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Possible Impacts of C-ITS on Supply-Chain Logistics System

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Abstract

The purpose of this research is to introduce an analysis, which is qualitative and whenever possible quantitative, on how Cooperative Intelligent Transport Systems (C-ITS) can affect a Supply-Chain Logistics System by adopting a three-level approach. Considerations are made on the role and importance of Logistics within a company, its cost structure and the strategic relevance it assumes within the Supply-Chain, while considering its evolution from a Physical Distribution Management to a Supply-Chain Management. The increasing importance of logistics requires more sophisticated solutions to reduce or optimize its costs, as well as to find new opportunities to redesign the network configuration and the value-chain. These applications require a careful evaluation method in order to assess their effective adoption. The research is based on a literature review of the most relevant European Road ITS and C-ITS projects evaluation methods and benefits. The result of the investigation is an analysis that classifies the impact of C-ITS on the structure of the Supply-Chain according to different levels. Firstly, the paper reports the different impacts of a large-scale C-ITS deployment on the Logistics cost structure of a company and more in general, on the expected costs. After that, a second level of analysis deals with a possible redesign of the Distribution Network, oriented to the optimization of transportation costs over long distances. Finally, the third step of the analysis investigates a possible impact of C-ITS on the value-chain from several perspectives within the different roles of the subjects involved in the Supply Chain.

Keywords: Supply-Chain; Logistics Management; Cooperative Intelligent Transport Systems; Cost-Benefit Analysis; Truck Platooning

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1. Introduction

The Supply Chain (S.C.) can be defined as a network of facilities that produce raw materials, transform them into intermediate goods and then into final products, and deliver products to customers through a Distribution System. A S.C. is composed of different actors and sectors that are interconnected with each other: it involves a Purchasing & Supply area, aimed at searching and building a strong relationship with suppliers; the Operations Management area, devoted to the development and manufacture of the final product; the Marketing area, oriented at selling and promoting the products on the market; the Logistics & Transportation, whose role is to punctually and accurately deliver the final products to the final customers. The Supply Chain Management consists in the integration of all the different members, infrastructures and resources, processes and activities, including their relations, in order to create value for every company belonging to the network.

"Logistics Management is that part of S.C. Management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements." (Council of Supply Chain Management Professional, 2009).

Thanks to the market and technology evolution over time, Logistics has continuously changed its role for the last decades. Currently, the increasing need of integration between inbound and outbound activities transformed the meaning of Logistics from the basic Physical Distribution Management to the Integrated Logistics and finally to the Supply Chain Management (Ballou, 2013).

1.1. Aim of the research

Nowadays the Supply Chain (S.C.) must face the growing issue of Globalization. According to Dornier's Four Forces model, four main driving forces and measuring factors are involved in globalization: Global Market forces, Global Cost forces, Political & Macroeconomic forces, Technology forces. Considering the last one in particular, a contribution to the Technological forces comes from advances in Transportation and Communication: Transportation costs have drastically declined by historic standards with a compound average growth rate between 3.4 and 6.7 (Baldwin, 1999; Abele, Meyer et al., 2008), and lost importance as a barrier to Globalization.

However, by analyzing Logistics costs it is possible to highlight the major impact of Transportation in terms of relative weight:

