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New business model for freight logistics: the M1M case study

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Alla mia famiglia, che ci ha creduto

prima che ci credessi io

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Abstract

Transportation and Logistics industry in recent years has undergone a significant expansion, becoming a key component in the economy of all countries, since through a continuous optimization of logistics processes it supports decisions on a tactical, strategic and operational level, influencing thus the final cost of the product.

This growth was supported by digitalization which, through the introduction of many technological innovations, makes the market very competitive meeting the high quality standards required by customers. In particular, the advances made by the Internet of Things (IoT) technologies allow accurate collection of data related to loads and vehicles, and this allows for more efficient planning of logistics activities.

Therefore, the logistics sector faces various challenges in order to meet customer's needs, which require higher quality of service, shorter delivery times and greater flexibility. Economic and operational sustainability are certainly two important aspects, to which are added the challenges related to environmental sustainability, since the regulations in force are aimed at reducing carbon emissions. Finally, supply chain management is increasingly demand-driven, particularly due to the influence of the global pandemic. Hence, logistics service providers must be able to adapt to changes in demand, using real time data.

Over the past years, many studies have focused on the operational and technical aspects to address these challenges, neglecting the dynamic business perspective, and thus causing the failure of many projects. Only a European project on synchromodality, SYNCHRO-NET, has shown how the combination of operational aspects and business models represents a solution much closer to the market.

Therefore, on the basis of the results obtained by SYNCHRO-NET, this paper aims to fill this gap, in particular regarding the case of the M1M system. Among the many benefits, this system allows for more efficient planning of operations and reduces carbon emissions by alleviating traffic congestion and avoiding unnecessary waste of time and money.

However, it is a very complex system, characterized by multiple actors with conflicting objectives. So such a stakeholder-driven approach can give end users a real competitive advantage. In fact, particular emphasis is placed on understanding what customers value and on providing users with support on how to design and deliver value to their customers. Therefore, an efficient supply chain management relies on integrating multiple perspectives from key stakeholders.

Thus, the purpose of this thesis is the development of a Solution Canvas for the M1M system, to face the challenges mentioned above, and to bring a competitive advantage on the market. The solution was developed following the GUEST methodology, and then it was applied to a real case.

The results obtained demonstrate a reduction in costs, times and emissions, and also greater reliability and sustainability through the optimization of the planning process.

In conclusion, this study confirms how the integration of a strategic approach, to the

technical and operational one, can help the company to stand out in the market by creating value.

Keywords

Freight transportation - Sustainability - Business model - GUEST method - Supply chain

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1 Introduction

Over the past two decades, the freight transportation sector has undergone a significant expansion, becoming a very important percentage of the global economy. That is because it plays a very essential role in the economies of all countries, since through the continuous optimization of logistics processes it supports decisions at the tactical, strategic, and operational level. Therefore, influences the final costs of the product [1]. In such conditions, Intermodal transport has become the backbone of freight transportation industry.

This growth has been supported by digital evolution that makes the environment even more competitive as customers expect higher quality standards. More specifically, the advancements in Internet of Things (IoT) technologies are used in the intermodal systems to identify loads and vehicles, capture data and share it among actors.

Also, the rapid evolution of on-demand economy has led to a shift towards a demand-driven approach. This inclination has been accelerated by the pandemic as the enforced closures have increased the use of e-commerce. In fact, after a first initial paralysis, mainly due to the lack of preparation to deal with such a pandemic, in mid-2020 trade flows resumed thanks to the supply of medical material useful, precisely through e-commerce. So, delivery services and consumer satisfaction are a crucial step.

Moreover, as citizens pay more and more attention to the quality of life in the city and customers start considering the sustainability of logistics operations, institutional authorities are setting regulations to reduce environmental impact.

Consequently, it is a very fragile environment, as the global supply chain is made up of several links that must function properly and be in balance for the whole system in order to be efficient.

However, these conditions could also be the basis for an important opportunity to rethink the supply chain and take up the technological challenge more quickly. In this regard, it is essential to have an organization as flexible and efficient as possible, in order to optimize logistic processes, guarantee just-in-time logic and minimize inventories. Therefore, there is a need for an innovative process that knows how to improve the collection and management of information, its availability and its distribution. This is possible through a platform model supported by advanced technologies. In addition, there is also the need to consider and train new skills given that transport companies are changing or have already changed their business model, as an inevitable response to digitization and the new operational scenarios resulting from the pandemic emergency.

These issues can be solved through the use and improvement of information technologies, such as Internet of Things (IoT) and data-driven services, the synchronization of activities , and the support of OR methods, such as business models, to support decision makers. There is a lack in the literature regarding the creation of a solution that can respond to these needs. So, it is necessary to adopt an approach that is not based only on decisions and optimization models, but also on business model as there are strong advantages from the connection of these two parts.

Therefore, the aim of this paper is to develop a Solution Canvas for M1M system, as it has the optimization part, but it lacks the business vision. The solution will be elaborated through the GUEST methodology [2]. This implementation will bring many benefits to the company, including a competitive advantage that will give it a higher market acceptance.

The paper is organized as follows. The next chapter summarizes the context we are analyzing, namely intermodality. The next section reviews the literature on freight transportation, and the challenges highlighted. Then, there is illustrated the methodology that will be applied to obtain the solution. As we mentioned above, it is based on a Lean Business approach. The chapter on the M1M system describes the network taken into consideration, and its main actors. Finally, the solution is developed, analyzed and applied to a real case. Therefore, the results and conclusions are summarized and discussed.

2 Freight Transportation

Freight transportation is an essential component to ensure efficient handling of goods respecting times and quality levels.

More specifically, the demand for freight transportation originates from the interactions between producers and consumers, and so from the distance that separates them. Shippers generate the demand for transportation, and carriers provide services to supply the request.

So, the shipment takes place between shipper location and consignee location through physical links. It is about a trade off between the will to connect as many places as possible and the constraints regarding cost and infrastructure development. The concept of transportation network is associated with the framework of routes within a system made up of nodes that denote terminals, shipper, and consignee facilities. Routes are the links between the nodes. The latter are locations across the multimodal network, and they allow the access to the transport network through logistic zones. Instead, the links enable the connections between different nodes. The arcs constitute the connections that occur between the nodes. There are different types of arcs. One of them represents P&D activities. The long-haul arcs, instead, have arrows at both ends, so that the flow is practicable in both directions. Moreover, the requests and the offers have time and economic attributes, then the activities are optimized in time and space. Therefore, it is required to create corridors which are links that connect geographically two or more nodes across the flow of several transport modes. There are different ways to develop and implement multimodal transport corridors, which connect the logistics centers and economic zones [3]. This concept allows to improve the logistic and transport activities regarding the ports-hinterland connectivity or the land transport. Thanks to the corridors, it is possible to have a collaboration between all the parties involved in providing these services, such as public and private sector companies.

A network is considered efficient when criteria such as speed, capacity, and safety are met and when it is capable to guarantee an adequate level of service even in critical conditions.

In recent years, intermodal transport has become the backbone of the freight transportation industry, as it offers many significant benefits. The intermodal network is made up of different actors, who are related to each other directly or indirectly. They interact and share information, yielding thus a Multi-Actor Complex System (MACS). There is the need to have an intermediary to make cooperation happen as the system is very complex. That is why companies outsource their activities to logistics service providers [4]. Therefore, the main stakeholders are:

- Shippers create the demand, as they request transportation for product loads. These requests are denoted by several attributes, such as economic, time and identity. They aim to satisfy the needs of their customers. In doing that, they can in turn participate in managing the movements of their goods, defining so their own effective logistics strategy;
- Carriers accomplish shippers' requests offering capacity for transportation. Their

offers are denoted by several attributes, such as economic, time and identity too. In providing this service, there can be several transport modes: rail, air, maritime, and road. Vehicles can be full or less-than-truckload. Moreover, some of them serve only a single customer (dedicated service), and others serve different customers (consolidation);

- Institutional authorities regulate and tax the industry by establishing policies and procedures. They can be governments, private and public administrations, and also transnationals institutions. They are also the providers of infrastructure, such as roads, maritime ports, rail, airports. The goal is to coordinate economic, political and environmental aspirations. Since policies are integrated in laws, there can be legal interventions. The regulations can relate to environmental impacts, the utilization of corridors and vehicles, the switch between different transport modes;

- Facility and infrastructure managers coordinate and manage the aspects of all the services within the building, such as maintenance, contracts, space, inspections, administration;

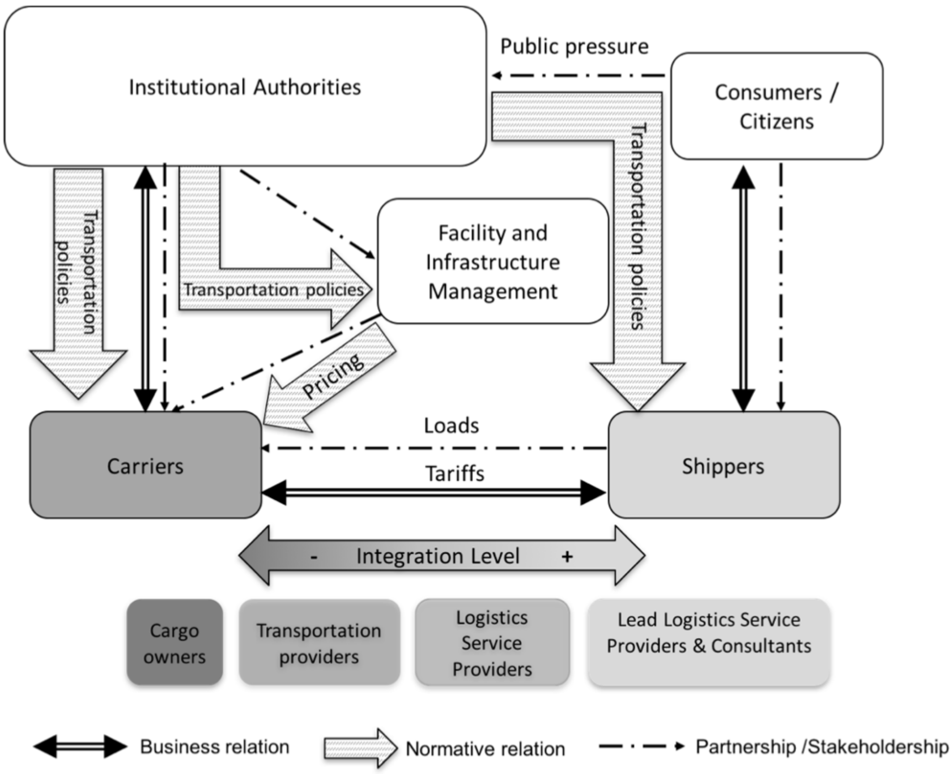
- Shipping companies deal with the transportation of their goods. They also offer innovative warehouse management; they coordinate inbound freights and provide outbound shipping. Strong collaboration is the key to provide logistical solutions;

- Research institutions work to enhance the system by developing new technologies, models, and methods. They can be universities and researchers;

- Trade associations are groups funded by businesses in a certain sector. They meet in community to share information, set laws, solve problems within the industry, maintain standards, provide tools for businesses.

- Logistic service providers are intermediaries (third parties) that manage P&D activities across long distances. There are several benefits by integrating them, such as cost savings, safety and efficiency of the delivery, then high customers service satisfaction.

- Customers receive the shipments. They can be retailers, final clients, distributors, wholesalers, citizens. They have knowledge regarding the environmental impact and city quality life. Their opinions are important since they could influence the governments by voting.



Representation of the Multiple-Actor Complex System
Simulation of Intermodal Freight Tranportation Systems: A Taxonomy [5]

In accordance with Crainic et al [6], intermodal transport consists into the movement of goods from their origin to their destinations by using several modes of transport. The transfer between modes is performed at an intermodal terminal. Its aim is to reduce costs and environmental impact by combining multiple modes. It concerns a multi-modal chain, made up of container-transportation services, that links the connects the location of the initial shipper to that of the last receiver across long distances. The chain involves also intermodal terminals that are an important component of this type of transportation as they ensure an efficient shift between the different transport modes. Through consolidation transportation systems it is possible to use a single vehicle or convoy for different customers with distinct locations. Moreover, there are customized carriers that provide dedicated and personalized services for each type of customer. The intermodal transportation systems are organized as hub-and-spoke networks that manage better huge volumes of services between origin and destination connections.

As we mentioned above, there several benefits by using intermodal transport, such as the reduction of delivery times, low prices for shippers, low handling costs, low fuel costs, increased capacity, safety, reduction of the environmental impact. Moreover, it supports efficiency of the innovative operational and business models for this industry. However, it is a complex system, as it involves several stakeholders, decision makers, operations, transportation modes and intermodal terminals. They all have different goals and needs, so there are also some disadvantage, such as reliability, distance, communication, and unease of monitoring [7].

In addition, planning activities can be divided into [8]:

- Strategic planning, that concerns long-term planning decisions. At this level forecasting processes and network design problems take place;
- Tactical planning, that regards medium-term decisions. This phase focuses on the allocation of resources, and the improvement of the efficiency of the system;
- Operational planning that consists of short time decisions, such as real-time decisions.

