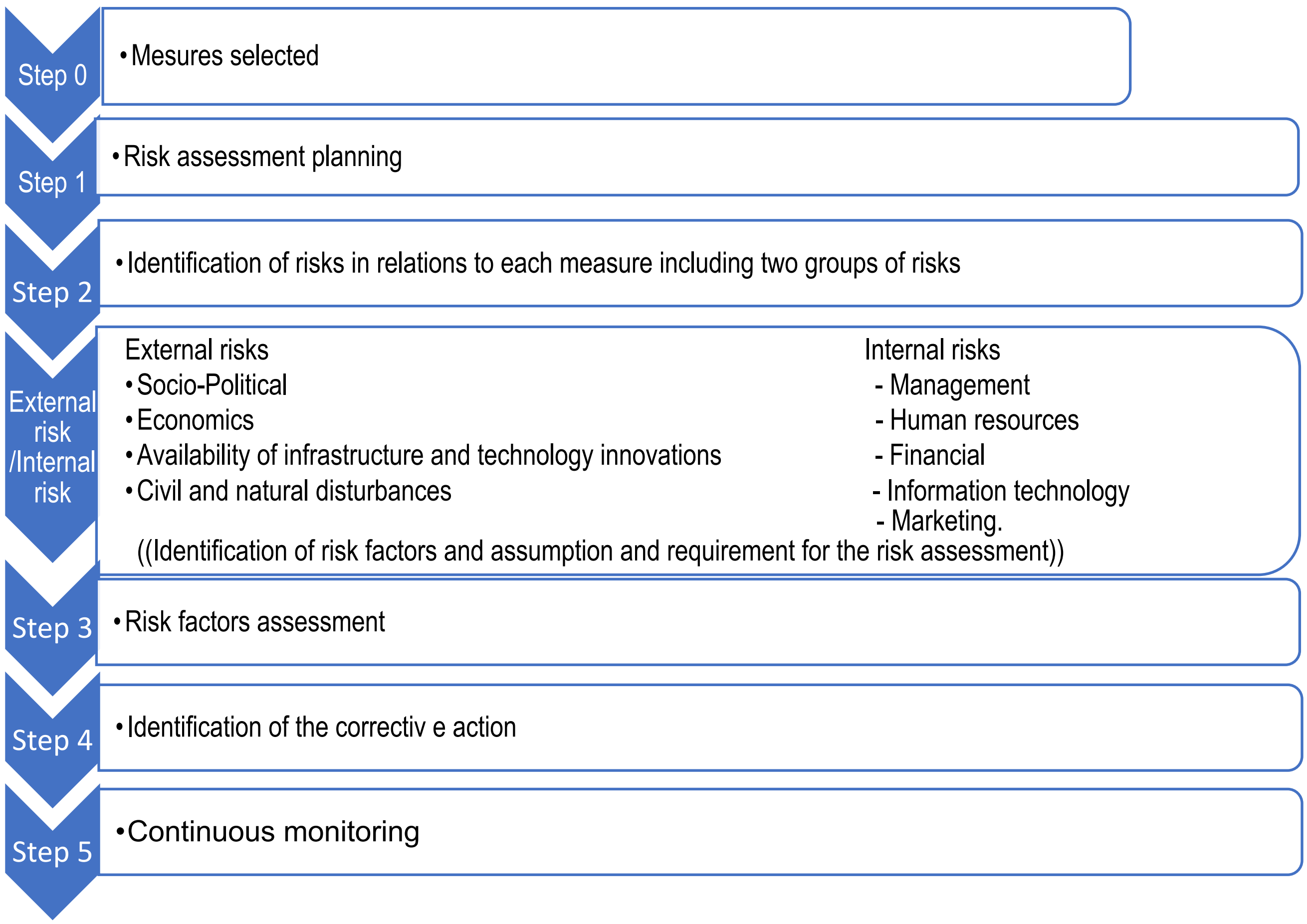

Figure 2. Reference model of risk assessment for SCL measures' implementation Source (Maja Kiba-Janiak,2016)

3.2 Identification of the selected risk factors in the field of SCL

To identify risk factors concerning each measure, it needs an understanding of the strategic goals of the city, the purposes of each CLP measure and different expectations and purposes of stakeholders. There are many different risk categories in the literature. In point of view of IRM (2000) the risk sources is categorized in five steps: financial, operational, strategic, knowledge management and compliance. Four types of risk are highlighted by the Project Management Institute (Project Management Institute, 2000). There is no universal ranking of risk sources that satisfies every organization. In our project, the risk sources in SCL mesures is categorized into external and internal risks. The external risk is broken down into economic factors, law regulations, socio-political factors, infrastructure and technology innovations and civil and natural disturbances, and the internal sources of risk include human resources, management, marketing, finance and information technology (Janiak, 2016) (Table 1).

There are many types of tools and techniques for risk identification including questionnaires, scenario analysis, Delphi technique, SWOT analysis, interviewing, checklist, surveys, FCM, assumption analysis and brainstorming. In this thesis, we deal with risk assessment of SCL arrangements as the most important phase of risk assessment, and proposes an advanced decision support tool called “FCM” to overcome the shortcomings of current risk evaluation tools applied in SCL such as failure mode and effect analysis (FMEA) (C. Welborn, 2007). FCM is a useful artificial intelligence technique which represents and analyzes the dynamic behavior of complex systems composed of interrelated variables (B. Kosko,1986, A. Jamshidi et al., 2015). This tool recently has been applied successfully in evaluating risks in complex and critical environments such as Enterprise Resource Planning (ERP) maintenance (Lopez, 2014, Ahmad, 2012) and IT projects (Salmeron, 2010) and therefore we think it has a good potential to be applied in complex SCL initiatives for evaluating risks and forecasting the impact of each risk by considering interdependencies.

The specific features of FCM that are shown above in table 1, make it differentiated from other modelling techniques, such as neural networks, systems dynamics, Bayesian networks.

Table 1. Selected risk factors in terms of risk sources in the field of SCL

Classification	No.	Source of risk	Selected risk factors
Internal	1	Management	1.1. The differences in organisational cultures among UFT stakeholders Excessive bureaucracy 1.2. A large number of UFT stakeholders from the SME sector 1.3. The lack of objectives for UFT in long-term plans (strategies) of the city
	2	Human resources	2.1. Poor or lack of know-how and insufficient experience in planning and implementing UFT measures 2.2. Lack of acceptance to implement a solution from one or more stakeholders 2.3. Lack of willingness from stakeholders for cooperation
	3	Financial	3.1. Excessive maintenance costs of the investment 3.2. Poor financial situation of stakeholders 3.3. Shortfall of funds in the budget
	4	Information technology	4.1. Conflicting interfaces of work items 4.2. The low level of information technology among UFT stakeholders
	5	Marketing	5.1. Lack of knowledge about stakeholders' requirements 5.2. Inaccurate predictions / forecasts about the size of the cargo flows within a city 5.3. Failure to inform the public about the implemented solutions
External	6	Socio-political	6.1. Frequent changes in legislation at national and EU level 6.2. Extending the duration of the project due to delays in obtaining permits from local governments 6.3. Changes in consumer behaviour of society 6.4. A large cultural diversity of society 6.5. Protestant interference of nearby residents 6.6. Bad habits of UFT stakeholders in the organisation and execution of transport in the city
	7	Economics	7.1. Tax change 7.2. The rising cost of fuel, machines and materials 7.3. An increase in payrolls and tax payments in transportation sector in the region
	8	Availability of infrastructure and technology innovations	8.1. Poorly developed transport infrastructure or lack of it 8.2. Poor quality of transport infrastructure 8.3. Restrictions on development and change of the existing infrastructure 8.4. Lack of access to modern technology
	9	Civil and natural disturbances	9.1. Wars 9.2. Riots, strikes 9.3. Natural disasters

CHAPTER 4 The proposed risk assessment tool for SCL

In this section, we present the proposed risk assessment such as FCM in order to deal with SCL risk management. At first, we present Fuzzy theory and in the following, we talk about fuzzy cognitive maps method and in the last part, we work on the numerical example of risks assessment in SCL.

4.1 Fuzzy theory

There are two methods for assessing a risk factor such as a qualitative and/or quantitative method. One of the most element that is very important regardless of the type of is the selection of the selected method of experienced experts to analyze, who, based on their knowledge and skills will be able to assess individual risk factors. This step is including the evaluation of the impact and probability of identified risk factors. Because probability is the possibility of a given factor occurring at a given time, it could be defined both in a qualitative way, as well as quantitative or as a frequency.

In this sector, we present two definitions of the concepts of fuzzy sets and triangular fuzzy numbers.

- A fuzzy set

  It is created from a refrence set called univers of discoursew. It should be noted that the reference set is never fuzzy. Assume that $U = \{x_1, x_2, x_3, \dots \dots .., x_n\}$ is the universe of discourse, then a fuzzy set T in $U (T \subset U)$ is defined as a set of ordered pairs $\{(x_i, \mu_A(x_i))\}$ where $x_i \in U, \mu_T: U \longrightarrow [0,1]$ is the membership function of T and $\mu_T(x) \in [0,1]$ is the degree of membership of x in T. (Werro 2015).

- A fuzzy variable

For determining a fuzzy variable we use a triangular fuzzy linguistic variable which is demonstrated by the triplet $T[l, m, u]$of crisp number with $(l < m < u)$. They are characterized by the following member function (Jamshidi, 2017):

$$\mu_T(x) = \begin{cases} \frac{x-l}{m-l}, & if\ l \leq x \leq m \\ \frac{u-x}{u-m}, & if\ m \leq x \leq u \\ 0, & \text{othwerwise} \end{cases}$$

You can find a simple fuzzy triangular number in Figure 3. As it is shown, the values l, m, and u designate the lower, medium and upper bound for the assigned linguistic term. In each linguistic term, the purpose of considering lower and upper bounds is to take into account the uncertainties in experts' opinions.

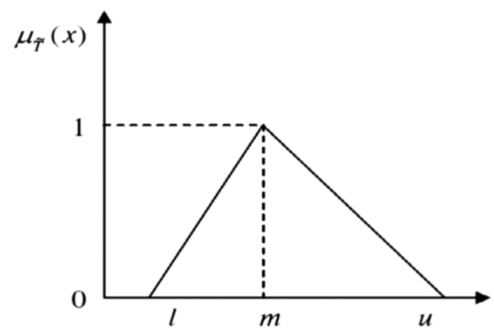

Figure 3. A simple of triangular fuzzy number.