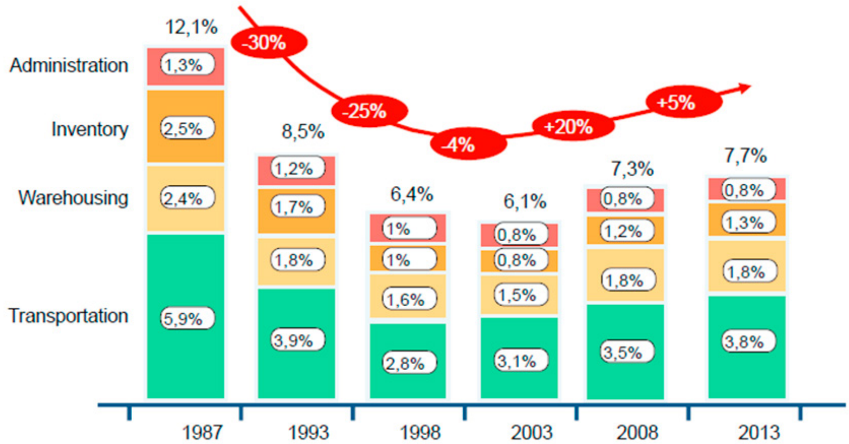

Fig. 1. Evolution of Logistics costs (European Logistics Study 2008-2009, ELA – AT Kearny)

In 2014, 72% of goods travelled across EU28 by road. Therefore, roads represent almost ¾ of the total volume transported (ANFIA, 2017). Road transportation can benefit of big subsidies, but also has a negative impact on the environment and the quality of life of the citizens of the European Union, since it is responsible of around 1/3 of the energetic consumption and of the total CO2 emissions within the EU. In this perspective, both promoting efficient and sustainable transport modes and adopting smart devices and technologies like ITS could reduce the Europe dependency on oil imports, air pollution, costs related to road congestion as well as the number of victims involved in road accidents. The aim of the research is to investigate a way to optimize Road Transportation cost structure by analyzing the impact generated by the implementation of Cooperative Intelligent Transport Systems (C-ITS). These represent one of the emerging and most promising branch in the field of Road ITS, advanced applications which aim at providing innovative services relating to different modes of transport and traffic management, and enable users to be better informed and make a safer and more coordinated use of transport networks (Lu, 2016).

The scope of the study is also to understand how C-ITS can affect the S.C. Logistics channel within its two main components: the Distribution Network and the Transportation Systems. The final goal is to redesign the Logistics network by increasingly adopting C-ITS, and by discussing the individual roles that actors belonging to the Logistics value chain are currently covering.

2. Methodological aspects

The Total Landed Cost Model is an effective framework to model the proper cost structure of a single company belonging to the Supply-Chain. Within this framework, a first step of the research analyzes the cost structure of Road Transportation, as it is one of the most significant items of the Operating Costs of a company.

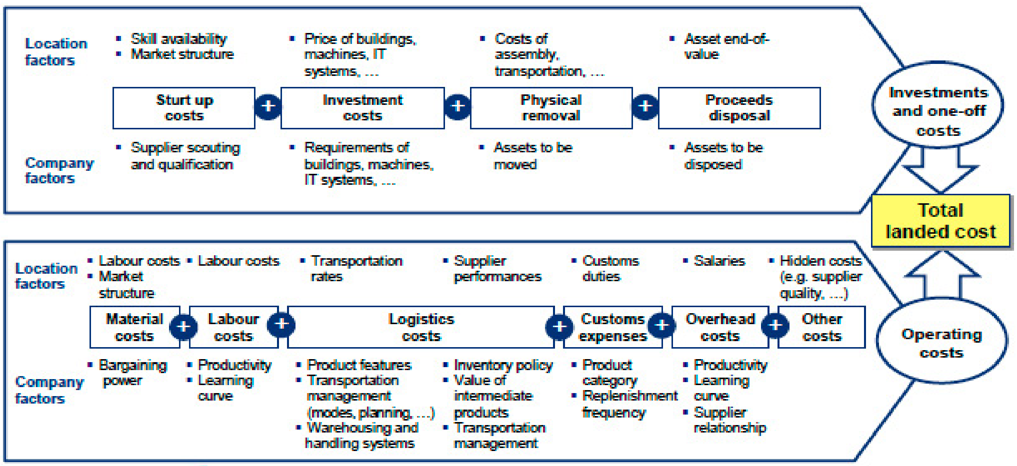

Fig. 2. Total Landed Cost Model (Melacini, Total Landed Cost Model, 2016)

The analysis is based on a study conducted by the "Albo Nazionale Autotrasportatori, 2006", considering a 5-axle truck with a permissible total weight ranging from 38 to 44 tons, performing three different ranges of km/year, and encompasses the following cost items: Purchase (Amortization), Insurance, Ownership tax, Maintenance and Repair, Tires, Fuel, Driver and Tolls.