So, there is a need to find a balance that makes the system work efficiently. It is required a support to manage and monitor these activities and the planning levels, in order to improve decision-making process and to deal with these issues.

This need has emerged even more in recent years, as the freight transportation sector has experienced strong and significant expansion, becoming a very important percentage of the global economy.

The following table shows the index concerning the volume of freight transport relative to GDP in Europe. The index is determined as the ratio between freight transport performance (in tonne-kilometres) and Gross Domestic Product.

	June 2018	Dec. 2018	June 2019	Dec. 2019	June 2020	Dec. 2020	June 2021	Dec. 2021
Belgium	1.220.776.509	1.037.393.671	1.270.640.074	1.136.807.255	1.198.994.518	1.205.982.699	1.500.124.342	:
Bulgaria	15.080.638	14.842.118	17.882.290	13.996.635	17.251.519	18.391.652	16.510.664	:
Czechia	41.699.533	33.548.504	33.931.866	31.886.876	31.305.881	33.063.561	33.471.491	121.263.822
Denmark	46.964.681	38.682.176	41.697.370	31.678.721	57.582.582	53.676.446	39.149.412	:
Germany	987.653.876	869.190.039	973.537.693	989.078.253	1.295.633.083	1.046.370.707	1.298.149.115	1.194.863.365
Estonia	2.365.249	4.272.758	2.516.120	2.515.523	1.862.941	1.956.784	2.092.462	3.210.615
Ireland	273.527.132	325.040.217	267.129.648	292.922.806	372.966.574	355.148.140	455.630.019	333.735.109
Spain	362.258.453	262.684.639	342.416.529	296.209.815	439.891.105	290.521.319	1.289.211.636	1.420.950.579
France	330.883.413	285.608.437	285.463.316	242.178.317	336.929.344	304.897.037	768.738.593	642.139.688
Croatia	17.616.217	24.359.536	12.386.589	8.973.083	9.212.266	12.201.454	17.262.277	:
Italy	500.772.973	520.360.415	483.021.935	324.417.025	469.298.490	293.045.316	373.555.882	:
Cyprus	6.544.180	6.238.615	4.484.163	6.009.398	7.332.851	6.923.725	7.252.910	:
Latvia	5.429.484	6.931.378	4.859.498	6.084.497	6.993.032	3.591.642	6.467.298	6.717.090
Lithuania	4.716.722	4.495.212	3.076.227	3.213.899	4.821.769	7.037.967	4.231.720	5.208.705
Luxemburg	3.115.705	286.035	260.672	484.004	497.996	3.462.789	363.118	:
Hungary	85.517.386	48.055.518	102.697.851	61.344.372	122.136.940	142.637.690	51.125.739	:
Malta	13.484.364	14.103.919	9.857.941	13.534.497	12.563.969	16.633.070	19.961.147	:
Netherlands	1.499.367.623	813.621.374	1.661.717.002	1.115.297.387	1.503.023.914	1.341.188.998	1.230.530.986	:
Austria	59.313.717	61.206.197	66.868.252	39.797.454	94.080.648	83.740.841	131.430.101	:
Poland	83.355.219	94.394.173	78.103.920	66.074.734	91.080.755	64.258.188	71.111.396	:
Portugal	40.413.504	23.360.806	24.583.293	13.877.857	33.812.775	22.546.644	20.731.919	27.514.810
Romania	38.566.647	22.094.625	34.951.251	23.407.043	62.596.423	37.434.238	61.352.169	:
Slovenia	38.860.860	132.775.366	217.848.477	346.162.807	385.526.602	420.425.376	288.136.639	:
Slovakia	21.627.248	12.359.005	13.034.310	11.608.024	17.303.188	9.728.257	11.227.992	:
Finland	23.583.136	18.174.757	15.628.264	12.491.018	17.244.412	12.975.905	19.810.206	:
Sweden	68.495.420	37.889.819	42.163.743	49.589.160	78.498.479	43.404.033	53.926.192	:

Volume of freight transport relative to GDP
Eurostat, the statistical office of the European Union [9]

That is because it plays a very essential role in the economies of all countries. In fact, through the continuous optimization of logistics processes, it supports decisions at tactical, strategic, and operational level, influencing so the final costs of the product [1]. This growth has been supported by digital evolution that makes the environment even more competitive as customers expect higher quality standards. Also, the rapid evolution of on-demand economy has led to a shift towards a demand-driven approach. This inclination has been accelerated by the pandemic as the enforced closures have increased the use of e-commerce. In fact, the dynamics of trade linked to the typology of essential goods, especially pharmaceuticals and foodstuffs, had an impact on supply and distribution. For some goods, such as essential medical devices, the relocation of production areas, the scarcity of stocks and distribution difficulties have played a heavily negative role.

The following table shows sales of medical consumables in recent years in Europe.

As a demand-driven supply chain (DDSC), there are some key factors that make the system more reactive to changes in demand. These aspects are the traceability of information along the supply chain, the robustness of infrastructure, cooperation between stakeholders and optimization of the overall performance of the supply chain. The main focus is on the flow of information which must be updated in real time between all stakeholders. So, the current logistic services must be innovated in order to fit this system. Synchromodality helps improve service quality, as customers and end-users have greater control of their supply chain [4].

In such a context, customers can order what they want at any time, and they can have it

	June 2018	Dec. 2018	June 2019	Dec. 2019	June 2020	Dec. 2020	June 2021	Dec. 2021
Belgium	1.220.776.509	1.037.393.671	1.270.640.074	1.136.807.255	1.198.994.518	1.205.982.699	1.500.124.342	:
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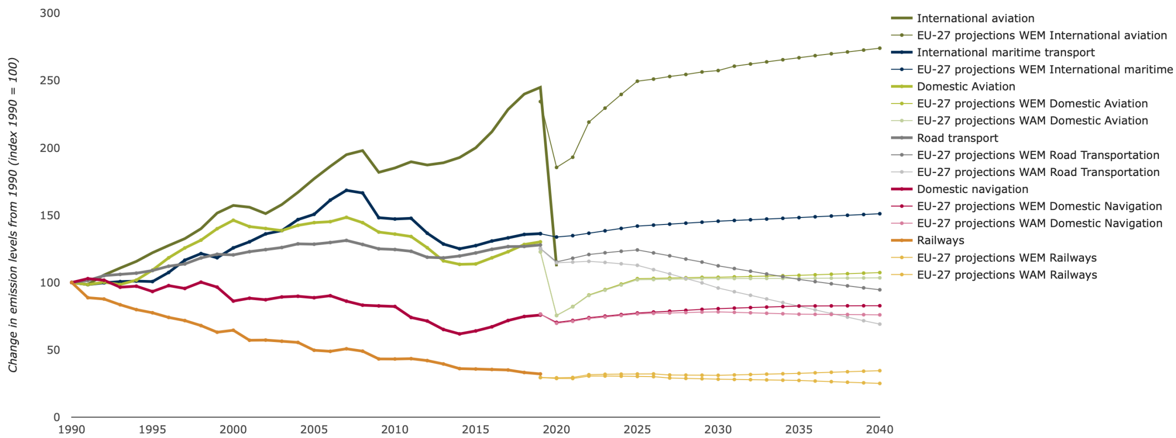
EU trade since 2018 of COVID-19 medical supplies
Eurostat, the statistical office of the European Union [10]

shipped wherever they want. So, transportation operators must be able to use resources efficiently and at the highest possible level, in order to be able to make decisions in real time and to be able to fit this dynamic context. That is why supply chain management is becoming a vital component, as it allows to manage the relationships between actors, as carriers, shippers, intermediates, and customers. Logistic service providers have to optimize and enhance their logistic operations as e-commerce is generating huge demands for logistic services. Then, there is also the need to reorganize logistic spaces to speed up processes and the movement of goods. This requires intelligent, data-driven, and real-time decisions.

Moreover, as citizens pay more and more attention to the quality of life in the city and customers start considering the sustainability of logistics operations, institutional authorities are setting regulations to reduce environmental impact. In fact, the European Commission White Paper has the goal of reducing emissions by 55% by 2030, compared to 1990 [11].

The following figure shows greenhouse gas emissions from the transport sector, and the emissions projected up to 2040 under several scenarios. They include the implementation of policies in the EU Member States.



Greenhouse gas emissions from transport in the EU, by transport mode and scenario
European Environment Agency, EEA [12]

Therefore, companies rely on information technologies and OR methods to gather information about consumer needs, and to anticipate stakeholder behavior, in order to optimize demand forecasting. In fact, the emergence of platforms where the actors can meet and interact, and the advancements on the Internet of Things (IoT) are proposed to face these challenges and to help decision makers.

More specifically, e-commerce has added links to the transportation, and it has changed the way they connect, impacting so on the supply chain. Moreover, the customer possibility to choose and have preferences has led to a growth in the customization of products, and therefore also in the diversification of demand. The customer's experience with the company is even more relevant as it can make or break the relationship with him, and this will impact the sales. Delivery services therefore are a crucial step. The main aspects that impact the supply chain are indeed product quality, price, service level, and the forecast of future sales of a product. Therefore, there must be changes in the supply chain to face these challenges.

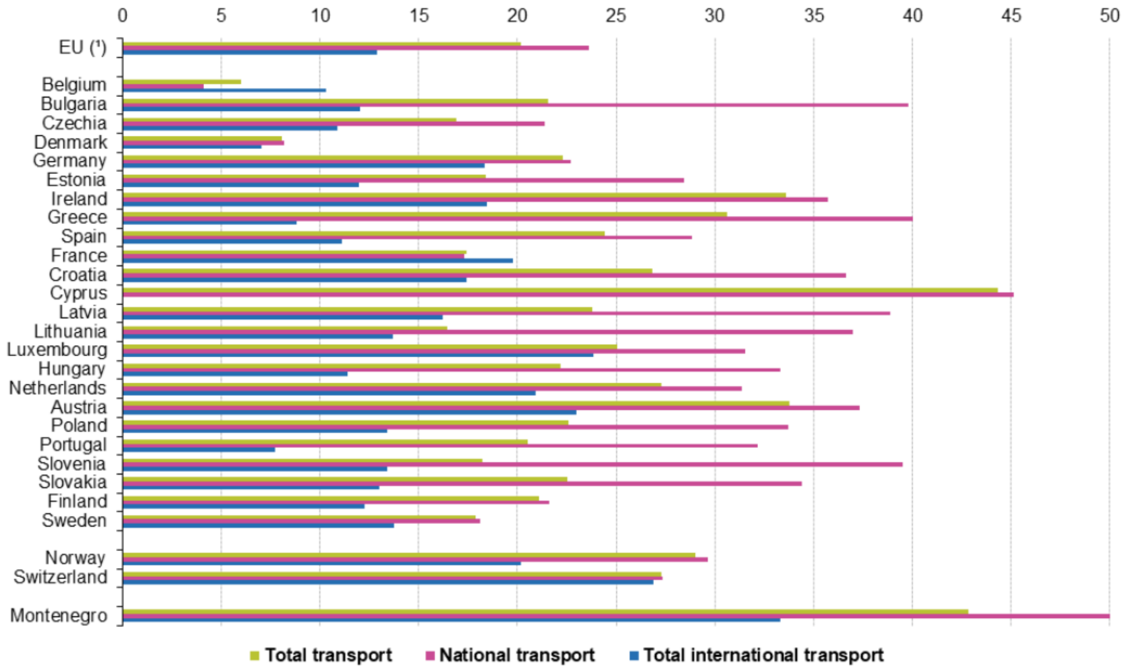
In this context, logistic providers have to make warehouses capable to stock goods and to pick items for each individual order. Also, moving the distribution hubs closer to the delivery centers would speed up operations and reduce fuel costs. Furthermore, now there are also specialized sorting centers that arrange the items before sending them to the delivery center. Finally, technology plays a crucial role in e-commerce supply chains. The integration of technologies as Internet of Things (IoT) provide several benefits, such as an accurate price quote for shipping, order tracking, order status, bills and invoices for any order, optimization of routes, data analysis and customer experience history.

As a result, there is a different infrastructure, with a new organizational framework. As one of the most important aspects is consumer demand, companies have more and more responsibility in meeting their needs. Especially, customers are looking for free and same day shipping. So, they must develop strategies and practices to keep pace, to minimize shipping costs and to optimize shipping speeds. The outcome is the need to adopt new goals, such as improvements in communication between customers and companies, capability to handle more inventory, waiting time reduction, cost reduction, fast delivery, focus on customer feedback, simplified return operations. So, in this vision, it is the customer who imposes the constraints, therefore whoever sends the products must respect them by trusting and delegating the delivery activities to the operators.

Moreover, in EU, one fifth of total road freight performance is taken by empty trucks. This involves energy expenditure, additional costs for companies and end users, and an unnecessary aggravation of air pollution. In this scenario, digital plays a fundamental role as the use of cargo booking platforms for shippers and carriers allows the optimization of deliveries and it reduces empty trips.

Finally, considering the increasing use of intermodal transport, the remarkable growth of e-commerce, and the shift from an offer-driven to a demand-driven logistics, it is necessary to address the issues associated with these changes.