4.2 Fuzzy cognitive maps (FCM)

Kosko in 1986 introduced Fuzzy Cognitive Map (FCM) as an evolving soft computing technique to describe the causal relationships between the principal factors (concepts) which determine the dynamic behaviour of a system.This method includes neural networks and fuzzy logic that could be considered the relationships between the nodes and uncertainties in experts' opinions (Kosko 1986). Generally, FCMs are classified into two groups.

- Supervised: This type is based on historical data.
- Unsupervised: The knowledge and experience of experts play an important role in this type.

FCMs are a combination of fuzzy logic and neural networks that are used to describe both qualitative and quantitative data. Newly, the most important uses of FCM is widely in the decision analysis, engineering science, application of political decision making, fault detection, process control, data mining, medical decision system, and many other industries. For aggregating the experts' opinions, we can use by different methods such as Delphi (Glykas, 2010). Salmeron (2010) believe that FCM is the most effective tool in terms of requirements for complex risk assessment of dynamic systems (See Table 2). The indicated characteristics in table 2 make FCM differentiated from other modelling techniques, such as Bayesian networks, systems dynamics, neural networks.

Table 2. Analyzing the features of different modelling techniques (Salmeron 2010).

Features	Modelling techniques			
	Bayesian networks	Neural networks	Systems dynamics	FCM
Considering scare information		√		√
The propagation does not follow an established pattern			√	√
Considering directed graph with cycles			√	√
Considering uncertainties	√	√		√
Considering all dependencies among nodes	√	√	√	√

An FCM includes some nodes/concepts which show some edges/arcs between nodes and the relationships between them and also the main features of the system (Maja Kiba-Janiak, 2016) (See Figure 3).

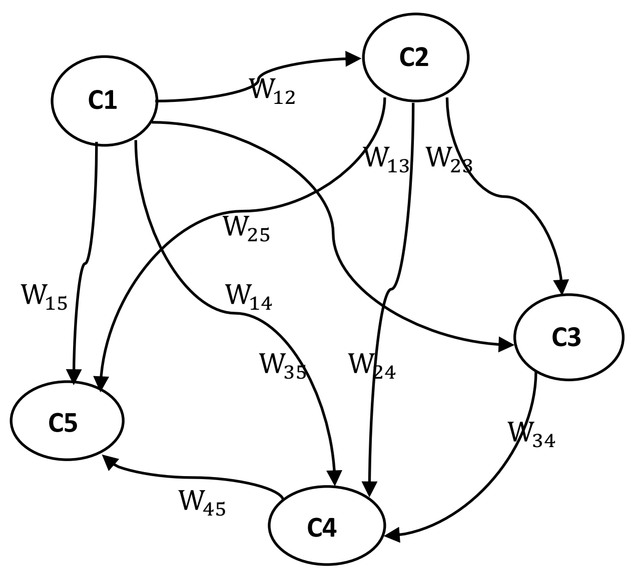

Figure 4. A simple Fuzzy Cognitive Map

The value of each initial concept Ci could take a value in the interval [0,1] and the arc weight between concepts Ci and Cj (W_{ij}) could be ranged in the interval [–1, 1] which show the impact of each concept on the other concepts. The first task in design the FCM is to calculate the value of initial weight matrix using fuzzy linguistic terms, such as very low (VL), high (H) by the experts. The next step is aggregating the assigned fuzzy linguistic terms and defuzzifing them to numerical values (Papageorgiou 2014). Finally, the stability of FCM is accomplished by Equation (1).

Papageorgiou (2004) presented the following equation to updated the value A_i of the concept C_i at each simulation step :

$$A_i^{k+1} = f(A_i^{(k)} + \sum_{\substack{j=1 \\ j \neq i}}^{n} W_{ij} A_j^{(k)}), \qquad (1)$$

Where,

$W_{ij}$is the initial weight of the arc between concepts C_i and C_j;

A_i^{k+1} is the value of concept C_i at simulation step k + 1;

k stands for the iteration counter;

f is a threshold or barrier function, which is used to restrict the concept value into [0,10] range. Different types of threshold function f could be applied in Eq. 1 depending on the concept's interval. The most common types are; bivalent function (f(x) = 0 or 1), trivalent function (f(x) = -10, 0 or 10), tangent hyperbolic ($f(x) = 1/(1 + t\,anh(x)$, and sigmoid function ($f(x) = 1/(1 + e^{-\lambda x})$).

At each iteration, Eq. 1 produces a new value for the concepts and when FCM arrives at one of the following three states, the iterations end and it results in a steady state (Papageorgiou, 2014);

- The value of concepts have stabilized at a fixed value (fixed equilibrium point),
- A limited state cycle is reached,
- Chaotic behavior has appeared.

4.3 Numerical example

In this part, we demonstrate how to dealing with complex risks by using FCM. It will be a hypothetical numerical example. To do so, we derived the SCL selection risks from Kiba-Janiak et al (2016). Identification and assessment of CL risks are one of the most important areas of SCL risk assessment. There have been many efforts of research in recent years for developing CL risk assessment tools (Maja Kiba-Janiak, 2016; Taniguchi. 2010). However, very few studies have discussed the impact of considering the dependencies among risk factors in more effective SCL risk assessment. They provided an insight into the understudied causes of freight transport in SCL disruption propagation. They identified some themes giving an increased level of granularity into disruption propagation, including correlation of risk, cyclical linkages, compounding effects, counterparty risk, and herding and misaligned incentives. In this project, we emphasize on considering these themes, their interactions and dependencies among risk factors to effectively deal with SCL risks and disruptions. We know that the CL risks could be different for each organization/company based on its perspective and they should be identified by each organization. The related FCM diagram is shown in Figure 5 and the risks are shown in Table 3.

Table 3. The identified risks and their definitions

Risks	Index	Definitions
Management	R1	The inability to deliver the end product within the originally specified period of time
Human resources	R2	Overseeing all things related to managing an organization's human capital. Both the people who work for a company or organization and the department responsible for managing resources related to employees.
Financial	R3	The inability to complete the project within a given budget
Information technology	R4	Basically any threat to business data, critical systems and business processes. It is the risk associated with the use, ownership, operation, involvement, influence and adoption of IT
Marketing	R5	The possibility of an investor experiencing losses due to factors that affect the overall performance of the financial markets in which he or she is involved.
Socio-political	R6	Social criteria refer to both benefits and negative impacts on society because of decisions made regarding the city logistics initiatives and partner selection. Examples are: facilitation of goods movement condition and passenger travel inside cities, issues regarding corporate social responsibility, society welfare, etc.
Economics	R7	Refers to the use of monetary resources. Among the most commonly considered criteria by researches we have: implementation costs, infrastructure investment, taxes, operational costs, maintenance costs, and fuel costs, among others.
Availability of infrastructure and technology innovations	R8	The inability of an organization to respond to potential internal or external changes in a timely and cost effective manner
Civil and natural disturbances	R9	The inability of an organization to comply with appropriate regulations (local and global)

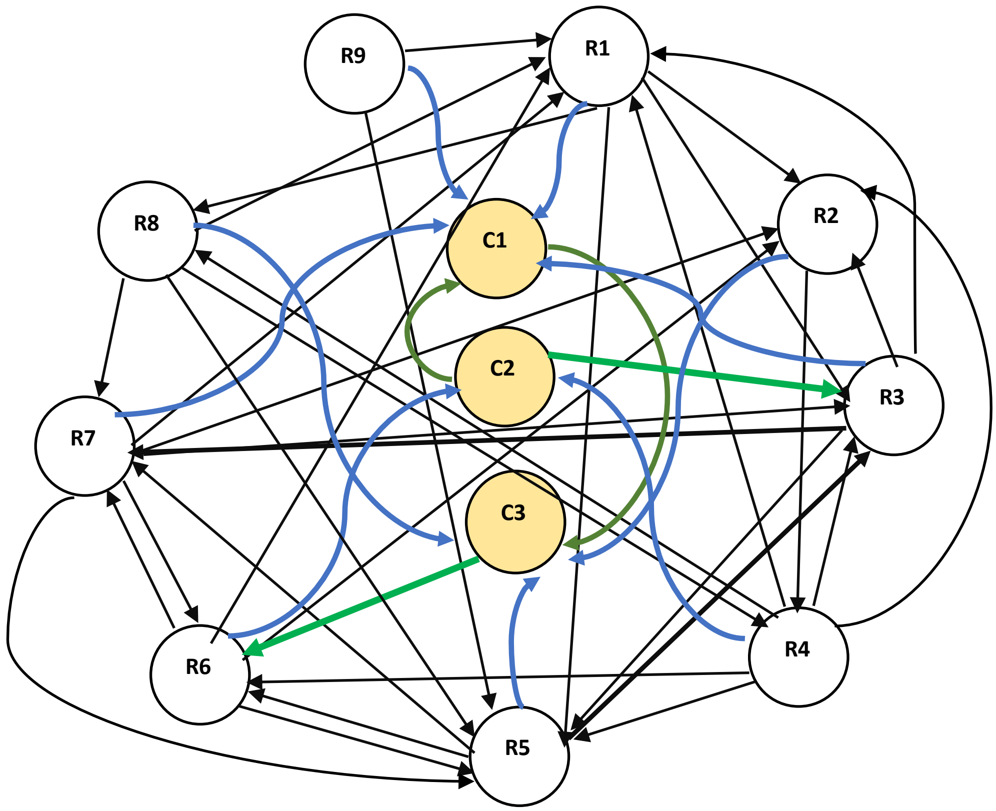

Figure 5. Fuzzy Cognitive Map

Generally, the authors applied FCM in order to consider the dependencies among risk factors in the SCLP selection problem. In this project, we apply the same risks and investigate another feature of FCM which is the ability in prioritizing risks by considering the dependencies among them and also in predicting the impact of each risk or a group of risks on the other risks or on the outcomes of projects over time.

Step 1: In this numerical example, nine risk factors adopted from Kiba-Janiak (2016) are considered to be evaluated by one Experts (Ex.1). Steps 2 and 3: In table 4, we indicate the hypothetical linguistic values assigned for each risk factor. The initial weight matrix is shown in Table 4. In order to obtain this matrix, each expert is asked to determine the weight (Wij) on each arc. It should be noted that the sign and direction of arcs between risks are adopted from Kiba-Janiak (2016). Finally, it will be interpreted the impact of each risk category and also each individual risk factor on the other risks by the weight (Wij) on each arc.