Table 1: Road Transportation Cost Structure (based on a model processed by the Albo Nazionale Autotrasportatori, 2006)

Cost items	Annual cost (€/year) 75.000 km/year	Annual cost (€/year) 100.000 km/year	Annual cost (€/year) 150.000 km/year
Amortization	19.633,14	26.177,17	39.266,25
Insurance	8.152,00	8.152,00	8.152,00
Ownership tax	718	718	718
Tires	8.844,00	12.160,50	18.793,50
Fuel	22.918,50	30.558,00	45.837,00
Maintenance and Repair	5.026,20	8.426,98	10.112,37
Tolls	5.480,00	10.275,00	13.700,00
Driver	49.380,07	49.380,07	49.380,07
Total annual costs (€/year)	**120.181,91**	**145.848,06**	**185.959,19**
Costs per km (€/km)	**1,6**	**1,46**	**1,24**

As shown by the result of the comparison, if the number of km/year (150,000 instead of 75,000) is doubled, a saving in the cost per km equal to 22% will be recorded. Most importantly, the longer is the distance travelled, and the lower transportation costs will be, thus increasing efficiency together with the utilization of trucks. Moreover, it is possible to evaluate the incidence of the different cost drivers and to classify them into Fixed, Semi fixed and Variable.

According to the literature review considered, specific solutions can affect the annual travel distance per truck and more in general the efficiency of truck management. Examples are the adoption of Intelligent Transport Systems, such as the dynamic traffic rerouting, as well as other innovations like, for instance, the Triangulation and Continuous Movement (Ballou, 2003). A relevant innovative solution that could enhance the efficiency of long-distance routes is Truck Platooning. Especially when platoons have to be formed on the fly, the platooning solution becomes more convenient as the kilometers in formation increase. This happens because, while in platoon formation, trucks are able to drive with strongly reduced headways between them, which in its turn means reduced aerodynamic drags and increased fuel savings (Brizzolara D., Toth A., 2016).

The European Community has co-financed ITS projects in the road sector since 2001. The Directive 2010/40/EU of July 2010, promoted the diffusion of Intelligent Transport Systems within the road transport sector and by other transport modes. ITS projects (in chronological order TEMPO, EASYWAY and European ITS Platform - EIP) aim at enhancing the use of the road capacity, improving road safety and mitigating environmental damages. These objectives are supported by the joint effort of different stakeholders such as National Ministers, Road Authorities, Road Operators and partners from the public and private sector. Starting from TEMPO, this effort focused on the collection and processing of the results of evaluation studies to allow a comparison between the different projects implemented in different areas. The evaluation of the projects shows the benefits of the single implementations as well as of ITS implementations as a whole. The method followed within the context of European Union is the Cost Benefit Analysis – CBA. In 2014 the European Community C-ITS Platform was established to support a common vision across all the stakeholders involved in the value chain facing the potentiality of C-ITS. It provided a CBA based on the most promising C-ITS scenarios and on the impacts and outputs generated by their implementation (Miller, Biedka, 2015). Afterwards, the C-ROADS Platform was implemented to develop harmonized specifications, taking EU C-ITS Platform recommendations into account and linking all C-ITS deployments into several European and international C-ITS projects.

Moreover, another relevant European project that is directly focused on both C-ITS and Truck Platooning is CO-GISTICS. Within this project different C-ITS are planned to be deployed and exploited by trucks: Intelligent Truck Parking and Delivery Areas Management, Cargo Transport Optimization, CO2 Footprint Monitoring and Estimation, Priority and Speed Advice and Eco-Drive Support (Barradas P. 2017). CITRUS is another project focused on the exploitation of Day 1 C-ITS for freight transport, aimed at obtaining both an improved safety and a decrease in carbon emissions. Its implemented services are Traffic Jam Ahead, Stationary vehicle ahead warning and Road Works Warning (for improved safety) and Truck-aware traffic signal regulation, Real-Time logistics-specific traffic information and Intelligent dispatching (for a decrease in carbon emissions) (https://www.citrus-project.eu/).