It is clear there must be a connection between the commercial vision and the solutions to implement. These issues can be solved through the use and improvement of information technologies, such as Internet of Things (IoT), the synchronization of activities, and the



Road transport performed by empty vehicles by type of operation, 2020
Eurostat, the statistical office of the European Union [13]

support of OR methods, such as business models, to support decision makers. In fact, the digital technology adopted by e-commerce platforms can increase retailers market demands. Through data mining and decision support system, it is possible to gather reliable information and data, and to help companies make informed decisions. The activities synchronization reduces cost and environmental impact. Finally, the implementation of a solid business model gives the company a competitive edge in the market. Therefore, a systemization that links the part of the business approach and the optimization part is needed.

In the next section, we will analyze the research that has been done about it, and the possible solutions that have been found

3 Literature review

Intermodal transport is becoming essential in international freight transportation during the last decade, as it supports the efficiency of the operating and business models that are emerging recently. Its purpose is to achieve both economic, environmental and social objectives. This expansion affects numerous stakeholders, decision makers, operations and planning activities, therefore it increases the complexity of the network. Synchromodal strategy appears to improve flexibility in supply chains, cooperation between stakeholders, and allocation of resources. Moreover, as supply chain management has greatly shifted to demand-driven supply chain, companies have to use real-time information efficiently, and combine advanced technologies into their business. Therefore, as it is required an approach that balances the actors' business and operational models. We will address this need by adopting a Lean Business approach. In this chapter, we investigate the literature on this topic. In particular, the most significant literature is split into three main parts: intermodal transport issues and optimization models, the collection of information and data supported by new technologies, and emerging business models.

The first section covers intermodal transport issues and optimization models related to the planning of transportation activities. The levels taken into consideration are tactical, strategic, and operational. To respond to the several issues present in this network, different models and methods have been introduced over the years. Crainic et al overview the evolution of intermodal freight transportation and the taxonomy[6] [14] and [5]. In [**2**], [8] and [15], the authors provide methodological developments to address tactical planning issues, focusing on models. Regarding capacity planning issues, they are especially addressed in [16] and [17]. The authors focus on the uncertainty related the capacity loss, introducing a stochastic variable cost and size bin packing model. Instead, [18] contribute to the tactical planning issues for the M1M system, incorporating capacity-allocation revenue management concepts. Another papers, [19] and [7] , explore intermodal transport barriers and how they could be overcome by providing innovative technological solutions.

The second axis focuses on the collection of information and data supported by advanced technologies. The freight transportation industry has faced a shift to e-commerce [20] [21] and [22]. Even before the pandemic there was this inclination, but with the closures imposed by various countries, the use of e-commerce has become ever greater. It certainly brings many benefits to customers, such as low shipping costs, low waiting time, delivery of goods at home, and also to the companies, as faster buying process, cost reduction, improvements in warehouse management. However, it also brings negative effects as it is increasing traffic congestion, and so it leads to higher carbon emissions [23]. Another negative effect concerns energy and resource consumption [24]. Despite these negative aspects, the positive ones are much more. Regarding this, there are several studies that analyze what is driving this increase [21]. In this context, the supply chain management is becoming a demand-driven supply chain (DDSC) [4]. There is a need to reorganize the supply chain [22], especially the management of logistic facilities, in order to speed up the delivery processes.So, the main focus is on the collection of information and data in order to efficiently coordinate all the interested actors. This is the basis to be able to react to real-time demand requests across a complex network. More specifically, it is mandatory to keep track of the flow of information in real time through digital technologies, such as data mining and decision support system. Kauffman et al. [25] show how these technologies had a huge impact on e-commerce by creating business network-based value. Another study [26] shows how the data and information generated by the Internet of Things (IoTs) can be used to gain knowledge, that is applied to the monitoring of the business network operations. Therefore, these technologies will be integrated into the development of the solution.

The last section covers the emerging business models. This approach enables cooperation between operators, under the regulation of the authorities. As we mentioned above, the shift from supply-oriented to demand-oriented logistics requires higher quality levels and standards in the supply chain management. Therefore, by adopting a lean business approach, it is possible to address this change. Several business models have been developed in the literature. In particular, [27] they build a system dynamics (SD) model for a freight transportation. By implementing this approach, the authors prove how it is possible to save in CO2 emissions and operating costs. Another business approach is shown in [28]. However, the most famous one is the business model developed by Osterwalder and Pigneur [29] [30]. There is a very efficient example in a European project, SYNCHRO-NET project [31] [32].

Analyzing the studies that have been done, it is clear there is a need to achieve a global optimization to mitigate these challenges. More specifically, in our literature review, two approaches have emerged: the SYNCHRO-NET project and the M1M system. Even if both are based on the use of corridors, there are major differences between the two solutions.

The Synchro-modal supply chain eco-NET (SYNCHRO-NET) [31] [32] was an innovative project funded by the Horizon 2020 Programme, with the purpose to optimize and aimed to optimize the supply chain by means of synchro-modality and slow steaming strategies. The scope of SYNCHRO-NET project was to reduce the costs and the carbon emissions in long-haul container shipments, making the process more efficient. Slow/smart steaming allows to reduce emissions and fuel costs through making cargo ships work at a slower speed than designed, and to manage better their speeds in order to gain optimization at all levels. The other strategy is inter/ multimodal transportation approach that enable to switch the transportation modes in real time. In this project, the solution was developed by introducing the business model of participating stakeholders, adopting so a stakeholder-driven approach that considers their actual needs and requirements. They defined the corridors and they considered them in an aggregate way, as a network of corridors. Moreover, SYNCHRO-NET has no technological constraints. The only constraint is the availability of goods when they are requested. Finally, they optimize the system globally.

Instead, as regards the M1M system, the vision adopted is of the single corridor [33]. The corridor is a logical entity based on a physical entity, so it has several technological constraints. Moreover, the corridor is already given, so we can not see the operations in detail, as it not possible to make exchanges. In this context, there are many actors interacting and there is a platform in the middle that collects information to optimize the system and to meet the needs of all the actors involved. M1M has a multi-period optimization model that maximizes the profit, but it has no connection with the real intermodal transportation system.

It emerges that M1M and Synchromodality are representations of operational response, not of operational decisions, as there is no link between the systematization of the business model and the solution. Moreover, while a solution, intended as a business solution, has been defined in SYNCHRO-NET, in M1M there is none. In SYNCHRO-NET we have seen how an exploitation business modeling approach works because it leads to an easier definition of what could be a commercial use. So, since the two systems must work together, the aim of this paper is to fill this gap.

There are different methodologies to define a business model. We will focus on the GUEST methodology [2].

4 Methodology

At this time of digital revolution, innovation is necessary and above all continuous. The way of thinking of people is also changing, and this greatly affects the markets, which are increasingly overcrowded due to competition, which is becoming stronger and stronger. Therefore, every company needs more than ever to use business models, since they are the most effective tool in situations of transformation and they offer a great potential for innovation, essential to differentiate themselves from the competition. In fact, the context of the business model is dynamic and flexible since no business model can generate value forever while remaining the same. It modifies and it adapts to external changes indeed, bringing significant benefits. Most research focuses on optimization issues, and there is a lack on the implementation of business models regarding M1M systems.

The Synchro-NET project [31] [32] is certainly the most recent and effective proof of how this integration works and brings several benefits. The authors developed a business model that aims to develop a solution that satisfies the stakeholders' needs. This innovative approach and the integration of the operational models brought to Synchro-NET a strong market acceptance. It also consolidated the efficiency and the economic sustainability of the project.

This tool allows to describe the organization of the company, highlighting its purpose, how it intends to achieve it, who it is intended for and what are the resources. It generally serves to illustrate how the company can function economically, through an economic logic that allows it to create and provide value to customers. Precisely for this reason business models are the foundation of every company [30]. The elements of a business model [34] are:

- strategic choices: competitors, customer, value proposition, pricing
- create value: resources, processes
- value network: suppliers, customer information, customer relationship, information flows
- capture value: costs, financial aspects, revenues

These elements serve to cover both the demand side and the supply side. In fact, they include the strategic choices that describe the business, the resources, and processes through which a company creates value. Moreover, it helps to define the network in which the company is positioned in order to select the target of customers for which it is possible to create a differentiated value, and finally the structure of the financial aspects, costs and income. Following the development of a business model, it is possible to generate strategies, business plans, profits, losses and financial projections.

There are different approaches to represent a business model, in fact they are not only different between sectors, but also in the same sector. The main difference concerns the focus, which can be on a single company, or on an entire ecosystem.

The most famous business model is certainly the Business Model Canvas, proposed by Alexander Osterwalder and Pigneur in 2008 [29]. It graphically represents the business model that creates, generates and captures value to emerge in the market [30]. In detail, this model is made up of nine blocks which are the building blocks of the business model:

1. Customer segment: constitutes the specific target that the company intends to reach;
2. Value proposition: constitutes the set of tangible and intangible benefits that the company offers to its customers; it is the value proposition created for a specific target;
3. Channels: it is about the way in which the company interacts with the customer segment to provide the value proposition;
4. Customer relationship: these are the relationships established between the company and the customer segment;
5. Flows of revenues: they represent the revenue that the company generates from each individual customer segment;
6. Key resources: these are the key resources necessary for the model to work and be efficient;
7. Key activities: the fundamental activities that the company must carry out for the model in order to work;
8. Key partnership: they constitute the network of suppliers and partners useful for the functioning of the model;
9. Cost structure: it represents the costs incurred for the management of a business model. It is divided into two structures, cost-driven and value-driven.

Furthermore, these elements belong to four main areas of a business:

- The customers;
- The offer;
- The infrastructure;
- The financial health.

Through this representation it is possible to obtain an overall reproduction of the company reality. The reading starts from the central part, where there is the value proposition. Non-financial information is represented in the upper part of the model and financial information in the lower part.

In this paper, the Business Model Canvas is used as an integration of the GUEST methodology [2]. This procedure was developed by a group of researchers from the Polytechnic of Turin, and its aim is to improve and increase efficiency and quality of companies. It can be applied to the entire decision-making process. It consists of 5 steps:

1. GO: this is the phase in which we have the first approach to the company and the first information is collected in order to evaluate whether the project is feasible or not. This phase has four steps. The first one is the collection of the information by a questionnaire and meetings. This procedure allows to describe the project and to understand which aspects can generate its success. PEST analysis and Porter Five Forces frameworks could be used in place of questionnaires. PEST analysis collects the external factors influencing the company business. It provides opportunities and threats to deal with the external environment. Such information may be used by Business Model Canvas, SWOT and the risk analysis. The Porter Five Forces analysis places the company in the corresponding market segment, providing the strategy to be implemented in order to gain competitive advantage. The next step is the development of the Social Business Network (SBN), that shows the relationships among the stakeholders. It helps to understand the environment and the different levels of business competences. The Actor ID card provides social and economic information of the stakeholders. It is inspired to the Value Proposition Canvas build by by Alex Osterwalder and Yves Pigneur [30], namely a tool that provides customers' pains and gains. In fact, the Actor ID card is made up of the information contained in the Value Proposition Canvas. Finally, the Value Ring is composed by layers that represent the temporal priority, and portions related to the stakeholders identified in the previous steps;

2. UNIFORM: there is the consolidation of the information collected in the first phase, and the development of the business model that characterizes the company business. It is understandable and also easy to apply. This document supports cooperation between all the actors involved in the business. Its role is very crucial as it enables the company to meet the market needs and requirements;

3. EVALUATED: evaluation of the initiatives taken, and identification of opportunities in order to develop a plan of actions to be undertaken. It is composed by SWOT analysis, Balance Scorecard and ICE-Diagram. The first one identifies internal variables that are combined in the system as they can be managed, and external variables that are independent of the system, so they are monitored to reduce risks and to improve performances. The Balance Scorecard defines the strategy through the strategic map, the strategic execution and evaluation. The ICE Diagram is a table composed by three columns: identify, control and evaluate. It is used to define and to prioritize tangible actions to implement. Its outcome provides the inputs for the Solve phase.

4. SOLVE: analysis of the problem identified in the previous phases. The main outputs of this step are the Executive ICE-Diagram and the Solution Canvas. The first one is the selection and assignment of priority of the information gathered in the previous step. The aim of the Solution Canvas is to design the solution of the business;

5. TEST: implementation and evaluation of the previously actions stated during the GUEST's application.

The last step may be the input to generate ongoing improvements in the system, by making modifications to the original business model. This method allows companies to test their product or service and to adapt them to the market requirements, without wasting time.

As mentioned above, we are going to illustrate how a business model can be developed for the M1M system based on the GUEST methodology [2]. The current system involves several stakeholders that interact with each other, yielding thus a Multi- Actor Complex System (MACS). The output of these interactions is the value. A synthetic business model is developed and studied. More detailed, we will analyze the contracts with shippers and carriers, capacity types, the market framework, the ability to secure the carrier capacity, service quality levels, and pricing. The purpose is to apply this series of steps on our problem, in order to get an output and then to analyze it. The solution gained will be the Solution Canvas, that is a strategic template developed by Osterwalder [29].