Table 4. Initial weight matrix

$\mathbf{W}^{\mathrm{Aug}}$	R1	R2	R3	R4	R5	R6	R7	R8	R9	C1	C2	C3
R1	0	0.7	0.4	0	0.8	0	0	1	0	1	0	0.3
R2	0	0	0	0.26	0	0	0	0	0	0	0	0.2
R3	0.55	0.5	0	0	0.6	0	0.7	0	0	-0.3	0	0
R4	0.7	0.5	0.2	0	1	0.36	0	0.82	0	0	-0.2	0
R5	0	0	0.5	0	0	0.7	0.8	0	0	0.4	0	0.7
R6	8	2	0	0	0.7	0	8	0	0	0	-0.3	0
R7	8	7	9	0	1	0.75	0	0	0	0.4	0	0
R8	0.7	0.55	0	0.65	0.86	0	5	0	0	0	0	0.5
R9	0.45	0	0	0	0.65	0	0	0	0	0.3	0	0
C1	0	0	0	0	0	0	0	0	0	0	0	0.8
C2	0	0	1	0	0	0	0	0	0	0.6	0	0
C3	0	0	0	0	0	1	0	0	0	0	0	0

To demonstrate the risk evaluation process, we only assess the impact of three risks such as "Information Technology" ''Economics'', ''Availability of infrastructure and technology innovations'' on other risk.

First scenario:

In this scenario, none of the risks in the initial vector are activated at the initial time, but **Information Technology risk (R4)**:

C= [0, 0, 0, 1, 0, 0, 0. 0, 0, 0, 0, 0] ;

In our project, we applied MATLAB software (version R2018) to obtain the updated concept matrix C^{*}.

C^* = [**0.9**, 0.4, 0.3, 0.1, **0.99**, 0.3, 0.1, **0.9**, 0.1, 0.4,0. 2. 0.3];

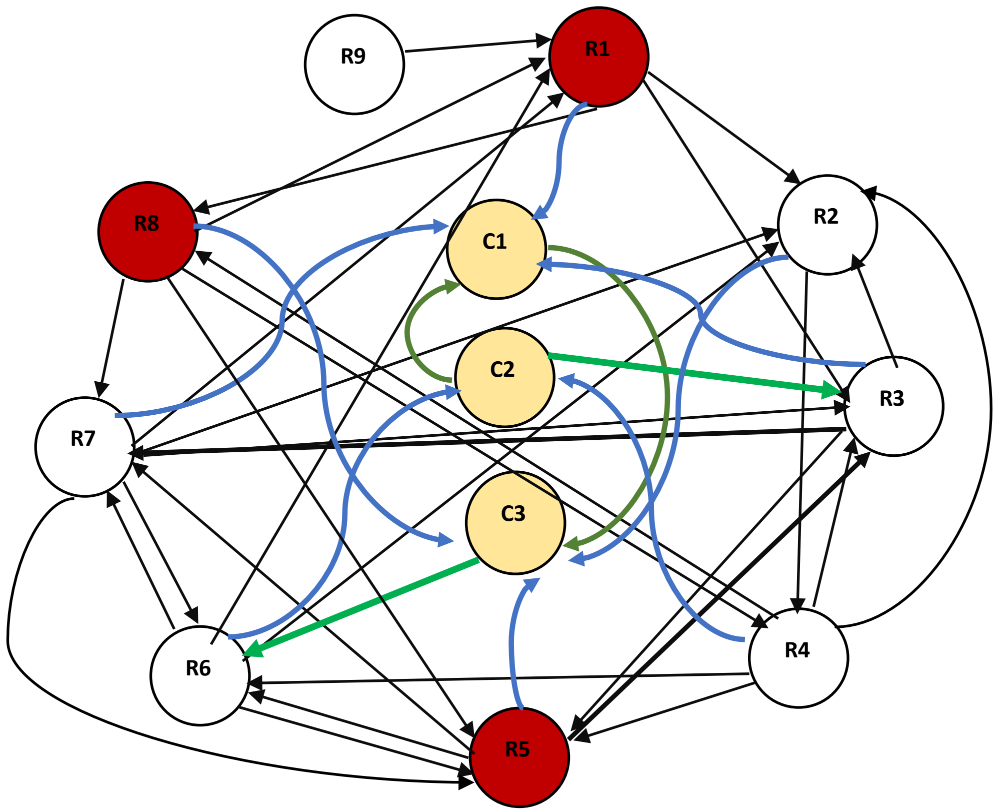

Figure 6. Activating service risks (R4) and their impact on R1, R5 and R8.

After analysing the process in MATLAB software, the steady state vector C^* shows that activating “Information Technology” risk have a strong influence over the risks R1, R5, R8 and also it has a strong effect over the consequence C1 [Fig. 6].

Second scenario:

In the second scenario, none of the risks in the initial vector are activated at the initial time, but **Economy risk (R7)**:

C= [0, 0, 0, 0, 0, 0, 1. 0, 0, 0, 0, 0] ;

We try to obtain the updated concept matrix C^* by MATLAB software (version R2018):

C^* = [**0.85**, 0.6, **0.9**, 0.1, **0.99**, **0.75**, 0.05, 0.1, 0.1, 0.4, 0.1 0.15];

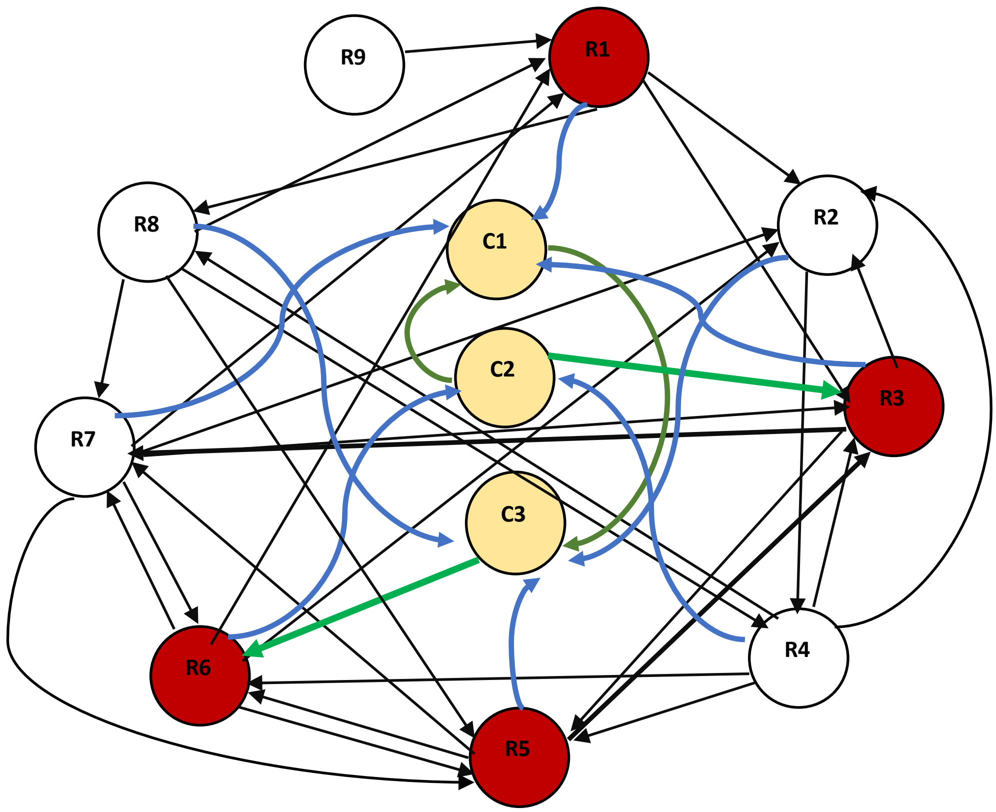

Figure 7. Activating service risks (R7) and their impact on R1, R3, R5 and R6.

After analysing vector C^* in the process of MATLAB software, we figured out that activating "Economy" risk have a strong influence over the risks R1, R3, R5 and R6 and also it has a strong effect over the consequence C1 [Fig. 7].

Third scenario:

In this scenario, none of the risks in the initial vector are activated at the initial time, but "**Availability of infrastructure and technology innovations risk (R8):**

C= [0, 0, 0, 0, 0, 0, 0. 1, 0, 0, 0, 0] ;

We try to obtain the updated concept matrix C^* by MATLAB software (version R2018):

C^* = [**0.85**, 0.6, **0.9**, 0.1, **0.99**, **0.75**, 0.05, 0.1, 0.1, 0.4, 0.1 0.15];

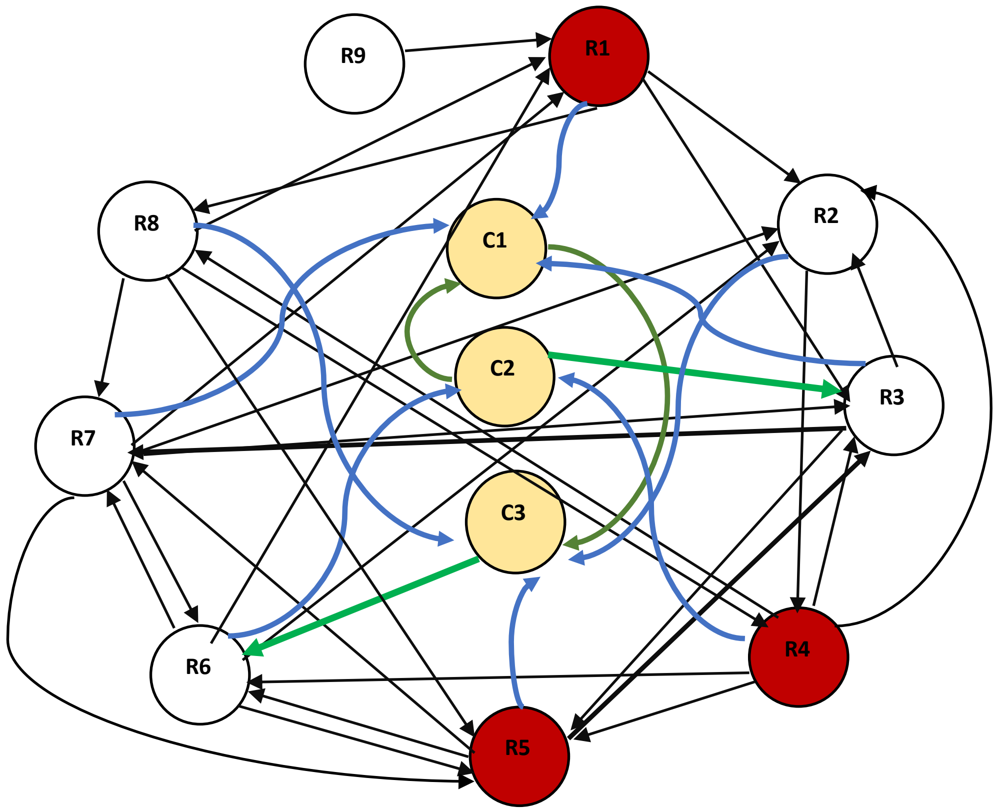

Figure 8. Activating service risks (R8) and their impact on R1, R4 and R5.