The investigation carried out within this study collects methodologies and results coming from the implementation of the CBA for projects evaluation (Sartori, Catalano, 2014). It was, also refined with the contribution of the European project EIP + (Marsili, 2015), in particular regarding the adoption of common Evaluation KPIs (Cullem, Marsili, 2015), and of the UK Department for Transport approach (UK DfT, 2013), with the concept of the Appraisal Summary Table that stresses the need to group all monetized, quantified and qualified impacts into a unique scheme and from the C-ITS platform CBA (Miller, Biedka, 2015).

The final output is a classification of C-ITS into homogenous groups representing the basis for the definition of commonly agreed additive deployment scenarios, for which economic, social and environmental impacts can be defined. The starting point of the analysis is a list of technologically mature and highly-beneficial C-ITS services, provided by the C-ITS Platform and defined as the Day 1 C-ITS Services list (COM(2016) 766). Starting from the first unit of the analysis, i.e. the assessment of C-ITS impacts in a single company, it is possible to depict a qualitative effect of Day 1 C-ITS Services on the operating costs of the company. Afterwards, the CBA provided by the European C-ITS Platform is a useful tool to estimate costs and benefits coming from the implementation of C-ITS services over a defined time horizon, as it can be adjusted to the specific sector of Freight transportation. Finally, considering the dimension of the entire Logistics Channel, the reference model adopted reflects the Hub-and-Spoke distribution channel, compared to the Point-to-Point network that is typically adopted.

3. Originality of topics

2030 was chosen as a reasonable and compliant time horizon to consider long time effects. The Supply Chain Logistics System will be strongly affected by these new technologies: the main contribution will be provided by Cooperative Vehicle-to-Vehicle (CV2V) and Vehicle-to-Infrastructure (CV2I) communication and by Platooning (Nowak, 2016). Later, and as a future evolution of the concept of Platooning, Autonomous Driving will be implemented. The first tests of this technology are currently in the embryonic stage, nevertheless some experimentations are carried out around the globe, e.g. in Singapore (aimed at reducing the need for truck drivers by 75% - Ministry of Transport of Singapore and PSA the world's port of call 2017)).

Focusing on the economic issues, it is fundamental to estimate the costs of the implementation of C-ITS devices. Considering first the adoption of Day 1 Services (Miller, Biedka, 2015), at European level the total additional costs with respect to the actual situation will be around €3.2 billion in 2023, mainly caused by the introduction of new vehicles on the market. A unit cost of 300 €/truck for the implementation of C-ITS devices on a single truck is assumed.

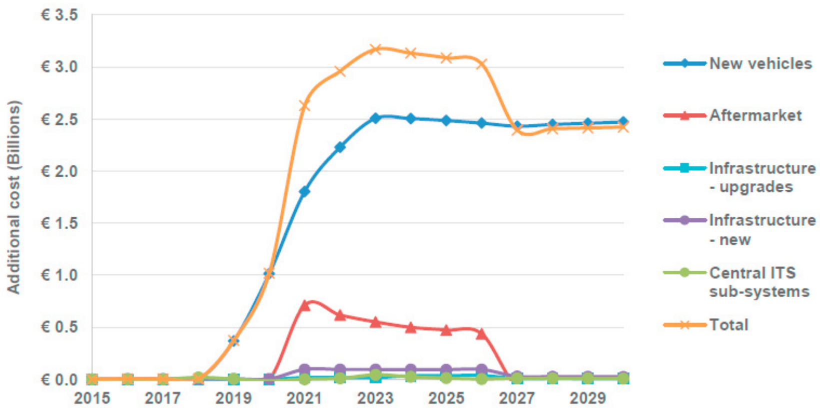

Fig. 3. Total additional annual equipment costs (Asselin-Miller, Biedka, 2015)