More specifically, the solution is divided into nine sections:

1. Decision makers that make the decisions identified in the solution;
2. Constraints that affect the actions requested to implement the solution;
3. Decisions to be implemented in order to make the solution work;
4. Information / Resources that led to the solution developed;
5. Users / DM Report are the relationships between customers and users;
6. Users are the stakeholders that will gain benefits from this solution;
7. Channels through which the solution is implemented;
8. Goals are the objectives to be reached thanks to the solution;
9. Costs represent the expenses to implement, not implement and maintain the solution.

This procedure is understandable for all the stakeholders, regardless of their level of knowledge, so they can be easily guided into decision-making process and they also gain several benefits. Therefore, following these steps and applying them to our problem setting, the following scheme comes out:

1. Go: the first approach is to define the network made by the stakeholders and the actors involved, and their interactions, so that a complete vision of the system will come out;
2. Uniform: definition of the value for the stakeholders through the Value Proposition Canvas [30], that does not only consider their needs, but also the potential gains and pains that affect the user. It can be qualitative or qualitative. Finally there is the Business Model Canvas, as we mentioned above, a tool that proves how the solutions developed are capable to create value for these stakeholders. It has nine blocks that are the key elements of the business model;

3. Evaluate: it is an operational step, namely the identification of the value-creating processes. The results of the previous steps are analyzed in order to develop opportunities and to elaborate an actual action plans;

4. Solve: given the third step and the problem setting, various operations models are suggested. An important outcome is the Solution Canvas, a tool that delineates the chosen solution;

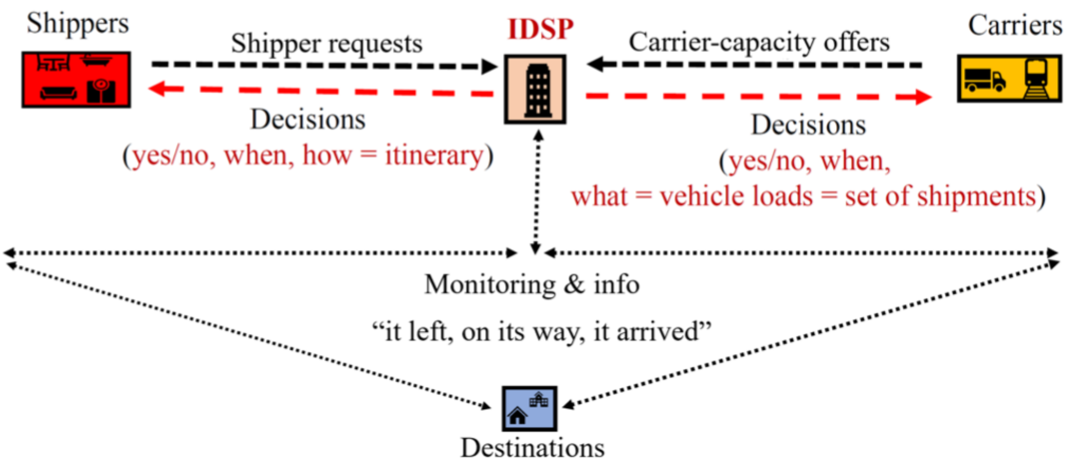
5. Test: the final step concerns the tools to run these processes and to implement the action plans. There is also an evaluation of the outcomes. This step is left as a starting point for further research.

The scope of this methodology is to assist the decision makers in their projects, from the beginning to the implementation of the solution.

5 M1M system

5.1 Problem setting

As we mentioned in the previous sections, the system taken into consideration is precisely the Many-to-One-to-Many (M1M) system, and more specifically, the single segment case. In this framework, there are many shippers, that could be producers of goods, logistic-service providers, wholesalers, intermediary firms, or distributors. They give rise to the demand for cost-effective and time-efficient transportation. The shipment will take place between shipper location and consignee location. Then, on the other side, there are many carriers that offer a service for transportation, being so trucking companies, terminal operators, logistics-service providers, and transportation service providers, or a combination of those just mentioned. Instead, in the middle, there is the Intelligent Decision Support Platform (IDSP) that satisfies the needs of all stakeholders by optimizing in time and space processes. That is possible as a result of an efficient communication between all involved stakeholders. In fact, they share not only data and decisions, but also resources. This condition leads to benefits for everyone, as vehicles do not travel empty, the delivery costs are minimized, and traffic congestion is avoided [33].



An integrated multi-stakeholders system structure
Tactical Capacity Planning in an Integrated Multi-stakeholder Freight Transportation System[18]

There are two types of shippers: contract-based and non-contract. The difference is that the demand of the contract-based ones has to be fully satisfied, while that one of the non-contract ones concerns selection decisions. Moreover, the demand can be standard or urgent. Instead, carriers can supply the demand individually or as member of a bundle. They can also offer warehousing space for goods at the terminals. The IDSP therefore makes also decision to select the terminals mentioned.

The integrated multi-stakeholders system is made up so by these three categories of actors: senders, receivers, and operators. In addition, there is one more category, the institution authorities that regulate and tax the industry by establishing policies and procedures.

They can be governments, private and public administrations, and also transnationals institutions. Instead, the owner of the platform can be private or public, and he is not an actor.

There can be multiple markets or a single market, and each one represents a different problem setting that is managed by a single-layer network. The core of these networks are corridors. In the present paper, the context considered is the connection between two regions, so the single-segment corridor case, that designs the P&D activities by means of costs. In doing that, it integrates P&D and long-haul trans- port. Zones can be urban or interurban, and all facilities located in those zones could be serviced by the terminals linked to them. These terminals could be guided by the IDSP or used just to do some required activities, or they may even be on their own. Instead, the infrastructures are provided by governments, that also supervise, by means of polices, and tax the sector.

Movements happen between different zones that are served by terminals. There are consolidation terminals and transfer terminals. The consolidation ones are used to perform:

- classification (sort and group);
- crossdock transfer;
- first/last mile for the zone.

Instead, the transfer ones are used to perform only classification and crossdock transfer of shipments. More terminals can service a single zone.

The physical network is made up by nodes that denote terminals, shipper, and consignee facilities. The arcs, instead, constitute the connections that occur between the nodes. There are different types of arcs, and one of them represents P&D activities performed through routes. The long-haul arcs have arrows at both ends, so that the flow is practicable in both directions. The feeder arcs assist the ingress of inbound and the depart of outbound traffic. The segments are combination of long-haul arcs, or of a feeder arc and its P&D arcs. There are so:

- The single-segment corridor, that consists of one long-haul segment and two feeder segments;
- Multi-segment corridor, that has all zones and terminals on the same path;
- Hyper corridor, where a certain number of paths connects a certain number of zones and terminals.

Transportation activities consist of shipments, that are picked up from the initial location after there has been a shipper request. It is moved to the terminals, and it is classified or transferred. Even consolidated freight can be moved to the final location. Finally, loads are separated at the destination terminals, and they are grouped into vehicles to be delivered. The P&D activities could be performed simultaneously in the same vehicles.

The requests and the offers have time and economic attributes, so the IDSP collects both type of needs and optimizes the activities in time and space. The platform combines consolidation and synchronization of activities to make the process efficient, less polluting and to reduce the costs.

More specifically, shipper demand requests are denoted by volume, origin, and destination attributes. Depending on them, the load can be split or unsplit. These details are available before making any possible decisions. There is also time information, as the release time and the due date. The contract-based shippers are the most common. They establish conditions in advance through contracts. Even so, there could be also non-contract shippers that ask for transportation without establishing a contract or negotiating, so with short notice. Then, their demand is classified in standard or urgent. Therefore, the revenue depends on the type of request, the distance between the locations and the features of goods. Finally, shippers inform the platform about a possible movement of goods earlier or later than the established date, paying a penalty.

Instead, carrier capacity offers are made to provide transportation services that can be accessible at certain points, terminals, or zones. They are denoted by attributes as terminals, capacity, and routes. Furthermore, there time features defining departure and arrival. Legs are time-stamped service arcs and their schedule identifies the duration of the service. These services are therefore called scheduled services, and they can be regular or fast. Each scheduled service is measured by fixed cost and unit transportation cost. As we mentioned above, carriers can be part of a bundle when there are large orders. In this case, there could be discounts, and there are not fixed selection cost. However, the platform selects each carrier capacity offer or as individual services or as bundle. Finally, there are carriers that offer also warehousing space where goods can be stored for the moment. Offering space has its price, so if the platform decides to use these spaces it pays a fixed selection cost to the carriers.

5.2 Tactical planning

As already mentioned, the IDSP optimize processes and activities of the M1M system. Such a system is very complex as there multiple actors interacting with each others. Therefore, a transportation plan is established in advance at the strategic, tactical and operational levels. Strategic planning regards long-term decisions that need a higher level of forecasting which require the highest level of forecasting, instead, operational planning concerns short time decisions, such as real-time decisions. At the tactical planning medium-term decisions are made. The scope of this phase is to delineate together demand and offer sides, and to define planning processes for them. The next step is to maximize the profitability of the system by selecting the valuable demands from non-contract shippers and satisfying both non-contract and contract requests. Regarding the supply side, its aim is to select single services and bundles of services to meet the shipper demand. The request is satisfied through efficient use of capacity. At the tactical level there is also the aggregation of demand requests and the definition of shipments itineraries.

So, the goal is to build a model to maximizes the profit of the platform. It is operated within the limits of a schedule length, and it may be performed multiple times. The problem setting is time-dependent, and the choices are made through space-time networks.

We make some assumptions before implementing the model. There is the differentiation between contract shippers and non-contract ones, and between standard demand and urgent one. Given that there is the possibility to anticipate or postpone the P&D activities, there penalty costs for the shippers. Hence, there is more flexibility, more efficient consolidation and the opportunity to make more profit as more demands can be met. Moreover, the service requested may be regular or fast, and each service can be provided individually or as part of bundles. The difference with the other models lies in incorporating revenue management concepts. This bond is seen when it comes to bundles. In fact, they are linked to the revenue management, so carriers can provide their services at a reduced fixed price. This increases their volume of services offered, and it brings profit to the platform.

The methodology that supports this planning is the Scheduled service network design (SSDN) that allows all the actors to gain benefits. Carriers have more income, shippers have lower delivery costs, the platform gains profit on each negotiation, and companies have economic, social and environmental benefits.

5.3 Elements and Notations

The time dimension

Information cab be known, or certain, or predicted, or uncertain, as demands and offers may arrive within time intervals agreed, or anytime. In both cases, it is stored until all information is available and known. The platform receives huge streams of information, so it responds to them through streams of decisions. In fact these stream support the decision makers to make decisions, such as the selection of shipper request, the assignment of the request to a specific service/vehicle, the selection of carriers capacity offer, the selection of the routes and of terminals and warehousing spaces. Such decisions have an impact on all customers involved. Therefore, they must be supported by appropriate optimization models to make them as efficient as possible. We consider the discrete time representation that defines time as a sequence of time instants. The period defines the duration between two instants. Given that, decisions can be made without considering what could happen next. This is called myopic decision making, and it is taken as a benchmark. The focus is on the decisions that take into account the future, evaluating the effect of actual decisions on the future conditions of the system. So, the model must consider both the decisions to be made on the spot and those that could be made later. Such a model has been build for the Operations Planning Horizon (OPH), and it is made up of instants and periods, known and unknown information. Therefore, the main components are the current implementation, when decisions made are implemented and they can not be changed, and the look ahead, when decisions are not put in practice now.

Shipper demand

The demand of the shippers consists in the production of one item or more than one. The request is defined by different attributes, such as identity of the demand, category, origin, destination, product, type of shipment, quantity, loading characteristics and rules. Moreover, there time attributes: acceptance, release, anticipation, due date, and the condition that defines if penalties should apply or not. Instead, the economic attributes concern revenues, penalties, handling costs.

Carrier offer

The supply side is made up of carriers that offer services by means of vehicles, capacity and various transportation modes. The service consists of a sequence of service legs that connect two carrier terminals. The legs have a specific capacity, that may be not the same as that one offered to the platform. Moreover, the service is defined by departure and arrival times, departure and destination locations. Then there is the travel time based on the distance. Finally, the path of a flow-service can be a long-haul path or a door-to-door path. Instead, the schedule can be fixed or IDSP-determined.

As well as for the demand side, the offer has several attributes, such as identity, ID of offer, category, transportation modes, services that make up the offer, origin, destination, routes, quantity, and capacity. The time attributes concern acceptance, schedule, availability time, travel time, anticipation and return time. Instead, the economic fixed costs are transportation and handling costs, the selection and use of the service. Then, there are variable costs based on volume and distance. Also in this case, there may be penalties on an early or late return.

5.4 Mathematical formulation

In the literature there is a mathematical formulation designed for this problem setting. The model developed can manage the split and unsplit cases [18].