After analysing vector C*, we figured out that activating "'Availability of infrastructure and technology innovations" risk have a strong influence over the risks R1, R4 and R5 [Fig. 8].

For all other risks, the same procedure should be done by activating their risk or related sub- risks each time. The results show that which risks are critical and which have a greater impact on the other risks. In addition, it reports that each risk factor on which consequence(s) has a strong effect. Therefore, it helps decision-makers to manage the risks properly and accurately.

CHAPTER 5: A review of priority criteria and decision-making method applied in selection of SCLI and collaboration partners

Afshin Jamshidi 1; Farzad Jamshidi 1; Daoud Ait-Kadi 2; Amar Ramudhin 3

1. Department of Mechanical Engineering, Universite Laval, QC, Canada

2. University of Hull Business School, Logistics and Humber Development Institute, Hull, England

Keywords: decision-making methods; multi-criteria approaches; city logistics initiatives; collaboration partners; review

Résumé :

Les plans de logistique urbaine durable pourraient avoir un impact significatif sur la qualité de la vie en milieu urbain. L'évaluation d'initiatives de logistique de ville durable (SCLI) telles que les centres de distribution urbains, la tarification de la congestion, le délai de livraison et les restrictions d'accès est un problème complexe, car plusieurs critères et contraintes subjectifs et objectifs doivent être pris en compte. D'autre part, la sélection de partenaires de collaboration dans le contexte de la planification logistique municipale joue un rôle important dans l'efficacité opérationnelle dans le cadre des réglementations relatives au fret municipal, telles que les restrictions d'accès, de dimensionnement et de synchronisation. Cette étude identifie et examine les critères / sous-critères appliqués, ainsi que les techniques de prise de décision multicritères pour la sélection d'initiatives de logistique de la ville durable (SCLI), ainsi que les problèmes de sélection des partenaires de collaboration. Elle présente également un aperçu des critères / sous-critères communs -critères techniques de prise de décision pour les recherches futures. Les résultats de cette revue de la littérature révèlent que les articles récents visent à considérer simultanément des critères techniques, sociaux, environnementaux et économiques en utilisant la méthode du processus de hiérarchie analytique (AHP) dans la sélection des initiatives de logistique urbaine durable (SCLI). Ce résultat dans la section de sélection des partenaires de collaboration vise à considérer simultanément les critères de qualité et de coût en utilisant la méthode AHP.

Abstract:

Sustainable city logistics (SCL) plans could significantly affect the quality of life in the urban environment. Evaluating sustainable city logistics initiatives (SCLI) such as urban distribution centers, congestion pricing, delivery timing and access restrictions is a complex problem since several subjective and objective criteria and constraints

should be taken into account. On the other hand, collaboration partner selection in the context of the city logistics planning plays an important role in achieving operational efficiency under municipal freight regulations such as access, sizing and timing restrictions. This study identifies and reviews the applied criteria/sub-criteria, and multi-criteria decision-making techniques for sustainable city logistics initiatives (SCLI) selection and also collaboration partner selection problems and presents an insight into common criteria/sub-criteria and suitable multi-criteria decision-making techniques for future researches. The results of this literature review reveal that the recent papers aim at considering simultaneously technical, social, environment and economic criteria by using analytical hierarchy process (AHP) method in selection of sustainable city logistics initiatives (SCLI). This result in collaboration partner selection section aims at considering simultaneously quality and cost criteria by using AHP method.

5.1 Introduction

Nowadays, cities are confronted with a variety of problems including traffic jams, waiting times, noise and air pollution, raise in congestion, negative environmental impacts and energy consumption, and lack of public space from goods mobility in cities. Municipal administrations are investing in SCLI such as urban distribution centers, congestion pricing, delivery timing and access restrictions in order to improve the condition of goods transport in cities and reduce their negative impacts on citizens and their environment (Anderson, 2005). Therefore, urban freight transport and logistics operations have become critical issues in sustainable urban development.

According to the importance of sustainable development, city logistics initiatives such as intelligent fleet management systems, urban consolidation centers, use of electric vehicles, and putting in place various freight regulations such as vehicle sizing, access and timing restrictions, congestion pricing (Taniguchi2001) have been recognized as one of the best solutions for efficient urban freight transport and logistics with high environmental objectives.

Based on the European Commission 2014 report (Ambrosini, 2004), more than 70% of the world's population will live in cities by 2050. It is clear that new strategies, initiatives, and sustainable solutions should be devised in cities in order to improve quality of life of citizens. Despite the importance of this topic and the problems associated with it, little attention has been paid to it by researchers and policy makers.

There is a need to identify the most common and suitable criteria and factors for evaluating the SCLI and more importantly, advanced decision-support systems (DSS) which could be applied for selecting the best initiatives in different cities. This requires defining a large number of criteria in order to be applicable in all cities by considering all the requirements of stakeholders and the factors that covers different aspects of city characteristics.

In the context of city logistics planning, another important and relevant problem which should be addressed is collaboration partner selection. Collaboration is key to managing city logistics planning efficiently. Collaboration can take place in the form of partner selection issues. The issue of the collaboration partner selection is one of the key issues in the city logistics planning sector. Usually, in such cases, many and sometimes conflicting criteria should be considered in the final selection, and for this reason in these categories of component issues multi-criteria issues are considered. In situations like this, selecting the best alternative is a complex multi-criteria decision-making (MCDM) problem which include conflicting and uncertain elements.

To address the above gaps, in this thesis we present the state-of-the-art literature regarding the selection of SCLI and collaboration partner by identifying the influential criteria and factors and applied decision-making tools and present an insight into common criteria/sub-criteria and suitable multi-criteria decision-making (MCDM) techniques which could be applied for future researches. MCDM techniques have been widely and successfully applied for decision making problems in different sectors. In this study, we searched in different databases including Sciencedirect, Emerald, Google Scholar, and IEEE Xplore for research papers to identify relevant research for SCLI and collaboration partner decision makings. The source used for our study was academic journal articles published between 2000 and 2017. Publications in languages other than English were not included. Moreover, a search for additional papers in the reference lists of all papers was carried out.

In order to find the relevant papers in the above databases, we searched different keywords including multi-criteria decision-making, MCDM, decision making, prioritization, criteria, collaboration partner selection, SCLI planning and city logistics initiatives. We found a few relevant papers in the case of SCLI and collaboration partner selection problems after reading the full paper.

The research questions for the purpose of this paper are formulated as follows:

RQ1. What are the criteria used in the scientific literature to aid decision making on SCLI and collaboration partner selection?

RQ2. What are the MCDM approaches selected in the scientific literature to support decision making on SCLI

RQ3. What are the most common criteria and sub criteria used for SCLI and collaboration partner selection that could be applied in all cities?

In order to answer the above research questions, the underlying literature review methodology employed in the current study is explained in the next sections. To the best of our knowledge, this is the first work that has tackled this issue in a review to consider and has sought to a review of priority criteria and decision-making methods applied in city logistics planning. Finally, this paper contributes to show useful information about the most common criteria, sub criteria, and multi-criteria decision-making method in literature for evaluating the SCLI and collaboration partner selection applicable in different cities. This information would be most useful for researchers, stakeholders, and municipal administrations which have different, usually conflicting goals and interests, so it is necessary to define a large number of criteria and sub-criteria for accurate evaluation of variety of alternatives.

The rest of this paper is structured as follows. Section 2 presents city logistics and city logistics initiatives terms. Section 3 reviews the existing works on sustainable city logistic initiatives and collaboration partner selection and presents the applied criteria/sub-criteria, and multiple-criteria decision- making (MCDM) approaches. Section 4 provides an insight about common criteria and sub-criteria and MCDM approaches, and Section 5 describes the most common criteria applied for city logistic initiatives selection and collaboration partner selection. Section 6 introduces the applied MCDM methods in literature and software that could be applied for evaluating city logistic policies. Finally, conclusions and future research are drawn in Section 7.

5.2 City logistics

The City Logistics concept addresses the issue of sustainable cohabitation and development of freight transportation and the city. Its main objective is to modify freight transportation and logistics for increased economic, environmental and societal efficiency and sustainability (Kosko, 1997). New organizational and business models for city logistics have been designed to reduce negative impacts of urban freight transportation, in addition to supporting the social and economic development of the city. In the last years, several city logistics projects have been undertaken around the world. Some major projects are presented in the following section.

- City Logistics Initiatives

Several policies related to sustainable city logistic are being investigated around the world mostly in Europe. The followings are some examples regarding city logistics initiatives:

a) From 2008 to 2012, 25 European cities took part in five pilot schemes (www.civitas-initiative.org) in order to promotes city logistics schemes in terms of sustainable, clean, and efficient urban transportation measures,
b) The OECD Working Group (Papakostas, 2011) on urban freight logistics focuses on solutions to minimize pollution, noise, and congestion caused by freight transportation,
c) The projects BESTUFS I and II summarized best practices of urban freight solutions from a European perspective (www.bestufs.net),

d) Trendsetter describes 54 projects aiming at the improvement of mobility, quality of life, quality of air, reduction of noise, and congestion; five European cities participate in the implementation of innovative city logistics concepts (www.trendsetter-europe.org),
e) The Institute for City Logistics (www.citylogistics.org) canalizes research activities on all aspects arising from and around urban freight transportation.