Given this required additional investment, a great contribution in truck optimization is expected, possibly according to several factors. First, CV2I communication allows trucks to be in constant contact with their surroundings by means of GPS signals and digital links between trucks and roads and devices, in order to enhance traffic flows, automated routing and also parking efficiency. Secondly, CV2V communication could effectively affect safety issues by reducing accident rates: if trucks are able to communicate with other vehicles on the road, sharing data about position, speed and direction, accident rates, fatalities and injuries will decrease.

In the field of CV2V communication, Platooning is increasingly used. It consists of tight convoys of trucks travelling on highways strictly linked between each other in constant communication via digital links and at a shorter safety distance than the current one. A large number of tests and demonstrations conducted at European level, requiring a collaboration among different Original Equipment Manufacturers (OEM), demonstrated an actual reduction of fuel consumption with reference to a 3-truck platoon with an average value of around 7%: a lower value of around 4% is reached by the leader truck, progressively increasing in the followers, with an 11% of fuel reduction (European Platooning Challenge, 2016; Daimler, 2016). Besides a reduced fuel consumption, other benefits can arise from the Truck Platooning solution. Let's see for example two other value cases reported in (L.A. Tavasszy, R. Janssen, 2017): maritime container positioning and truck/driver productivity. The authors in (L.A. Tavasszy, R. Janssen, 2017) used plausible ranges of values to obtain a magnitude of the arising benefits for both these value cases: a range of 100 ÷ 800 million Euro/year with a market penetration of 10 ÷ 20% for maritime container positioning and an average of 8.8 billion Euros per year with a workload reduced by 50% for the drivers of the following vehicles. Moreover, a specific bundle of the Day 1.5 services is focused on zone management (loading zone management and zone access control management) and is potentially able to add value to the Supply Chain (N. Asselin-Miller et al. 2016). The reduced transport cost, which is achievable through Truck Platooning, can foster a modal shift from other traditional solutions such as the rail or the inland waterways ones to the road one. This potential modal shift in (Bakermans, 2016) is estimated to range between around 2 and 20 %, depending on the kind of freight transport considered (e.g. ores, chemical products, oils etc.), for different levels of automation and market penetration.

The transitions of trucks from traditional to digitally connected vehicles can also affect the efficiency of sea port locations, as shown in an increasing share of literature focusing on ICT applications in the last years (Mondragon et al. 2011, Sonntag et al. 2012). In (Mondragon et al. 2011) the role of ITS solutions in achieving paperless information flows is analyzed through the application of DSRC as a background infrastructure to exchange data. The resulting benefit is an enhanced mapping both of trucks inside sea port locations and of the flow of materials, especially of bulk ones. In (Sonntag et al. 2012), the application of ICT solutions on the subject of container transport in the hinterland of seaport container terminals is studied. Again, an increased digitalization of trucks thanks to Truck Platooning can have a positive effect. Different ICT tools are mentioned: Inbound and Outbound processes at transshipment terminal, Truck pre- and post-haulage, Settlement and location and Asset management terminal organization. Moreover, the Berlin-Brandenburg case is presented and the following impacts were hypothesized in said paper: an increase in efficiency and capacity by 10% and a reduction of the asset-costs in the work and order planning.

Furthermore, another important aspect related to Platooning is the possibility to create new opportunities of collaboration between companies' competitors, sharing information between each other to save money and to improve their performances and competitiveness on the market. Technology also offers the opportunity to adopt a vehicle maintenance schedule by applying remote diagnostics. In case of unexpected problems, if a truck continuously monitors its maintenance status, it will be able to notify any possible anomaly to the fleet manager and, in real time, to the repair shop, which can in its turn be prepared, or schedule a just-in-time spare part order or a replacement vehicle. This approach can extend truck service life with a reasonable rate of an additional 5% and also reduce maintenance costs (Nowak, 2016). The integration in logistics systems of real time data coming from trucks connectivity allows automated coordination processes to be applied within all the Supply Chain, introducing the concept of Integrated Digital Supply Chain, changing the negotiated rate and adjusting the following logistics process chain with new time schedules and alternative options.