The decision variables are:

- $z_k = 1$, if shipper-demand request $k \in \mathcal{K}$ is accepted, 0 otherwise;
- $r^k_{(o(k),t)} = 1$, if shipper-demand request $k \in \mathcal{K}$ is picked up from its origin $o(k)$ at time $t \in \mathcal{T}$, 0 otherwise.
- $x^k_a = 1$, if shipper-demand request $k \in \mathcal{K}$ is traveling on arc $a \in \mathcal{A}^{\mathrm{E}}$, 0 otherwise, where $x^k_{a_l(\sigma)} = x^k_a$, for $a = a_l(\sigma)$, $a_l(\sigma) \in \mathcal{L}(\sigma)$, $\sigma \in \Sigma$.
- $\xi^k_a = 1$, if shipper-demand request $k \in \mathcal{K}$ is held on holding arc $a \in \mathcal{A}^{\mathrm{H}}$, 0 otherwise.
- $r^k_{(d(k),t)} = 1$, if shipper-demand request $k \in \mathcal{K}$ is delivered at its destination $d(k)$ at time $t \in \mathcal{T}$, 0 otherwise. This is an auxiliary variable dependent on $r^k_{(o(k),t)}$, x^k_a, and ξ^k_a which corresponds to the delivery time of shipper-demand request $k \in \mathcal{K}$.

- $y_\sigma = 1$, if service $\sigma \in \Sigma$ is selected, 0 otherwise.
- $\gamma_b = 1$, if bundle $b \in \mathcal{B}$ is selected, 0 otherwise.
- $\lambda_n = 1$, if the warehousing space of terminal $n \in \mathcal{N}^{\mathrm{P}}$ is used, 0 otherwise.

The mathematical formulation for the unsplit version is:

$$\begin{aligned}
\max \quad & \sum_{k\in\mathcal{K}} w_k \Big[\rho_k z_k - \sum_{t\in\mathcal{T}} \psi^k_{(o(k),t)} r^k_{(o(k),t)} - \sum_{t\in\mathcal{T}} \psi^k_{(d(k),t)} r^k_{(d(k),t)} - \sum_{a\in\mathcal{A}^{\mathtt{E}}} c^k_a x^k_a - \sum_{a\in\mathcal{A}^{\mathtt{H}}} \bar{c}^k_a \xi^k_a\Big] - \sum_{\sigma\in\Sigma} f_\sigma y_\sigma \\
& - \sum_{b\in\mathcal{B}} f_b \gamma_b - \sum_{n\in\mathcal{N}^{\mathtt{P}}} f_n \lambda_n && && (1)
\end{aligned}$$

$$\begin{aligned}
\text{s.t.} \quad & z_k = \sum_{t\in\mathcal{T}} r^k_{(o(k),t)} && k\in\mathcal{K} && (2)\\
& z_k = \sum_{t\in\mathcal{T}} r^k_{(d(k),t)} && k\in\mathcal{K} && (3)\\
& r^k_{(o(k),t)} + \sum_{a\in\mathcal{A}^{\mathtt{E}(-)}(o(k),t)} x^k_a + \xi^k_{((o(k),t-1),(o(k),t))} = \\
& \quad \sum_{a\in\mathcal{A}^{\mathtt{E}(+)}(o(k),t)} x^k_a + \xi^k_{((o(k),t),(o(k),t+1))} && k\in\mathcal{K}, (o(k),t)\in\mathcal{N} && (4)\\
& r^k_{(d(k),t)} + \sum_{a\in\mathcal{A}^{\mathtt{E}(+)}(d(k),t)} x^k_a + \xi^k_{((d(k),t),(d(k),t+1))} = \\
& \quad \sum_{a\in\mathcal{A}^{\mathtt{E}(-)}(d(k),t)} x^k_a + \xi^k_{((d(k),t-1),(d(k),t))} && k\in\mathcal{K}, (d(k),t)\in\mathcal{N} && (5)\\
& \sum_{a\in\mathcal{A}^{\mathtt{E}(-)}(n,t)} x^k_a + \xi^k_{((n,t-1),(n,t))} = \\
& \quad \sum_{a\in\mathcal{A}^{\mathtt{E}(+)}(n,t)} x^k_a + \xi^k_{((n,t),(n,t+1))} && k\in\mathcal{K}, (n,t)\in\mathcal{N} : n\neq o(k), n\neq d(k) && (6)\\
& \sum_{b\in\mathcal{B}:\sigma\in\Sigma(b)} \gamma_b \leq 1 - y_\sigma && \sigma\in\Sigma && (7)\\
& \sum_{k\in\mathcal{K}} w_k x^k_{a_l(\sigma)} \leq u_{a_l(\sigma)}(y_{a_l(\sigma)} + \sum_{b\in\mathcal{B}:\sigma\in\Sigma(b)} \gamma_b) && a\in\mathcal{A}^E && (8)\\
& \sum_{k\in\mathcal{K}} w_k [\sum_{a\in\mathcal{A}^{\mathtt{E}(-)}(n,t)} x^k_a] \leq u^{\mathtt{MH}}_{(n,t)} && (n,t)\in\mathcal{N} && (9)\\
& \sum_{k\in\mathcal{K}} w_k \xi^k_{((n,t-1),(n,t))} \leq u^{\mathtt{W}}_n \lambda_n && (n,t)\in\mathcal{N} && (10)\\
& z_k = 1 && k\in\mathcal{K}^{\mathtt{C}} && (11)\\
& z_k \in \{0,1\} && k\in\mathcal{K}^{\mathtt{NC}} && (12)
\end{aligned}$$

$$\begin{aligned}
& r^k_{(o(k),t)} \in \{0,1\} && k\in\mathcal{K}, (o(k),t)\in\mathcal{N} && (13)\\
& r^k_{(d(k),t)} \in \{0,1\} && k\in\mathcal{K}, (d(k),t)\in\mathcal{N} && (14)\\
& x^k_a \in \{0,1\} && k\in\mathcal{K}, a\in\mathcal{A}^{\mathtt{E}} && (15)\\
& \xi^k_a \in \{0,1\} && k\in\mathcal{K}, a\in\mathcal{A}^{\mathtt{H}} && (16)\\
& y_\sigma \in \{0,1\} && \sigma\in\Sigma && (17)\\
& \gamma_b \in \{0,1\} && b\in\mathcal{B} && (18)\\
& \lambda_n \in \{0,1\} && n\in\mathcal{N}^{\mathtt{P}}. && (19)
\end{aligned}$$

Mathematical formulation
Tactical Capacity Planning in an Integrated Multi-stakeholder Freight Transportation System [18]

The profit is maximized by summing up the revenue gained from satisfying both types of demand, minus the total costs. The cots include penalties, delivery costs, services costs and warehousing costs. The model chooses the option that minimizes transportation costs.

The constraints of the model are listed:

1. the guarantee that all requests are picked up from the first locations and delivered to their destinations (2) (3);
2. flow balance for all demands at each location (4) (5) (6);
3. the optimal route for each shipper-demand request (2) to (6);
4. the guarantee that all services are selected individually or with a bundle (7);
5. capacity limit for each service leg (8);
6. limitation to the quantity of shipments that can be managed at terminals (9);
7. restriction to the number of shipments on the holding arc (10);
8. all the contract demands must be served (11);
9. requirements on the decision variables (12) to (19).

By relaxing the unsplit acceptance, and by permitting the possibility of splitting the demand, this formulation can be adapted to the split case. Through computational tests both case have been tested, adapting them to three different network topologies: hyper corridor network with 7 terminals, bipartite network with 8 terminals, and grid network with 9 terminals. The results have been evaluated through performance indicators, such as total cost, total profit, relative yield, capacity usage. The outcome proves that these approaches improve the consolidation of the system, increasing the satisfaction of demand and profit. It is clear that including non-contract shippers brings advantages as it makes more profit for the IDSP, and a better use of capacity. Moreover, also considering different demand types is profitable as the platform selects more urgent non-contract requests with demand diversification. So, it can make a better use of the capacity. Then, there are positive effects by anticipating or postponing shipments. The demand routing is feasible it leads to more efficient consolidation. Regarding instances with bundles, it comes out that it is the most efficient setting.

The mathematical formulation optimizes the spare capacity of the M1M system, but it emerges that the system still has no connection with the real intermodal transportation system. Therefore, to fill this gap, we adopt an exploitation business modeling approach, that can link the system with the commercial world, as we have seen in SYNCHRO-NET project [31] [32].

6 Business model

6.1 Definition of the network

In the previous section the general problem setting of the M1M system was defined and described. In our paper we will consider a simplified version of the system. Specifically, we focus on the single segment, we assume that the solution is developed internally and we exclude the presence of the public stakeholder.

Before analyzing the actors involved, we focus on the barriers that affect this system. First, uncertainty plays a crucial role in the M1M system, and decision-making process. Since the system generates huge volumes of data, the IDSP reacts to these streams by taking several decisions. The available information can be known or predicted, so decision can be taken through myopic decision-making, or through look-ahead method for predicted data. In both cases, the IDSP transform information into data in order to gain knowledge to help decision making processes. Then, as data is the essence for efficient forecasts and decisions, it is necessary to anticipate the behavior of involved actors, and so their performances. Demand forecasting and predicting behaviors are challenging as there is a lack in the literature on freight transportation. However, the integration of OR methods could lead to accurate demand and time estimations.

Data gathering is also a challenge in this framework. In fact, there are issues regarding the collection of information by means of activities performed succeeding decisions. It is hard indeed to identify the activities to track, then to choose the right data collection method. The reason is because business models have not yet been defined for non-proprietary systems, namely the M1M. A major boundary is the volatile economy and fuel price, as there are always price movements. As we said above, predicting stakeholders' behavior and gathering information from the interactions between the actors enhances the forecasting process. So, building a business model and analyzing it could make the system more resilient to risks and price fluctuation. Moreover, by introducing synchro-modality, the system will be more flexible as it is possible to switch transport mode without reducing the quality of service. Another challenge is the lack of the lack of flexibility indeed, and it is an issue since the service offered is not fixed and regular. Therefore, the implementation of synchronization tools will allow to change transport mode on the route in order to meet stakeholders needs and to reduce transfer waiting times.

Also, innovation and technological change represent a barrier to M1M. In this period technological progress is rapidly increasing, and the implementation of new innovations is required in all sectors. Even the freight transportation industry is developing, and high efficiency is increasingly required. The combination of OR methods and information technology are able to support this expansion. Business models help companies to embrace change and to create value in order to gain a higher market acceptance. Finally, there are environmental policies that regulate the impact of companies on the environment. In this case, OR methods could make logistics activities more sustainable and efficient as they improve capacity planning. Instead, from an operational point of view, the implementation of synchro-modality tools is capable to reduce carbon emissions by switching transport modes anytime on the routes.

After defining the network and its boundaries, we proceed to identify the actors involved, so stakeholders and customers. As we highlighted above, the network is made up of different actors who interact with each other and share information and resources.

The actors can be grouped into three general categories: senders, receivers, and operators. This is because the same actor can belong to two different categories, it depends on his role as it is a multichannel logic. Therefore the flow can be b to b to c, or just b to b direct. The retailer, for instance, can be the sender in the e-commerce as he sends goods to his customer, or the final destination if it receives items from the main company. Also, the logistic service provider can be the one that operates on the platform, or the one that ships by using a subcontractor, such as the carrier.

Therefore, the main actors can be described and listed:

1. Senders: the origin can be a private individual, a company, a shipper, or a logistic service provider. Senders create the demand, as they request transportation for product loads. These requests are denoted by several attributes, such as economic, time and identity. They aim to satisfy the needs of their customers in order to increase the service reliability. In doing that, they can in turn participate in managing the movements of their goods, defining so their own effective logistics strategy. They have to ensure efficient planning and scheduling of shipping activities, to respect deadlines, to ensure a high service quality level, and to ensure that goods arrive at destinations on time and in good conditions. They can aggregate several types of products to save capacity. Senders usually negotiate in advance a transportation plan to be capable to ensure the needed capacity and to perform the delivery activities. They need to optimize processes to reduce their shipping costs and to avoid traffic congestion, hence delays.

2. Receivers: the destination can be a private, a company, it can also be a facility operator when someone delivers to a facility and then they take care of it, a final client or a retailer. Their need is to obtain the requested product or service on time, in good conditions, and with high quality levels. They should anticipate and control uncertainties by gathering, collecting and sharing data about their past experiences. Furthermore, they establish and negotiate contracts in advance. Therefore they must be clear in order to avoid possible misunderstandings. Moreover, they have knowledge regarding the environmental impact and city quality life, so their opinions are relevant.