The basic idea underlying the above initiatives is to instead of considering each shipment individually, consider them as components of an integrated logistics system, where shippers, carriers, and movements are coordinated and loads of different customers and carriers are consolidated into the same "green" vehicles (Kosko, 1997). This refers to the optimization of advanced urban freight transportation systems in city logistics.

5.3 Review of the existing literature

According to the papers in city logistics sector, there are several studies that have been conducted by researchers on city logistics planning and optimization and several classical and heuristic methods have been proposed to solve city logistics planning problems in order to have SCLI. These methods and solutions could be considered by municipal administrations in order to solve city logistics planning problems and improve freight deliveries in urban environments. Generally, city logistics planning can be classified into five categories including survey-based approaches, Simulation based approaches, MCDM-based approaches, Heuristics-based approaches and Cost-benefit analysis-based approaches.

In this paper, we only focus on the MCDM-based approaches and we evaluate the existing works with regard to the selection of the SCLI and also collaboration partner. In MCDM-based approaches, city logistics initiatives (alternatives) and collaboration partner selection are evaluated against several criteria and alternatives with the highest performance score is finally chosen based on the opinions of some experts. Based on our literature review, we identified only a few studies related to the selection of SCLI and collaboration partner.

Fig 9 shows the distribution of the reviewed articles. It depicts the stable status of research from 2000 till 2017, despite the importance of the sustainable city logistic planning across the world. In addition, it reveals that not much research has been presented in the literature during 12 years to address proper strategies and methods for implementing them, while multi-criteria decision-making approaches are widely applied in other industries. Our review of literature reveals that most research regarding SCLI decision making and collaboration partner selection has been performed in Canada [See Fig. 10].

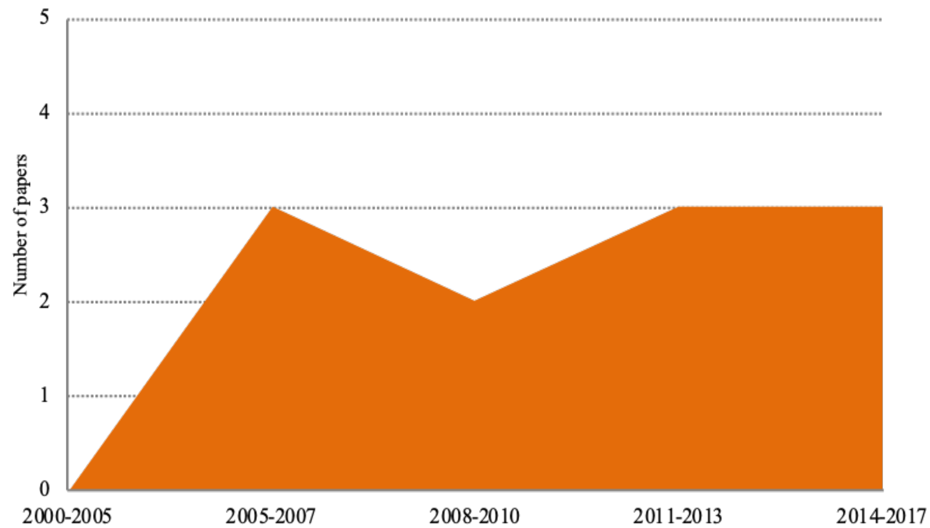

Figure 9. Distribution of the reviewed articles.

We divided our literature review into two distinct categories. The first category involves the papers related to SCLI selection, while the second category involves the papers related to collaboration partner selection for city logistics planning. The following sections present detailed information regarding relevant papers for the first and second categories, respectively.

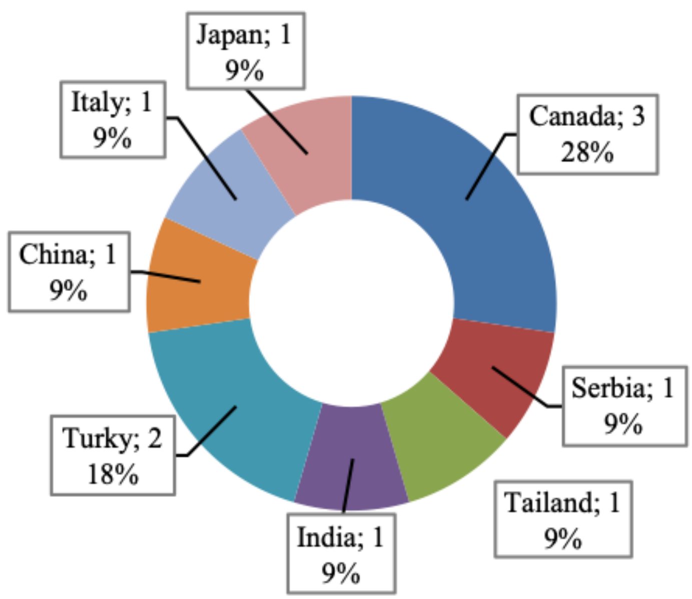

Figure 10. Percentage of research work performed in different countries regarding SCLI decision makings.

5.4 MCDM approaches for SCLI selection

Kunadhamark et al. (2008) proposed a methodological framework for service quality improvement to evaluate the logistics performance of intermodal freight transportation. They focused on an optimal way of transport which is done by container in order to obtain the suitable type of shipment for shifting from single truck mode to intermodal transportation. They also apply fuzzy set theory to measure the value of performance by integrating both the fuzzy-AHP and the fuzzy multi- criteria analysis (fuzzy-MCA). Four criteria and 13 sub-criteria were considered in this study (see Table 5).

Awashti et al. (2010) presented an MCDM approach under uncertainty for location planning in city distribution centers. Their method of study included identification of potential locations, selection of criteria for evaluation, using fuzzy theory to quantify criteria values under uncertainty and fuzzy TOPSIS to evaluate and select the best location for implementing a city distribution center.

In another work, Awashti et al. (2010) improved their study by presenting an approach involving Affinity Diagram, AHP and fuzzy TOPSIS for solving the city logistics initiatives problems. Four initiatives considered in this study are; vehicle sizing restrictions, congestion charging schemes, urban distribution center and access timing restrictions. The proposed approach in (Awasthi, 2010) consisted of four steps. Four criteria and 16 sub criteria were considered in this study. The first step consisted of identification of criteria using Affinity Diagram. In step 2, a decision-making committee is formed. The committee members weight the selected criteria using AHP. As a result, environmental criterion was identified the most important among others. In addition, loading factor, Costs, Air pollution, and Freeing of public space were identified as the most important sub-criteria. In step 3, the decision makers provide linguistic ratings to the alternatives to assess their performance against the selected criteria using Fuzzy TOPSIS method. In the last step, the authors perform sensitivity analysis in order to evaluate the influence of criteria weights on the selection of the best alternative.

Tadic et al. (2014) proposed a structure for selection of the city logistics concept which would be suitable for different participants, stakeholders, and which would follow attributes of the surroundings. They believed that selecting the best alternative is a complex MCDM problem that involves a contradictory and uncertain component. They used novel MCDM approaches that included a combination of fuzzy Decision-Making Trial and Evaluation Laboratory Model (DEMATEL), fuzzy Analytical Network Process (ANP) and fuzzy VIKOR methods.

Parezanovic et al. (20124) presented a multi-criteria decision-making approach for evaluating SCLI or measures based on qualitative information, using fuzzy TOPSIS method. While the AHP method is used to analyze the structure of the SCLI measure problem and to determine weights of criteria, fuzzy TOPSIS method is used to obtain final ranking. In this study, the three sub-criteria including Accidents, Trip effectiveness, and Logistical efficiency related to social and technical criteria were identified as the most important sub-criteria.

The major limitations of above studies are as follows:

1- The complexity of the AHP/ANP based models increases when considering a large number of factors, criteria and alternatives,
2- Another problem could be related to the way of fuzzyfication and forming the unique fuzzy grades in case of involving multiple decision makers in the decision-making process.
3- None of the above studies have considered the difference in experience and knowledge of decision makers or stakeholders,
4- In addition, criteria importance weight is overlooked in some studies which could affect the selected initiatives by decision makers,
5- Last but not least, in each study some important criteria such as costs and social aspects are ignored.

Table 5. Applied criteria/sub-criteria, city logistic initiatives, and MCDM approaches for selecting the best city logistic initiative.

Year	Author	Criteria	Sub criteria	Alternatives	MCDM approach
2007	Kunadhamraks et al.	Logistics costs Services quality Reliability Security	Transport Handling Holding Travel time Qualification Information systems Flexibility Frequency of disruption Frequency of delay Duration of disruption Duration of delay Severity of freight damage Frequency of freight damage	- Service quality improvement	- Fuzzy-AHP - Fuzzy-MCA
2010	Awashti et al.	Accessibility Security Connectivity to multimodal transport Costs Environmental impact Proximity to customers Proximity to suppliers Resource Availability Conformance to sustainable freight regulation Possibility of expansion Quality of service		- Location planning	- Fuzzy TOPSIS
2012	Awashti et al.	Technical	Logistical Service	- Vehicle sizing restriction	- Affinity diagram - AHP

		Social Economic Environmental	Loading factor Customer coverage Volume of freight handled Trip effectiveness Mobility Accessibility Freight of public space Accident Revenues Cost Congestion Air pollution Noise Energy conservation	- Congestion charging schemes - Urban distribution center - Access timing restrictions	- Fuzzy TOPSIS
2014	Tadic et al.	Economic Environmental and Natural Social	The level of economic development Generators of goods flows The road network development Logistics systems Workforce Technological development Natural traffic corridors Natural resources and habitats Air pollution The topography and geography of the terrain Environmental protection Sustainable development initiatives The process of decision-making Spatial and urban plans Social structure Regulation	- Decentralized, satellite system with the dominate role of road transport - Centralized-decentralized system with the use of cargo trams - The network core with the use of cargo trams and electric vehicles - The network system with intermodal transport	-Fuzzy DEMATEL -Fuzzy ANP -Fuzzy VIKOR
2014	Parezanovic et al.	Economic Environmental Social Technical	Operational cost Energy consumption Revenues Air pollution Noise Land use Congestion Accident Mobility Accessibility Freight of public space Logistical efficiency Trip effectiveness Loading factor Service quality Customer coverage	- Under consolidation supplies - Clean urban logistics and goods distribution platform - City freight delivery plan - Access - Timing Restrictions	- AHP - Fuzzy TOPSIS

5.5 MCDM approaches for Collaboration partner selection in city logistics planning

Collaboration planning plays an important role for city logistics operators in achieving operational efficiency under municipal freight regulations such as access, sizing and timing restrictions etc, (Diego Falsini, 2012). In recent years, logistics outsourcing or third-party logistics (3PL) has received considerable attention from logistics researchers. 3PL involves the use of external companies for the management of some or all of the firm's logistics functions and has several benefits including cost savings, competitive advantage, and customer service improvements. Therefore, 3PL provider selection is strategically vital to companies that wish to concentrate on core competencies that are critical to competitive advantage, and leaving the rest to specialized firms (Rajesh, 2010). The selection of 3PL problem is a complex problem due to the availability of tangible and intangible criteria that should to be taken into account in the decision-making process.