4. Results

The first unit of the analysis of the impact of C-ITS on a single company within the Supply-Chain can start by providing a qualitative impact of Day 1 C-ITS services on the Operating costs of the single company. In fact, the road Transportation cost structure is expected to be affected by the introduction of different kinds of C-ITS applications.

	Cost items		Emergency Brake Light	Emergency Vehicle approaching	Weather conditions	Road Works Warning	Slow or Stationary Vehicle	Other hazardous location notification	Traffic jam ahead warning	In-vehicle signage	In-vehicle speed limits	Probe vehicle data	Shockwave damping
			List of Day-1 Services										
Total Landed Costs	Production costs	Material costs											
		Direct labour costs											
		Indirect labour costs											
		Machine costs											
	Inventory costs					X			X				X
	Transport costs		X	X		X			X	X			X
	Logistics facilities costs												
	Duties and taxes												
Logistics costs	Administration												
	Inventories					X			X				X
	Warehousing												
	Transportation		X	X		X			X				X
Road Transportation cost structure	Amortization	17,95%											
	Insurance	5,59%			X	X	X	X	X				
	Ownership tax	0,49%											
	Tyres	8,34%	X	X									
	Fuel	20,94%									X	X	
	Maintenance and repair	5,78%	X	X	X	X	X	X	X			X	X
	Tolls	7,05%							X	X		X	X
	Driver	33,86%				X			X	X	X		X

Fig. 4. Possible impacts of different kind of Day 1 C-ITS services on Supply-Chain costs

Taking as a reference the modeling supposing 100,000 km/year, it is possible to state how Amortization, Insurance and Ownership tax, representing the Fixed costs, will not be affected by C-ITS applications. They represent 24% of the cost structure. Instead, importance benefits will come from an overall reduction (estimated around of 5%) of the costs related to Maintenance and Repair for an estimated value of around 420 €/year, as well as from saving on Fuel costs. With Tires and Tolls, they represent the Variable costs and 42% of the cost structure. Insurance costs, which are not at first affected, could then be renegotiated favouring an overall reduction of the risks of fatalities. The role of the driver can also change.

The Driver cost represents 34% of the cost structure and a semi-variable cost item. It can be affected by the implementation of C-ITS applications, considering that the time that was previously taken by the truck driving or handling activities inside the warehouse, can be now re-thought: as the usual driving tasks are simplified by the adoption of C-ITS technologies, some easy administrative functions may also be added, thus streamlining office roles and saving costs. Considering the Total Landed Cost Model, the possibility to re-allocate the Driver's tasks also makes C-ITS affect other operating costs: in the Overhead costs, the cost items related to Salaries can be reduced within the overall period assessment by an estimated value of 10%.

Based on the simulation conducted by Miller and Biedka in the C-ITS CBA in 2015, which was adjusted by considering the only reference framework of freight transportation, it is possible to assess a quantitative costs estimation of C-ITS implementation within 2030:

C-ITS Economic Impact		
Costs		
Main cost item	Specification	Monetary estimation
In-vehicle sub systems (connecting new vehicles)	71,8% of the peaking costs in 2025	1,6 billion €/year * 8 years
Aftermarket devices (personal ITS applications)	22,8% of cumulative costs in 2030	450 million €/year * 4 years
Infrastructure costs		95 million €/year * 6 years
Central ITS sub-systems		47 million €/year * 6 years
	Total	15,45 billion €/assessment period

Fig. 5. C-ITS cost items and estimation until 2030

Adopting the same approach, it is also possible to provide a C-ITS benefits estimation, with the most important benefits expected within the time horizon of 2030 in terms of travel time, accidents and fuel consumption reduction.