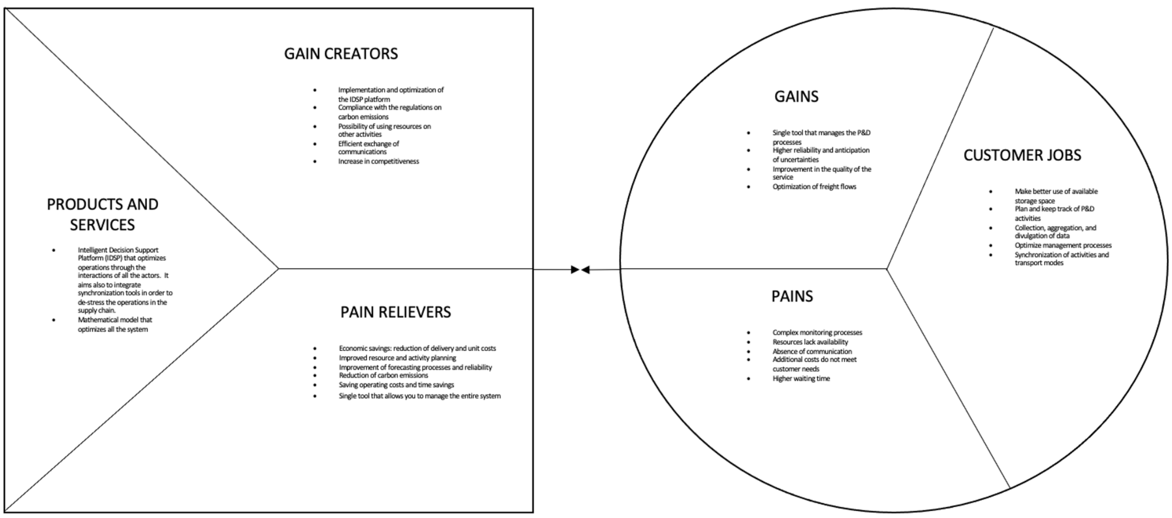
3. Operators: The actor in the middle is the operator, who can be a 3PL, a carrier, a logistic service provider, or simply a logistic operator who makes the delivery. The scope of the operator is to select the demand from non-contract shippers that generate profit and to satisfy these ones and those ones from contract-based shippers. From the supply side, the goal is to select the services, individual or with bundles, in order to meet the shipper requests. They have to make decisions in order to optimize the processes, to select terminals and warehousing spaces. Their job is to maximize the profit, to reduce the costs, to satisfy customer needs, to reduce environmental impact. Instead, carriers accomplish shippers' requests offering capacity for services transportation. Their offers are denoted by several attributes,

such as economic, time and identity too. In providing this service, there can be several transport modes: rail, air, maritime, and road. Vehicles can be full or less-than-truckload. Moreover, some of them serve only a single customer (dedicated service), and others serve different customers (consolidation). Their needs are to reduce empty trips and to increase the quality of service provided. This is possible by efficiently allocating capacity and resources. Moreover, there are carriers that offer also warehousing space where goods can be stored for the moment. Logistic service providers are intermediaries that manage P&D activities across long distances. There are several benefits by integrating them, such as cost savings, safety and efficiency of the delivery, then high customers service satisfaction.

The actors have their needs, and they make decisions to reach their own goals. All of them interact and communicate, making the M1M a complex system, more specifically it is a Multi- Actor Complex System (MACS), and the output of these interactions is value. The benefits indeed can be obtained only if there is cooperation and coordination between them. It is crucial to understand the relationships that take place between the players as these ones influence their behavior.

6.2 Value Proposition

After getting a complete view of the network and MACS, we can develop the Value Proposition Canvas, a tool proposed by Osterwalder and Pigneur that highlights and summarizes the actual needs of stakeholders and customers. In doing that, gains and pains are contemplated as they could affect the users. The common ones are represented graphically, and they are divided into two blocks. The blocks concern the actor profile that points out gains, pains and services provided by actors, and the value map that defines the value that our system offers to customers. As we mentioned, there are some common needs and goals. For instance, optimization of activities helps shipping companies and logistic service providers to allocate resources avoiding capacity problems. An efficient exchange of communications is useful for all the actors, since it prevents problems before they happen, and therefore to better plan operational activities. Regarding the pain relievers and gain creators, the main commonality is the use of a single tool that manages the entire system, namely the platform, together with the optimization model. Instead, concerning customers, the analogies are linked to service quality level, reliability, efficiency, and optimization of freight flows. In fact, by optimizing the processes, adopting sustainable methods, and anticipating uncertainty it is possible to increase the market acceptance, so consumer satisfaction. Finally, the pains are related to the use of a single platform, as without it processes are more complex, resources lack availability, there is absence of communication, there higher waiting time and so higher costs.



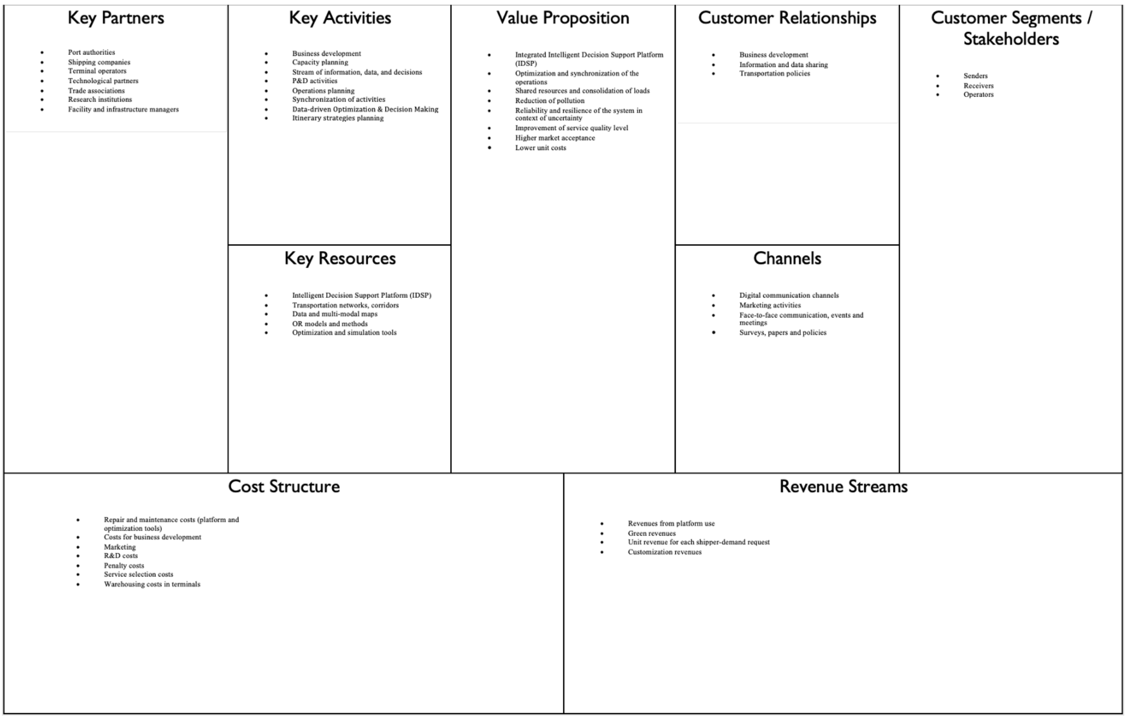
Value Proposition

Hence it is clear that the IDSP can increase efficiency and optimize the processes through the exchanges of information between all the parties involved. This allows firms and companies to enhance the service quality level of the products and services provided. It also reduces carbon emissions, it avoids traffic congestion and there is a better usage of infrastructures.

6.3 Business Model Canvas

Finally, we implement a feasible and innovative Business Model Canvas that synthesizes the information collected about the company during the first phase and it describes how the company creates and captures value. A solid business model gives a company a strong market acceptance, as it confers competitive edge.

The model consists of 9 blocks that show how the company wants to create value and generate profits.



Business model Canvas

We analyze these elements in turn, starting from the center, so the value proposition. The value that is created and captured is in terms of:

- Integrated Intelligent Decision Support Platform (IDSP): the single platform allows to optimize all the processes in the system, it enhances the exchanges of information, so it increases knowledge, and it satisfies the needs of all the participants. It represents the main feature of the project;
- Optimization and synchronization of the operations: the implementation of synchronization tools allows the switch between several transport modes reducing carbon emissions. Planning processes are optimized so it increases resources allocation, and it reduces empty running;
- Shared resources and consolidation of loads avoid capacity planning issues: a better resources allocation reduces empty running by maximizing load fill on trucks/vehicles. So, this avoids capacity planning as there are always available resources;
- Reduction of pollution: synchronization tools reduce carbon emissions as they avoid congestion of freight flows and they maximize the utilization of infrastructures.
- Reliability and resilience of the system in context of uncertainty: the platform generates huge volumes of information flows between stakeholders, and this leads to a solid knowledge, that is the key factor to improve forecasting processes. Also, the implementation of data-driven methods contrasts uncertainty. Synchro-modality also increases reliability and service levels;
- Improvement of service quality level: reliability and resilience are the inputs for a higher service level. The presence of innovative tools and methods allows companies to provide services with higher standards;
- Higher market acceptance: the knowledge of environment impact, a higher service quality level, less uncertainty makes the difference among customers;
- Lower unit cost: improved planning processes reduce deliveries costs, waiting time, operational costs and they minimize waste. Moreover, synchro-modality reduces costs for logistics operations.

The customers have been identified and defined in the first phase. The relationships between them are:

- Business development: continuous improvements and innovations make it easier for stakeholders to adopt the platform;
- Information and data sharing: there are exchanges of information between stakeholders, that are consolidated into data and shared to customers;
- Transportation policies: through policies it is possible to communicate the needs and requirements in order to satisfy the demand.

The strategic activities performed in order to create value and then to generate revenues are:

- Business development: a key factor to gain competitive advantage and a high market acceptance is improving and innovating its business strategies and models.
- Capacity planning: the allocation of resources is improved by implementing optimization tools;
- Stream of information, data and decisions: they increase knowledge and reduce uncertainty, so they enhance forecasting processes.
- P&D activities: Resources, routes, costs and time are optimized by the platform.
- Operations planning: the platform optimizes freight activities by sharing information and resources.
- Synchronization of activities: synchro-modality adds cost-effective solutions, as it reduces emissions and costs for logistics operations making the system more efficient;
- Data-driven Optimization & Decision Making: The single platform is the main re- source. It optimizes all operation processes and helps decision maker to make decisions that generates value in the long term;
- Itinerary strategies planning:monitoring the routes improves itinerary planning and avoids waiting times.

The satisfaction of customers is proved through revenue streams. Before defining how they can be generated, it is important to divide customers into two blocks: small ones and big ones. In fact, as there are customers that take the standard service so they pay only an entrance fee that may be discounted considering the operations. Instead, there big customers, as logistic service provider, that even if they generate huge flows, ask for several services. The most relevant is the customization. So, there is a fixed fee, as for the small ones, plus an annual fee. The revenue obtained from each shipper-demand request depends on the demand type. Moreover there are usage fees when the company grant to another one the use of the platform and the related tools. Finally there are incomes from implementing sustainable transportation modes and methods such as environmental resources and infrastructure, modal shift, energy management.

Instead, the strategic assets that allow a company to implement this kind of model are:

- Intelligent Decision Support Platform (IDSP): the main resource of the project. It plans and optimizes operations satisfying the needs of all stakeholders;
- Transportation networks, corridors: they are the essential network building blocks. The basic case models P&D activities by costs;
- Data and multi-modal maps: accurate and solid mapping make the result more efficient and optimal;

- OR models and methods: they support decision makers and develop solutions to gain efficiency and profitability;

- Optimization and simulation tools: modelling tools that supports decision makers minimizing costs and the resources spent and maximizing profits.

In the first phase we have defined the stakeholders involved, but there are other partners and suppliers essential to make the business model work:

- Port authorities: they guarantee an efficient usage of infrastructures available. Moreover, they offer users support by providing information about arrival and departure times of ships;

- Terminal operators:they are responsible of the safety and efficiency of transportation flows in the terminals;

- Technological partners: their core business is to ensure the maintenance, updating and innovation of technology tools. They also support users.

- Facility and infrastructure managers coordinate and manage the aspects of all the services within the building, such as maintenance, contracts, space, inspections, administration;

- Shipping companies deal with the transportation of their goods. They also offer innovative warehouse management; they coordinate inbound freights and provide outbound shipping. Strong collaboration is the key to provide logistical solutions;

- Research institutions work to enhance the system by developing new technologies, models, and methods. They can be universities and researchers;

- Trade associations are groups funded by businesses in a certain sector. They meet in community to share information, set laws, solve problems within the industry, maintain standards, provide tools for businesses.

The way the company interacts with stakeholders and customers, and it delivers its value, is through channels:

- Digital communication channels: they allow communication with all the parties involved. They are the main channel to spread information;

- Marketing activities: they make the solution available in the sector, promoting it for commercial implementation. In doing that, the platform could become a reference tool in the industry;

- Face-to-face communication, events, and meetings: the purpose is to increase understanding of needs, requirements, and improvements. It is an occasion to update the stakeholders involved;

- Surveys, papers, and policies: collection and sharing of data to gain interests and awareness. It also contributes to the literature.

Finally, the cost structure block identifies the costs that the company embraces to make the business model work. There are fixed cost to select and use the service of the offer, variable cost per unit of volume and of distance, P&D costs, marketing costs, repair and maintenance costs (platform and optimization tools, costs for business development and Warehousing costs in terminals.

6.4 Solution Canvas

The Solution Canvas outlines the solution developed. It reflects how the company may be by adopting the solution.

The decision maker in this context is the operator that uses the platform. Optimization tools, data, and OR methods support the operator into making decisions to make the system more efficient and to enhance P&D activities.

The users represent the customers of the system, they will gain benefits from the solution implemented. As we mentioned above, there three main categories of customers: senders, receivers, and operators. They continuously interact with each other to facilitate and make processes more efficient.