Table 6 presents relevant papers detailed for collaboration partner selection. Qureshi et al. proposed an integrated model in order to identify and classify key criteria, and to study their role in the selection process of third-party logistics (3PLs) services providers for shippers' logistics need. To do so, they applied an integrated model using interpretive structural modeling (ISM) and FMICMAC analysis. The key criteria were categorized into four broad classifications; dependent criteria, independent criteria, autonomous criteria and linkage- based criteria. Fourteen criteria were identified and categorized in this study (see Table 6).

Gol et al. (Hakan Göl, 2007) presented 3PLs provider selection to redesign its logistics operations and to select a global logistics service provider, using AHP method for multi-criteria decision-making. The focus of the paper is on automotive supply chain for export parts, however it could be extended to other products in different settings and in other sectors. In total, they considered four criteria with respect to the general company considerations including capabilities, quality, client and 24 sub criteria as shown in Table 5.

In another study, Selçuk Percin (2009) provided a good insight into the use of a-two-phase method AHP and TOPSIS approaches for the evaluation of 3PL providers. In this study, Percin considered three criteria and 12 sub criteria.

Peng et al. (2012) proposed a methodology for the analysis of the characteristics of logistics outsourcing industry using AHP and studied an actual case. The criteria that were considered in this study include logistics cost, the logistics operation efficiency, the basic qualities of service suppliers and logistics technology level. In addition, 12 relevant sub criteria were considered in this study.

In the same year, Falsin et al (2012) proposed the real case of an international logistics service provider with an integrated approach combining AHP, DEA and linear programming in order to support the multi-criteria evaluation of 3PLs service providers. The authors defined seven criteria with 37 sub criteria.

Recently, Awasthi et al. [Awasthi, 2016) presented a fuzzy BOCR–GRA approach for collaboration partner selection for city logistics planning in the presence of municipal freight regulations. In this study, at first four criteria and 21 sub criteria were identified using BOCR framework and weighted. Then, collaboration partners were ranked using fuzzy Gray Relational Analysis (GRA) method. The same limitations exist for applied MCDM approaches in the case of collaboration partner selection in city logistics as mentioned at the end of section 3.1.

Table 6. Applied criteria/sub-criteria and MCDM approaches for collaboration partner selection in city logistics

Year	Author	Criteria	Sub criteria	MCDM approach
2007	Qureshi et al.	Quality of service Size and quality of fixed assets Quality of management IT capability Delivery performance Information sharing and trust Operational performance Compatibility Financial stability Geographical spread and range Long-term relationship Reputation Optimum cost Surge capacity Flexibility in operation and delivery		- ISM - FMICMAC
2007	Gol et al.	General company considerations	Price Financial considerations Experience in the same industry Location Asset ownership International scope Growth forecasts Yearly efficiency Optimization capabilities	AHP
		Capabilities	Information tech. systems Customer service SC vision Creative management Responsiveness Service quality	
		Quality	Continuous improvement Key performance indicator (KPI) measurement and reporting	

		Client relationship Labor relations	Availability of top management Cultural fit Service cancellation General reputation Human resource policies Availability of qualified talent	
2009	Percin	Strategic factors Business factors Risk factors	Similar values-goals Similar size Financial stability Compatible culture Strategic partnerships Technical ability Management capacity Market knowledge Performance Loss of functional control Complexity in operations and delivery Risk in choosing the right partner	- AHP - TOPSIS
2012	Peng et al.	Cost Operating efficiency Service quality Technology level	Order processing cost Storage cost Transportation cost Operational readiness Operation speed Operation accuracy Culture compatibility Customer satisfaction Enterprise credit Storage technology Information technology Transportation technology	AHP
2012	Falsin et al.	Quality and reliability	% of orders delivered damage free % of orders checked at loading time % of orders delivered that are complete % of orders managed on time % of orders managed without security breaches	- AHP - DEA - Linear programming

		Speed of service Flexibility Costs Equipment Operators' safety Environmental safeguard	% of orders managed with correct shipping docs % of orders managed without administrative problems Average shipping lead time Average packaging lead time Flexibility to increase delivery volumes Flexibility to decrease delivery volumes Flexibility to increase shipping volumes Flexibility to decrease shipping volumes Capability to dispatch orders in 24 h Possibility to negotiate special conditions Packaging costs Transportation costs Auxiliary shipment procedure costs Payment terms Discount opportunities Quality system certification/assessment Subcontracting of key processes Efficiency of transportation processes Electronic Data Interchange capabilities Fleet size % of vehicles with satellite antitheft devices % of vehicles with ADR certification % of refrigerated vehicles for perishable goods Accident rate National Insurance contribution regularity % of employees able to give medical treatment % of employees able to manage emergencies % of employees with qualification to transport dangerous and perishable goods Average age of vehicles Quantity of NOx pollution Quantity of greenhouse gas pollution Quantity of HC pollution	

2015	Awasthi et al.	Benefits	Number of customers served Proximity to customers Service quality Goods consolidation Trip reduction Green resource sharing	Fuzzy BOCR–GRA
		Costs	Training Location and relocation Hiring costs Resources Distribution	
		Opportunities	Environmental impact reduction Energy conservation Participation in Green initiatives Technological development Knowledge transfer Organizational growth	
		Risks	Loss of clientele Lack of resource sharing Lack of information sharing Unfair profit allocation	

5.6 Common criteria, sub-criteria, and MCDM method

This section provides useful information about the most common criteria, sub criteria, and MCDM method in literature for selecting the best SCLI and also collaboration partner selection in city logistics planning. According to the literature, a total of five different criteria are considered in the literature of sustainable city logistic initiatives. The distribution of the different criteria found in the literature is depicted in Fig 11. In our review of research papers, we observed that social (Awasthi, 2012, Tadic, 2014, Parezanovic, 2014), environment (Awasthi, 2012, Tadic, 2014, Parezanovic, 2014), and economic (Awasthi, 2012, Tadic, , 2014, Parezanovic, , 2014), criteria were mainly considered in early works, while reliability, technical (Awasthi, 2012, Parezanovic, 2014), and service quality (Kunadhamraks, 2008) criteria have been considered in recent works. An interesting trend is therefore observed in recent publications: the latest papers aim at considering simultaneously technical, social, environment and economic criteria.

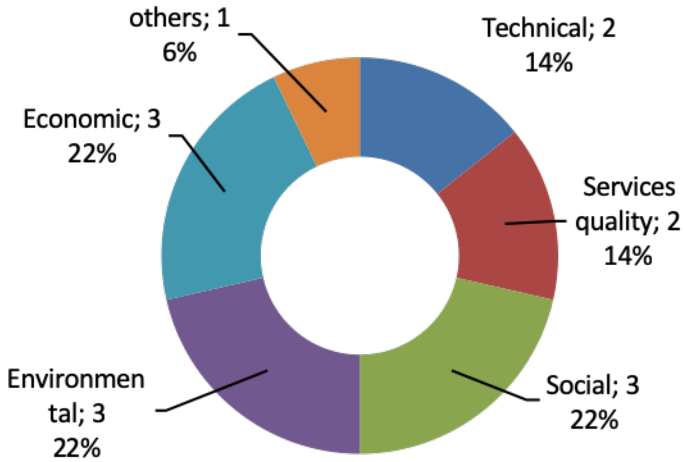

Figure 11. The applied criteria in sustainable city logistic initiatives selection.

Fig 12. represents the different sub-criteria which are considered in literature for evaluating the SCLI. According to this figure, Accessibility and service quality and air pollution are considered mostly in comparison to other sub-criteria.

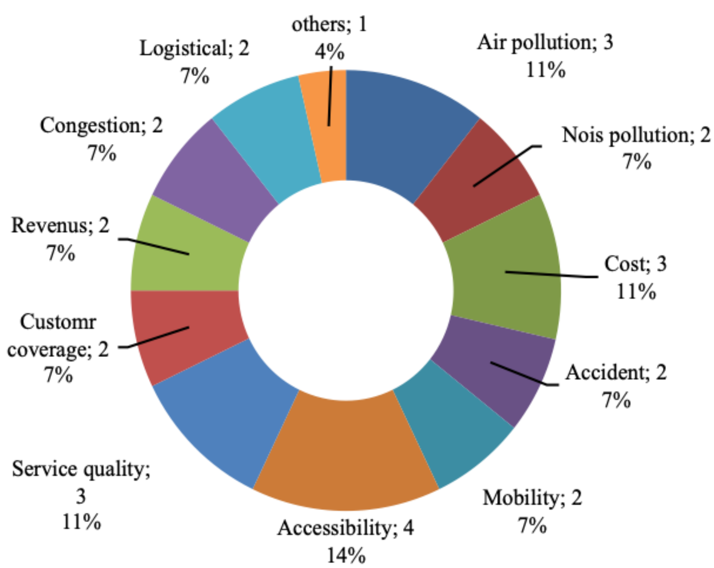

Figure 12. The mostly applied sub-criteria in sustainable city logistic initiatives.

Regarding the common criteria and sub-criteria for collaboration partner selection in city logistics planning, as shown in Fig 13., a total of 12 criteria are considered and the most common criteria were quality and cost. About the sub-criteria, we identified more than 100 different sub-criteria and due to lack of space we were not able to present them in Fig 13. However, we have shown all the identified sub-criteria in Table 6.