The operator makes several decisions to match demand and supply in order to satisfy all customers. The decisions are:

- Select shipper request
- Assign request to a specific service/vehicle
- Select carriers capacity offer
- Select the routes
- Select terminals and warehousing spaces

The constraints of the system are those ones from the mathematical formulation:

- All requests must be picked up from the initial locations
- Flow balance for all demands at each location
- Optimal route for each shipper-demand request
- All services must be selected individually or with bundles
- Capacity limit for each service leg
- Limitation to the quantity of shipments that can be managed at terminals
- Restriction to the number of shipments on the holding arc
- All the contract demands must be served
- Binary and non-negative requirements on the decision variables

The users and decision makers interact through the platform. They continuously share information and data to speed up activities. The relationship happens also through transport policies that allow customers and decision makers to operate in compliance with regulations.

The sources of information that led to this solution are:

- Intelligent Decision Support Platform (IDSP)
- Information about transportation networks, corridors
- Consumers experience
- Charatheristics carrier capacity offers
- Charatheristics of the shipments
- Charatheristics and conditions of vehicles
- Contracts

In our system the information can be known, or certain, and predicted, or uncertain. In both cases the information is stored until when all information is available to support decision making.

The channels through which our solution is implemented are supported by advanced technologies:

- GPS: its major feature is to tracking vehicles as it is possible to see which vehicle is in motion and towards which direction. The users are also enable to monitor vehicle speed and routes;
- 5G: the aim of 5G is to provide information to transport users, and to support transport operators with enhanced data in order to make real-time decisions;
- Artificial intelligent: This one includes all those solutions that use Artificial Intelligence algorithms for purposes related to the extraction of the information present in the data. The goals of companies that implement these kind of solutions are: Forecasting e Classification & Clustering;
- IoT: Internet of Things technologies are used in the M1M system to identify loads and vehicles, capture data and share it among actors;
- GIS: This technology allows the company to visualize transportation operations through zones and locations. It is applied in several areas, such as highway maintenance, traffic vehicles modeling, and route planning.

The goals to be achieved through the solution are:

- Optimize freight activities and flows
- Reduction of carbon emissions
- Efficient allocation of resources
- Reduction of operational costs
- Reliability and quality of the service

- Synchronization of activities
- Improved communication

These explicit objectives lead to efficiency and profitability benefits from sharing resources and an integrated IDSP. Moreover, they will enable the company to perform and operate at a higher level and to gain a competitive advantage in the freight transportation industry.

Finally, the costs block identifies the costs that the company embraces to implement (fixed cost to select and use the service of the offer, variable cost per unit of volume and of distance, human resources costs, costs for advanced technologies, costs for incentive mechanism), not implement (capacity costs and major vehicles costs, major penalties for delays and major unit and deliveries costs) and maintain the solution (repair and maintenance costs, costs for business development, marketing, R&D costs and utility costs).

Constraints

- All requests must be picked up from the initial locations
- Flow balance for all demands at each location
- Optimal route for each shipper-demand request
- All services must be selected individually or with bundles
- Capacity limit for each service leg
- Limitation to the quantity of shipments that can be managed at terminals
- Restriction to the number of shipments on the holding arc
- All the contract demands must be served
- Binary and non-negative requirements on the decision variables

Decisions

- Select shipper request
- Assign request to a specific service/vehicle
- Select carriers capacity offer
- Select the routes
- Select terminals and warehousing spaces

Information / Resources

- Intelligent Decision Support Platform (IDSP)
- Information about transportation networks, corridors
- Consumers experience
- Charatheristics carrier capacity offers
- Charatheristics of the shipments
- Charatheristics and conditions of vehicles
- Contracts

Decision makers

- Operators that use the IDSP platform

User/DMs relationship

- Information and data sharing
- Transportation policies

Solution channels

- GPS
- 5G
- Artificial intelligent
- IoT
- GIS

Users

- Senders
- Receivers
- Operators

Cost

Costs if the solution is implemented:
- Fixed cost to select and use the service (vehicles) of the offer
- Variable cost per unit of volume and of distance
- Human resources costs
- Costs for advanced technologies
- Costs for incentive mechanism

If the solution is not implemented:
- Capacity costs and major vehicles costs
- Major penalties for delays
- Major unit and deliveries costs

Maintenance / operating costs:
- Repair and maintenance costs (platform and optimization tools)
- Costs for business development
- Marketing
- R&D costs
- Utility costs

Objectives

- Optimize freight activities and flows
- Reduction of carbon emissions
- Efficient allocation of resources
- Reduction of operational costs
- Reliability and quality of the service
- Synchronization of activities
- Improved communication

Solution Canvas

6.5 Application

The analysis was carried out without the participation and direct involvement of Valeo Service Italia S.p.a. as it was taken as an example to build a case study. Data and information relating to Valeo Service Italia S.p.a. and used in this document are public as they are present on the AIDA public database (Bureau van Dijk database) [35] and on the Valeo website [36].

In this chapter we will apply the developed solution to a real company in order to evaluate the impact of our model. The areas affected by this solution will be identified and, by applying the model to different scenarios, we will identify its value added.

For our analysis we took into consideration the Valeo Service Italia S.p.a.

Valeo is a French multinational company active in the automotive industry and specialized in automotive components [36]. It is born in 1923 in a workshop in Saint-Ouen, just outside of Paris and it is specialized in components for the production of motor vehicles. Nowadays operates in more than thirty countries and partnering with several automakers worldwide. Italy has played a key role in the expansion of Valeo, which is now one of the largest automotive suppliers in the world. Valeo Italia has 4 main production plants located in as many regions, 2 R&D centres and 1 distribution platform for the Aftermarket. The country is a key location for both production and international research and development, including the production sites of Mondovì and Santena, in Piedmont. Valeo has different Business Groups, each structured in order to improve cooperation and growth for all the products. In particular, there are four principal fields of application:

- Driving Assistance Systems: with the aim of making user experience as innovative as possible, using perceptions systems and artificial intelligence;
- Powertrain Systems: which aims to clean as much as possible combustion engines;
- Thermal Systems: through which pollutant emissions from internal combustion engines are reduced and batteries for electric and hybrid vehicles are enhanced;
- Visibility Systems: getting better the lighting and washing systems brings to a safer and improved travel experience.

Moreover, considering that the automotive industry is passing through an important transformation, Valeo works with an eye on the future, indeed their strategy can be summed in this sentence: Accelerating today in tomorrow's key mobility markets [riferimento al sito]. Thanks to this strategy Valeo has become a leader in the four domains discussed before, being a great example of adaptability to changing time. Nevertheless, technological progress is strongly accompanied by the attention to environment, not just creating new eco-products, but also enhancing industrial processes making them as sustainable as possible. Besides this, Valeo is also a signatory of the "Business Ambition for 1.5°C" campaign, whose goal is to reach carbon neutrality by 2050.

Valeo company has a strong attention to its employees: its ethical code aims to improve the integrity between workers and workplace, as well as ensuring safety at work and business integrity.

Valeo has committed to achieving carbon neutrality by 2050 and will have already reached 45% of its target by 2030. Thus, considering these goals, we believe that our model can contribute to the achievement of these targets.

Below we will demonstrate in detail the areas impacted by our solution and any benefits it brings. Subsequently, through some assumptions and hypotheses, we will also demonstrate it numerically, in order to evaluate the effectiveness of our model.

The different impacted areas are the following:

1. Activities planning and allocation of resources:

   The Intelligent Decision Support Platform (IDSP) enables a continuous flow of information, data and resources leading to a best organization of the activities, by a controlled dispatch of the resources linked to an optimization of the time and the drop of cost needed to fulfill an operation. As consequence each actor profits from it. Fewer and fewer vehicles are circulating with a low charge, and as the traffic congestion is avoided and the track is well planned, the delivery costs are consequently minimized.

   This platform is meant to study the best track to specific logistic constraints, like the number of shipments, the addresses, the time needed for each delivery and the delivery modes, for example by choosing a groupage shipment. To guarantee such organization it is important to rely on a software of time-tracking. Its focus is the fragmentation of the activities by category, then to detail each class as precisely as possible in order to be able to attribute to different activities in a specific category a specific delay.

   Thereafter, the activities can be listed by the time span need so what the quickest could be accomplished at first.

   Moreover, it is a tool that simplifies the cooperation between two or more actors. In fact, its purpose is to analyze people at work, study the causes of dead times and preemptive and non-preemptive failures, and afterward to schedule more effective activities. Furthermore, this kind of implementation is not limited to the global view of the main activities, but it could be also used to report the workflow of each single worker, as well of the team and so to implement it.

   It would allow so:

   - the understanding of the employment of time
   - implement a technique of time management
   - analyze the outcome
   - to improve the most time-consuming operations, this result is mainly attended due to the interplay of innovative software.

The use of an advanced enterprise software ensures the company to identify the slowest activities, but also to segmentate them in smaller groups so that the unnecessary ones could be removed, and the repetitive ones, for which it is not fundamental an human intervention, to automate them (always keeping in mind that there are different levels of automation, going by a lack of automation with the solo human activity, to a cooperation between human and machinery, to higher level of automation represented by the robotic cell). As outcome the company finds itself to deal with a simpler and better supply chain, by putting in place actions to optimize the flow of resources in the warehouse, and to ease the communication with the suppliers.

2. Inventory management:

   As the number of managed SKU increases, it becomes essential to adopt specific software in order to ease the continuous flow of the storage, the main focus is to identify the most critical KPIs as to be able to set up the right procedures that would help to save time.

   All of this is part of the Supply Chain management, which is the interconnection of the flows that starts from the supplier to the consumer supported by an information system network. One of the main challenges is the inventory management, where it is important to ensure a sufficient stock to attend costumer's needs, but also not be in a condition of overstock. Beside the amount of stock, the flexibility and rapidity to reach and dispose the stock plays a key factor, because the product must respect specific restraint while being packed and delivered.

   Very often, as because of the cost, the difficulties and various challenges, many companies prefer to outsource the storage management to a third logistic part (3LP). In that way the main focus is moved from the warehouse to more corporate aspects, and of course, just a minimum part of the capital has been invested in the logistic field.

   Another solution is represented by the adoption of the Cross Docking, which a system that is conceived to directly deliver from the warehouse to the client, in that way it reduces the amount of stock in the storage, and thank to an innovative system of picking, it is possible to manipulate the order as less as possible saving time and reducing the prices.

   As the product as well as the market demand is different for each article, it is important to display the storage with an ABC analysis combined to stage of life of the product, by which the products with a higher demand are set closer to the access of the storage, so that it would quicker the picking, and the products with a lower demand are disposed far away. Plus, a combined and periodic marketing analysis would help to find the most requested products.

   The implementation of an advanced software, if possible, by being able to take track in real time of each product, is an efficient answer to all problems linked to a difference of stock and missing articles. The inventory is in fact easier to manage, and when combined to software which analyses the results in real time it would be possible to outsource crucial information and to be able to be more flexible.

   Another solution is the automatization of many processes. Not only the final cycle time would be reduced, but machineries and robots are usually more precise than actual workers, so the whole system would be more efficient as less defects are generated. In addition to that, when used in very difficult and dangerous operations, it can prevent the worker from accidents and work-related diseases, avoiding phenomena of absenteeism and medical fees.

Finally, even if our main goal is to minimize production waste, we could implement recycling processes for some discarded products in order to reuse them.

3. Administrative and legal management:

   There are fewer penalties to pay, as there are fewer delays, fewer shipping errors, and fewer production waste. This ensures that the contracts are respected, in fact the deadlines and contractual requirements are met, and the privacy of information is ensured thanks to the use of innovative technologies so as not to disperse sensitive data. Furthermore, a more efficient system is able to generate higher quality products and so to provide a higher service level; therefore, the request for liquidation of damages deriving from non-compliance with contractual requirements is lower. By this way the customer's expectations can be met.

   Even from an environmental point of view, there would be fewer penalties to pay as the regulations in force would be respected and implemented by integrating recycling processes, environmentally friendly vehicles and products, and by reducing traffic congestion.

   Finally, there would be a reduction in the bureaucracy of the corporate structure due to the fact that the business processes management becomes less articulated. The use of advanced software transforms formal obligations into activities with just a few clicks, ensuring that everything is done in compliance with the deadlines and procedures (or regulations).

4. Efficient communication:

   Thanks to the use of IoT technologies, it is possible to identify loads and vehicles, capture data and share them among all actors. Moreover, the flow of information is faster and safer, both between the actors involved and with suppliers and customers. In addition to the application of IoT technologies, there are other technologies illustrated in the model that would bring value added to the company, such as GPS, which allows vehicle tracking, or 5G, which provides transport users with real-time information for support them innto making decisions, or GIS, which allows the company to locate transport operations.

   In addition, the M1M system provides for continuous communication between all the actors involved; therefore, the lack of information is avoided, and so the margin of error is lower. Thanks to this transparency of information, it is possible to plan and manage activities and processes more quickly and efficiently.