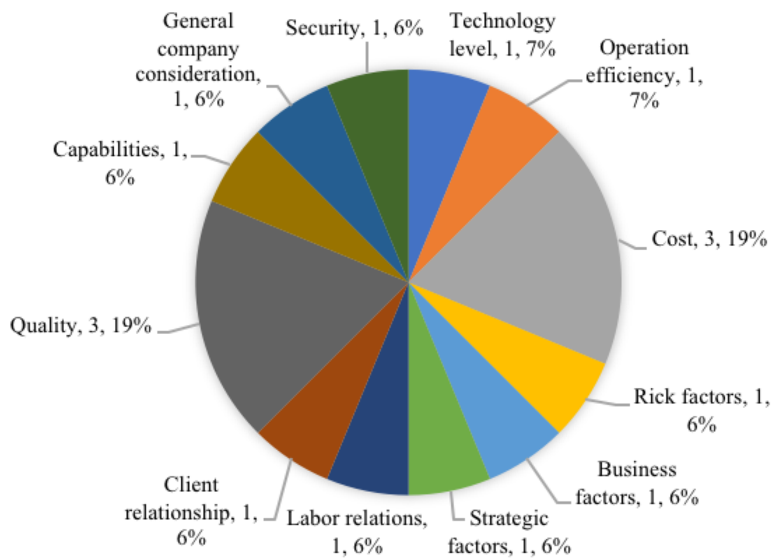

Figure 13. The applied criteria in collaboration partner selection in city logistics planning.

In the case of employed multi-criteria approaches, Fig 14. presents the frequency of the MCDM methods in literature for Sustainable city logistic initiative selection and also collaboration partner selection for city logistic planning. As shown by this figure, the AHP method and also its combination with other methods such as Fuzzy TOPSIS or DEA is the most commonly used approach by scholars. However, there are several shortcomings associated with AHP method which should be addressed and considered in future research.

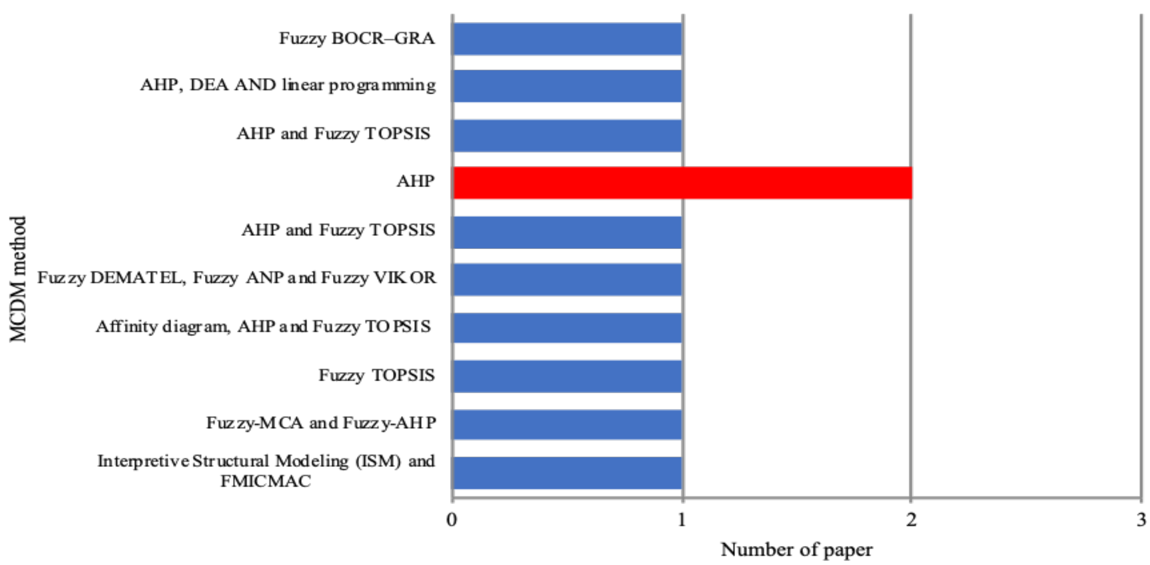

Figure 14. The applied MCDM methods in SCLI and collaboration partner selection.

5.7 Description of most employed criteria for decision-making in SCLI and collaboration partner selection

Due to the importance of the identified criteria for city logistics initiatives and partner collaboration selection problems, in this section we present the description of the most commonly applied criteria through Table 7 [Awasthi, 2012, Awasthi, 2016].

Table 7. Description of most employed criteria for decision-making in SCLI and collaboration partner selection.

	Criteria	Description	Sub criteria
Selection of SCLI	Economic	Refers to the use of monetary resources. Among the most commonly considered criteria by researches we have: implementation costs, infrastructure investment, taxes, operational costs, maintenance costs, and fuel costs, among others.	Congestion Air pollution The level of economic development Generators of goods flows The road network development Logistics systems Workforce Technological development Natural traffic corridors Energy consumption
	Technical and logistics	These criteria are related to issues regarding required technical requirements. Examples are: delivery targets successfully met by the logistical organization (measured by reduction in number of trips, distance, trip travel time, reliability of trip, etc.), capacity utilization of delivery vehicle, etc. Note that these criteria could be included as part of the economic category, as they impact somehow the economic issues of a transport system. However, we decided to keep them in a different class as they are not explicitly computed as monetary functions.	Logistical Service Loading factor Customer coverage Volume of freight handled Trip effectiveness
	Environmental	This set of criteria is explicitly associated to the impact(s) on the natural environment. The level of carbon emissions, energy or fuel consumption, ecological impact, use of natural resources, etc. are among environmental criteria.	Natural resources and habitats Air pollution The topography and geography of the terrain Environnemental protection Sustainable development Air pollution Noise Land use Congestion
	Social	Social criteria refer to both benefits and negative impacts on society because of decisions made regarding the city logistics initiatives and partner selection. Examples are: facilitation of goods	Accident Mobility Accessibility Freight of public space

		movement condition and passenger travel inside cities, issues regarding corporate social responsibility, society welfare, etc.	Sustainable development initiatives The process of decision-making Spatial and urban plans Social structure Regulation
Collaboration partner Selection	Cost	Costs involve packaging costs, transportation costs, auxiliary shipment procedure costs and payment terms, and etc.	We identified more than 100 different as shown in Table 5.
	Service quality	Service quality criteria consider the ability to assure timely and reliable service to client and Customer satisfaction with the delivery service performed.	

5.8 Multi-criteria Decision-Making models applied in evaluation of SCLI planning and logistics partner selection

Multiple criteria decision making (MCDM) is a method of operational research dealing with finding optimal results in complex situation including different indexes, contradictive objectives and criteria. This method is very popular in the field of SCLI planning due to the flexibility it provides to the decision makers for taking decisions while considering all the criteria and objectives concurrently. This method develops a conception of various multi-criteria decision-making techniques, progress made by considering city logistics planning over multi-criteria decision-making methods and future perspective in this part. Multi-criteria decision making is an effective tool in solving issues related to city logistics that are characterized with multiple criteria and objectives. MCDM problems are generally comprised of five components which are: goal, decision maker's preferences, alternatives, criteria's and outcomes respectively (Murat Köksalan, 2011, Dodgson, 2009). MCDM approaches can be classified as the following:

- Multi Objectives Decision Making (MODM)
- Multi Attribute Decision Making (MADM)
- Combination of MODM and MADM

Yoe et al. (2015) describes a general procedure of MCDM technique that could be considered in SCLI’ selection as the followings:

- Identifying the objective and define multi-criteria problem
- Define and select alternatives
- List and define criteria and sub-criteria
- Setting priority/ weight to alternatives

- Rank alternatives with interest groups
- Choosing MCDM method for the purpose
- Finding the optimal alternative

There are about 35 different multi-criteria decision-making methods, many of which are implemented by specialized decision-making software. In this section, we present a number of widely applied multi-criteria decision-making methods as well as the applied methods in Tables 6 and 7 that could play a key role in city logistics sustainability.

➢ Analytic hierarchy process (AHP)

The Analytical Hierarchy Process (AHP) is one of the most well-known multi-criteria decision-making techniques that were first developed by Saaty in the 1970s (Saaty, 2008). The AHP reflects natural behavior and human thinking. It is based on paired comparisons and allows managers to review different scenarios. This technique examines complex issues based on their interactions and turns them into a simple way to solve them. The Analytical Hierarchy Process could be used when decision-making practice is faced with several competing choices and decision criterion.

➢ Analytic network process (ANP)

The Analytical Network Process (ANP) is another decision-making technique that is a developed method of AHP (Saaty, 1996). With the difference that, in cases where the lower levels affect the upper levels and or the elements at the same level that are not independent of each other, the AHP method can no longer be used. The ANP technique is a more general form of AHP; however the ANP method does not require a hierarchical structure, and ultimately illustrates the more complex relationships between different decision levels as a network, and considers the interactions and feedback between criteria and alternatives.

➢ Elimination and Choice Expressing Reality ELECTRE (Outranking)

ELECTRE's family is the main characteristics of decision analysis methods that was first proposed by Bernard Roy (Roy, 1968) for multiple-criteria decision aiding that originated in Europe in the 1960s. ELECTRE methods are used as a preference model in outranking relation in the set of actions. It is constructed as the result of concordance and non-discordance tests involving specific input preference information.

- Grey relational analysis (GRA)

Grey relational analysis (GRA) is one of the Multi-Attribute Decision-Making (MADM) methods that were developed by Julong Deng in 1982 (Deng, 2002). GRA uses a specific concept of information. This information is divided into two parts with part of information known and other part of information is unknown.

- Measuring Attractiveness by a Categorical-Based Evaluation Technique (MACBETH)

Measuring Attractiveness through a Category-Based Evaluation Technique (MACBETH) is the most important of objective of the MACBETH approach that was designed by Carlos António Bana e Costa et al. (Bana e Costa, 2012, Bana e Costa, 2005, Bana e Costa, 2004). One of the most important goals of this method is evaluation of various options against multiple criteria. The distinguishing feature of this method with Multi-Criteria Decision Analysis (MCDA) methods is that MACBETH method needs qualitative judgement about the difference between two elements at a time, in order to generate the criteria weights and performance rating for the options in each criterion.

- Potentially All Pairwise RanKings of all possible Alternatives (PAPRIKA)

The PAPRIKA method involves the decision maker. This method answers a series of questions based on your knowledge, expertise and subjective judgment. The basis of each question is the choice between two alternatives that are defined only in two criteria at the same time.