5. Lower carbon emissions and greater sustainability:

   Current regulations are increasingly accelerating the transition to a sustainable value chain. Indeed, within a few years, attempts are being made to gradually move away from diesel-powered vehicles in some large European cities. Furthermore, consumers also pay more attention to environmental sustainability. In fact, they want products with a longer lifespan, and reusable, and they want electric vehicles, possibly with a longer battery life and lasting stability. Therefore it is necessary to find solutions to meet all these demands. This is possible in part thanks to our model, which aims to lower a company's emissions, through more sustainable processes and tools. First of all, thanks to the synchronization of the activity it is possible to use different modes of transport that pollute less, avoid road traffic, and optimize routes. Then, thanks to the platform that optimizes activities and processes in space and time, it is possible to better plan and allocate resources in order to avoid unnecessary waste of resources. In addition, thanks to the use of advanced technologies, the margin of error is lower, so there are fewer rejects. And, thanks to the use of recycling processes, it is possible to reuse otherwise discarded products.

Valeo Service has already been involved for years in this fight to reduce emissions [37], and has already achieved several goals. Therefore, thanks to the implementation of these solutions proposed by the model, it could increase the results in this field.

6. Technological efficiency:

   The implementation of advanced and innovative technologies such as GPS, 5G, Artifical Intelligent, Iot and GIS allow the tracking of goods and vehicles, allow for a more accurate demand forecasting,allow information to be shared between the parties interested faster and safer, and finally allow to recognize the risks. Thanks to enhanced technologies, it is possible to design innovative systems that allow the collection and sharing of information regarding goods along the entire supply chain. They allow also to implement a warehouse management software to monitor supply chain performance indicators and logistics and warehouse KPIs.

   Furthermore, according to the regulations in force, it is increasingly necessary to pay attention to the environmental impact of the vehicles along the entire value chain. Therefore, through technological advancements, it is possible to design and control eco-sustainable vehicles, which can alternate two types of fuel, which have a battery with a greater and more stable range, given also the strong interest in sustainability by final consumers.

   Therefore, if a portion of the budget were dedicated to the continuous research and improvement of these technologies, numerous benefits could be obtained.

Turning to the numerical application, we made the following assumptions.

1. Regarding the first point, 'Activities planning and allocation of resources', we can start from the following hypothesis, shown in the following table:

   According to what is hypothesized in the table above, it can actually be noted that in theory, as the number of resources (i.e. trucks and, consequently, vehicles used) increases, the number of deliveries made and the number of average kilometers traveled, can increase exponentially.

   We assume a maximum total of 10 hours a day as the Italian legislation requires [38]. This number may seem high, but in reality, it is not as most of the hours are

Vehicles	Drivers	Gross Monthly Cost	Fuel Price (assuming €1,20/l)	Medium Tank Capacity (liters)	Average kilometers with a full tank	Average Distance	Work Hours	Rest Hours
1	1	€ 3.000,00	840,00 €	700	800	500	10	12
10	10	€ 30.000,00	8.400,00 €	700	800	500	100	120
50	50	€ 150.000,00	42.000,00 €	700	800	500	500	600
100	100	€ 300.000,00	84.000,00 €	700	800	500	1000	1200
200	200	€ 600.000,00	168.000,00 €	700	800	500	2000	2400
500	500	€ 1.500.000,00	420.000,00 €	700	800	500	5000	6000
1000	1000	€ 3.000.000,00	840.000,00 €	700	800	500	10000	12000

Average Operating Costs

consumed during journeys, i.e. during the actual work of the truck driver. However, he does not always produce, as often the vehicle has to travel with a partial load, since, once a delivery has been made and the relevant load has been delivered, there is no new use of the empty space. Therefore, to analyze the average gross salary of a truck driver, which can be estimated at around 3000 euros [39], we can understand how, for example, the current waste of resources is very high. In fact, by using two truck drivers on a single vehicle, the average operating cost could be drastically lower, as it would be necessary to prepare only one truck, instead of two and they can take turns and share the load.

2. Concerning the 'Lower carbon emissions and greater sustainability' point, the model would also make it possible to reduce overall emissions, both because the number of wheeled vehicles in circulation would be reduced, and because the use of any vehicles involved would be improved. Moreover, it could also lead to rethink the entire logistics system thanks to synchromodality concept, going to evaluate a better implementation of transport on iron, i.e. rail, trying to use, where it is possible, trains, even of large dimensions (dimensions much larger than those ones of trucks that can circulate in Europe).

Anno	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Employees	101	93	88	84	85	79	83	79	78	75
Operating Profit (Aida database)	€ 72.892.632,00	€ 61.750.690,00	€ 61.750.690,00	€ 72.594.541,00	€ 76.240.771,00	€ 79.845.286,00	€ 76.629.211,00	€ 80.446.985,00	€ 79.336.742,00	€ 70.913.680,00
Employees working on activities related to transport	91	83	78	74	75	69	73	69	68	65
Kilometers driven per week by a single driver	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Kilometers driven per year by a single driver (we assume 48 work weeks)	96000	96000	96000	96000	96000	96000	96000	96000	96000	96000
Kilometers driven per year	7.776.000	7.008.000	6.528.000	6.144.000	6.240.000	5.664.000	6.048.000	5.664.000	5.568.000	5.280.000
Operating Costs per Kilometer	**€ 9,37**	**€ 8,81**	**€ 9,46**	**€ 11,82**	**€ 12,22**	**€ 14,10**	**€ 12,67**	**€ 14,20**	**€ 14,25**	**€ 13,43**

Operating Costs per Kilometer

Given the continuing need for wheeled vehicles, especially after the two-year period 2020-2021, it could also be considered how the resources currently used for the maintenance of such a structure are not always considered as assets, but can also be evaluated as sunk costs or as costs that could affect the company structure: for example, the current cost of fuel, even if considered for the specific sector (i.e. at a reduced price when refueling is carried out at the internal wholesaler) is an enormous element of economic deficit, since, as evidenced by the hypothetical assumption above, refueling is estimated at about one third of the monthly cost of an employee.

Given this difficult situation, it is easy to understand how three trucks in circulation at the same time cost the same as an employee. Therefore, it would make sense to reduce the number of vehicles in circulation, trying to better manage those that eventually remain, perhaps alternating two drivers for each vehicle and trying to optimize both delivery times (reducing, for example, the length of the route to go) and fuel expenditure.

Regarding this last point, the topic of bi-fuel vehicles could be introduced. This engine is capable to run two fuels. However, even if it is widely encouraged in the rest of the world, in Italy it is politically opposed. In practice, this arrangement would allow heavy vehicles to have greater autonomy (we consider that the average increase in autonomy would be about 200 km), with an increase in inefficiency (i.e. the load to be transported due to the additional tank), that tends not to be considered, as it is almost equal to 0. Therefore, from an environmental point of view, there are many different implications and possibilities for implementing the current business model, both in terms of practice and in terms of use of resources.

Now, we proceed to propose an equally brief analysis of the available economics taken from the Aida database, in order to explain how the average operating cost impacts on the company budget, both analytically and in a generic-absolute way.

Regarding the operating costs, we estimate them through the Operating Costs per Kilometer (OCK) [40].

$$\mathrm{OCK} = (\mathrm{FC} + \mathrm{VC})/\mathrm{TK} = ((\mathrm{v} + \mathrm{tx} + \mathrm{i} + \mathrm{p}) + (\mathrm{f} + \mathrm{t} + \mathrm{mr}))/\mathrm{TK}$$

- FC: total annual fixed costs;
- VC: total annual variable costs;
- TK: annual traveled kilometers.

- Purchase cost of vehicle (v): it refers to the cost of renting the vehicle, so it also includes depreciation. Usually the most used method is the straight-line method, based on the vehicle's life cycle;
- Vehicle taxes (tx): they refer to the taxes imposed on vehicles according to the regulations in force in Italy;
- Insurance (i): the price is calculated based on the vehicle capacity and also includes third party cargo insurance;
- Personnel costs (p): the total remuneration of the driver. It also includes taxes and contributions to be paid by the employees;
- Vehicle fuelling (f): costs related to the fuel supply of the vehicle;
- Tyres costs (t): there are several factors that influence the cost of tires, including the tire brand and size. Also, the more money that has been invested in researching and developing it, the more it will cost as it offers higher quality and they last longer over time;
- Maintenance and repair costs (mr): it is about vehicle maintenance expenses, and these maintenance activities can be temporal, preventative, or remedial.

Regarding the analytical level, it is necessary to purify the cost items in such a way as to obtain a hypothesis of operating cost, which remains so since there is no access to the detailed data of the financial statements. Given this basic assumption, an attempt was made to bring the cost items back to reasonable items as regards the operating cost. Concerning the number of employees, we used a statistical average assuming that every 100 employees, at least 10 are involved in activities other than those relating to actual transport. Therefore, going in chronological order from the most remote year to the most recent year, we can observe that the fluctuations in the number of employees also reflect fluctuations in the total number of kilometers traveled and then, fluctuations in the operating cost per kilometer.

However, these situations do not allow us to have full knowledge of the economic situation at an analytical level, as it was not possible for us to have access to the company's accounting records, T account and journal books, which would have allowed a correct definition of operating costs and an accurate evaluation of the kilometers traveled, without forcing ourselves to use a hypothesis based on absolute statistical data, which, of course, involve a certain error when compared as a universally valid general assumption adapted to a single specific case.

Therefore, after having highlighted the areas that will be improved thanks to the application of the model, after having made some assumptions and having also demonstrated them numerically, we can conclude this case study by stating that the model will certainly bring benefits to the company. In fact, not only there would be a significant reduction in operating, management and shipping costs, but the transparency of information brought about by the use of more innovative technologies, such as IoT, the implementation of an advanced platform that optimizes processes and activities and sharing the resources could make the company more efficient. Furthermore, the synchronization of transport modes, and the use of the most advanced technologies to adopt environmentally sustainable vehicles and products would certainly bring a sustainable benefit, which would allow Valeo Service to achieve its goals shown in Valeo's first climate report [37].

7 Results and Discussions

Although obviously it was not possible to apply all the complete solution, some results have been shown anyway.

From a methodological point of view, the application of the GUEST methodology to the M1M system has led to the development of a value-oriented business model. In this approach, in fact, much attention is paid to identifying the customer segment, and understanding their key needs, in order to support users in satisfying them. By doing so, the goals are achievable in less time and with fewer resources used, as they are able to respond to changes in demand in real time.

This method is ideal for the freight transport sector, in particular for the M1M system, as it assesses the needs of all stakeholder, the resources available and the requirements necessary to meet demand and gain competitive advantage in the market.

Furthermore, the use of the GUEST methodology has made possible to develop a flexible and innovative solution, that is able to adapt quickly to the rise of new technologies and capable of satisfying the demands of the market, which is becoming increasingly demand-driven.

Regarding the computational part, we applied the model developed to Valeo Service Italia S.p.a. We can summarize the results obtained as follows:

- Economic sustainability: as we have calculated above, also through the OCK formula, the solution involves lower operating, shipping and management costs, as there is a more efficient allocation of resources, more accurate demand forecasting and information transparency;
- Environmental sustainability: there is a significant reduction in carbon emissions as it allows for better allocation of resources, to reduce the circulation of empty vehicles and to use less polluting vehicles. Indeed, the value proposition of our model is to reduce the environmental impact of P&D activities by using sustainable vehicles and resources;
- Operational sustainability: through the implementation of an intelligent platform, green solutions, and the use of the most advanced technologies, employee productivity is optimized, leading them to seek continuous improvement. In this way, not only errors and waste are minimized, but, by using sustainable processes and solutions, concrete economic, environmental and social benefits are transmitted to both customers, suppliers and the whole community.

Therefore, this approach allows the company to gain a competitive advantage, and therefore to position itself at a higher market level.

8 Conclusions

In this paper, we studied from a managerial point of view the M1M system, developing a business model to support and perform the freight transportation activities. This tool enables decision makers to make efficient decisions, in order to obtain economical, social and environmental benefits. Indeed, a combination between optimization and business models must be guaranteed by the decision-makers to have a complete view of the industry in which they operate, and therefore, to effectively address the issues brought by the shift towards a demand driven approach, and by new technologies. In doing so, it is essential to consider the profiles of the multiple stakeholders involved, their costs and revenues structure.

However, as we stated above, this type of approach is not highly regarded among researchers. We contributed to fill this gap in the literature. In fact, differently from other similar projects, we combined operational aspects with a business approach. First, we proposed a full analysis of the network and of its mathematical formulation. Then, we applied the GUEST methodology to develop the Business Model and the related Solution Canvas, generating, so, a close-to-market solution. Finally, through an application, we adopted the developed solution, presenting its impact.

We understood the competitiveness of such a combination, illustrating strategies' potential profitability. Therefore, the results show that by combining qualitative and quantitative approaches, by integrating advanced technologies and green transportation solutions, it is possible to obtain a flexible transportation system, that deals with the increasing uncertainty generated by the increasing requests linked to the on-demand economy.

Despite these results, this paper presents a lack in the last step of GUEST methodology. In fact, we did not apply the TEST phase. Thus, it could be an interesting starting point for further research, as this step may be the input to generate ongoing improvements in the system, by making modifications to the original business model.

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