- Preference ranking organization method for enrichment evaluation (PROMETHEE)

The PROMETHEE method is a quite simple ranking method of multi-criteria decision analysis method that is developed by J. P. Brans and B. Mareschal (2005, 2004). Not only can the PROMETHEE method find the best solution to solve complex problems with multi-criteria decision makers but they also deal with ranking problems in the presence of in-comparability between alternatives.

- Multi-criteria Optimization and Compromise Solution methods (VIKOR)

The VIKOR method was created for multi-criteria decision making (MCDM) of complex systems. S. Opricovic (Duckstein,1980) had developed the basic ideas of VIKOR in 1979, and an application was published in 1980 . This method decides on arranging and choosing from a group of alternatives in the presence of conflicting criteria. It shows the multi-criteria decision making based on the particular criteria of “closeness” to the “best” solution.

- Fuzzy VIKOR method

Multi-criteria Optimization and Compromise Solution methods (or VIKOR) have been developed for multi-criteria optimization in a complex system (Opricovic, 2004). Compromise solution will be presented by comparing the degree of closeness to the ideal alternative and each alternative can be evaluated by each criterion function (Opricovic, 2007). According Tzeng et al. (2005) this approach aims to find the best compromise solution between decision-makers to be consistent with the objectives of human cognition.

- Data envelopment analysis (DEA)

Data envelopment analysis (DEA) is a linear programming methodology to measure the efficiency of multiple decision-making units (DMUs) when the production process presents a structure of multiple inputs and outputs (Zhang, 2014).

- Linear programming (LP)

Linear programming (LP, also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. LP is a special case of mathematical programming (mathematical optimization). In 1939 a linear programming formulation of a problem that is equivalent to the general linear programming problem was given by the Soviet economist Leonid Kantorovich (Alexander Schrijver,1998), who also proposed a method for solving it.

- The Multi-Actor, Multi-Criteria Analysis Methodology (MAMCA)

The MAMCA methodology differs from the classical approach of MCDA in the explicit introduction of stakeholders in a very early stage. These stakeholders will be key to identify and evaluate the criteria, which are here equal to the objectives of the stakeholders. In order to aid groups in complex decision-making processes, the Multi-Actor Multi-Criteria Analysis (MAMCA) methodology has been developed (Macharis, 2009). The MAMCA methodology differs from the classical approaches of Multi-Criteria Decision-Analysis (MCDA) in the fact that the different actors who are involved in a project, the so-called stake- holders, are explicitly involved throughout the steps. The MAMCA methodology has already proven its effectiveness in evaluating complex sustainable mobility and transport policy decisions (Macharis, 2012).

5.9 Software packages for multiple decision analysis

Based on the most popular MCDM approaches, several software packages are available for multiple decision analysis. Some of these packages are commercially or otherwise readily available. Since definition of maximum number of criteria for evaluating and finding their relative weights is a complex issue, in this sub-section we present some software (Table 8) which not only could be useful to achieve better communication against multiple actors such as experts, people from targeted community, government organizations, etc. but they also could help researchers to accommodate many criteria for evaluation.

Table 8. MCDM based software.

S1. NO.	Name / Link	Type (Open source or Proprietary software licenses)	About	Uses
1	MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) http://m-macbeth.com/demo/	Commercial	An interactive approach that requires only qualitative judgments about differences. It helps a decision maker or advising group to quantify the relative importance of options.	1. Strategic plan development 2. Resource allocation 3. Participative evaluation of social, economic and environmental impacts for major infrastructures 4. Public policy planning 5. Feasibility of projects and plans 6. Performance evaluation for employees, suppliers, tender evaluation.
2	1000Minds https://www.1000minds.com/decision-making	Internet-based and free for academic use.	Based on PAPRIKA (Potentially All airwise rankings of all possible Alternatives) method.	MCDM, prioritization and resource allocation
3	Expert Choice https://expertchoice.com/	Commercial	Software is based on AHP and comes in two different versions known as Expert Choice Comparison and Expert Choice Riskion.	Riskion is widely used in all type of industries such as aerospace, asset management, automotive, banking, energy, government, and many more for risk assessment processes. Comparison is being used in project management, capital budgeting, strategic planning,

				vendor source management's, trade studies etc.
4	Winpre http://sal.aalto.fi/en/resources/downloadables/winpre	Available free for research purpose	Workbench for Interactive Preference Programming.	Decision support, Spontaneous decision conferencing in parliamentary negotiations, Traffic planning. dealing with uncertainties
5	D-SIGHT http://www.d-sight.com/	Proprietary	Based on ROMETHEE methods, MAUT and AHP.	Used in corporation for taking various decisions and Support for PROMETHEE and MAVT methods. AHP weighting.
6	IDSS Software (natoonestam link peida konam)	Free version available for students	It is based on a team including top-level scholars and consultants with specialization in decision support based on various methodologies of operational research and artificial intelligence.	1. Preference Modelling, ranking and sorting. 2. Multi objective programming in fuzzy environment, interactive procedures for multi-criteria choice. 3. System programming for environment, regional planning, software engineering, water supply, agriculture, surgery.

5.10 Conclusion and directions for future work

The policies in developing countries are restructured for providing SCLI needs which require a better evaluation in synergy with multi-criteria. Considering the multiple sustainability structure and factors, MCDM is best suited for such objectives. To reach the best solution to solve the issues related to city logistics in real time, MCDM could be utilized on multiple criteria involving multiple topics. This paper has attempted to provide a literature review and assessment status of research dealing with criteria, sub-criteria and MCDM tools towards SCLI planning.

Over time, according to this review in recent years, technical, social, environment and economic issues in city logistics initiatives and cost and quality issues in collaboration partner selection have been considered as decision criteria. In addition, we observed the use of more formal MCDM methods such as AHP and TOPSIS in city logistics initiatives sector and most recently multi-criteria evaluation using DEA, as well as application-specific tools in collaboration partner selection sectors. The main suggestions for future work are as follows:

1- Current MCDM methods do not consider the dependencies between criteria, while in real-life problems such as SCLI planning there are several dependencies among criteria and sub-criteria. Considering these dependencies could significantly affect the evaluation results and therefore lead to cost-effective and more effective decision making. In order to consider the dependencies, fuzzy cognitive maps (FCM) is suggested as an advanced decision support tool for future research. FCM as a graphical representation of the knowledge combines fuzzy logic and artificial intelligence in order to model behaviour of complex systems. FCM has been applied widely in different domains in recent years (Jamshidi, 2017).

2- Since the number of criteria and sub-criteria for selecting the alternative are too high, adoption of methods such as Fuzzy Soft Sets (FSS) (Maji, 2007) and its integrated approaches which require fewer numbers of questions (pair-wise comparisons) to be asked from experts in comparison with other MCDM methods (such as AHP, ANP, etc.) is strongly suggested for future research. FSS is a new mathematical tool for dealing with uncertainties which has less limitations in comparison with the MCDM approaches.

3- Another line for further research is to better understand the purposes of such novel and dedicated techniques and if those techniques allow increasing objectivity when modeling the system's elements. Indeed, a big question still unsolved is if these techniques can be employed to solve other problems (similar or not) as a generic method for different projects reducing (or eliminating) any kind of subjectivity of the agent's decision, but preserving his/her ability to measure criteria difficult to be quantifiable (e.g. social, security, environmental). An extension of this analysis could be the study of such techniques for solving different multi-criteria decision-making problems, even if such problems do not concern logistics initiatives and partner selection. To do this, it becomes necessary to study both advantages and drawbacks of such techniques and methodologies, their structure and to what extent their design allows the incorporation of parameters that allow generalization.

4- Last but not least, an online survey could be conducted in order to validate and weigh the importance of the identified criteria and sub-criteria.

This paper provides a comprehensive insight for municipal administrations to apply some or all of the identified criteria and sub-criteria in this study depending on their objectives and plans for selecting the best initiatives. In addition, in this study the mostly applied software tools are presented for practical applications.

Conclusion

Nowadays, in many industries in order to consider all aspects of risks in the risk analysis process, need an advanced risk assessment tool. There are many conventional risk analysis tools that most of them are included MCDM methods such as AHP/ANP and other tools such as FMEA and FTA and their modified versions that are not able to predict the behaviour of complex risks accurately and analysis them in a dynamic way. One of the most important useful graphical tools that could represent and analyses the dynamic behaviour of complex systems composed of interrelated variables is FCM. The most essential features of FCM in contrast with other existing methods such as FMEA are;

1) To consider the several risk factors and their effects on the risk analysis process

2) Possibility to state opinions by several experts

3) To find the interdependence and the feedback effects amidst a variety of risk factors, the importance of the elements and also their effects

4) Manage both quantitative and qualitative factors,

5) Decision-makers can easily understand all of the components in a given problem and their relationships by transforming decision problems into causal graphs.

6) To consider uncertainties on the decision-making process

Recently, this tool becomes a popular technique that is applied to evaluate the risks in complex and critical environments. In this thesis, we recommend an integrated approach to induce and enhance its application as an advanced decision support system for dynamic risk analysis of complex systems and our focus is more on this feature of FCM into sustainable city logistics sector which can deal with risks of freight transport in SCL field by considering the relationships among risk factors and consequences. Another advantage of the application of this tool in risk analysis is adapted to a wide range of complex and critical multi-criteria decision-making problems in sustainable city logistics. To consider the possible interrelationships in risk analysis of sustainable city logistics, including interrelationships among risks & consequences and vice versa, relationships among risks and finally possible dependencies among effects is the significant contribution of this thesis. This is the first time in the literature of the sustainable city logistics sector that such interrelationships have been considered through an advance decision support tool. However, there are some limitations in this thesis that should be noted.

1- This is a numerical example of the SCL risks assessment. Therefore, according to the opinions of different experts, it is possible to change the dependencies between risk factors according to the opinions of experts.

2- Sometimes we have some simple applications with a small number of concepts, in this situation, we have to form FCM such a manually. However, you cannot use this method in real applications where a problem has too many variables; for this kind of cases, such problems could be solved by using data-based algorithms to construct and train an FCM, called FCM learning algorithms (Froelich, 2012).

3- The source used for our study was academic journal articles in English language and we searched in different databases including Sciencedirect, Emerald, Google Scholar, and IEEE Xplore for research information to identify relevant research for SCLI. Therefore, it may exist papers in another language such as French that was considered with this concept.

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