C-ITS Economic Impact		
Benefits		
Main Benefit reference	**C-ITS service Benefit's provider**	**Specification**
Time related impacts	Bundle 3: Intersection-related services	Reduction of 2 billion/hours year (3% of total spent time)
	Bundle 4: Parking information	
	Bundle 5: Traffic information / Smart routing	
Accidents reduction	Hazardous location warning	5% of accident reduction number
	In-vehicle speed limits	
	Intersection safety	
Fatalities and injuries reduction	Hazardous location warning	Reduction of 500 fatalities/year by 2030 (- 7% of fatalities)
	In-vehicle speed limits	Reduction of 14000 injuries/year by 2030 (- 7% of serious injuries)
	Intersection safety	Reduction of 46500 injuries/year by 2030 (- 7% of minor injuries)
Material damages reduction	Hazardous location warning	Reduction of 46000/year by 2030 (- 7%)
	In-vehicle speed limits	
	Intersection safety	
Fuel consumption reduction	Green light optimal speed advisory	2400 toe/year by 2030 (-1,2%)
CO_2 emissions reduction	Smart routing and Parking information	7500 t/year by 2030 (-1,2%)
Other emissions reduction	Smart routing and Parking information	0,5% yearly reduction
Impact on job creation		Additional 25.000 jobs (2030)
Impact on GDP		Increase of 0.01% yearly (2030)
Fuel duty reduction		1% reduction (2030)
Impact on modal shift		Time related benefits (+% 0,16 for road veh.)
Impact on job quality		Better comfort, travel time reduction, higher safety and revenues
Impact on SMEs		Risks/opportunities coming from the speed to enter the C-ITS market
Equipment providers and OEMs		The development of new services can potentially open new business models with new source of value for stakeholders
Vehicle operators and owners		Limited range of individual benefits that limits their willingness to pay extra for C-ITS services. Need to find new sources in order to encourage them

Fig. 6. C-ITS Benefits and estimation until 2030

Besides the aforementioned benefits, other valuable estimations concern the impacts, referring to (Asselin-Miller et al. 2016). For the Hazardous location notification service, the results given by the eSafety forum identify a speed improvement ranging between 2 and 10%, while the SmartRouting service can enhance traffic speed by 8% and reduce fuel consumption between 1 and 10%. The In Vehicle Speed Limits can foster a congestion reduction ranging between 2 and 10% (eSafety Forum) and an increase in speed on motorways ranging between 0.6 and 1.1 % (eIMPACT). The service Loading zone management can foster fuel savings by 0.79% for heavy vehicles on urban roads while, by the results of the Freilot project, it appears that the Traffic Signal Priority Request for heavy vehicles service can reduce their fuel consumption by 20%.

The CO-GISTICS Pilots (CO-GISTICS Project, 2017) provide some interesting results about emissions and fuel savings that are explicitly related to the freight transportation. Tthe Eco-Drive support service (composed of a Low Carbon Mobility Management app and a Green Light Optimal Speed Advisory) allows fuel savings ranging between 5 and 16% on urban roads. The Cargo Transport Optimization service is aimed at optimizing the processes within a port via information exchange, with a strong decrease in the average waiting time at the entrance of the ports (from 1740 s to 960 s in the Trieste pilot), also reducing the queue length at gates from 29 to 16 trucks.

Moving on the second level of analysis and considering the dimension of the entire Distribution Network, the implementation of C-ITS services can lead to a redefinition of the S.C. Distribution Network: the impact of C-ITS solutions developed into the context of TEN-T corridors will be reflected into a more established Hub-And-Spoke Network, which is currently not fully exploited, except for the case of the Business to Consumers e-Commerce or some rare examples from international freight forwarders. Long-haul hub-to-hub trips would be optimized by Platooning, with data-driven trucks routings and freight-matching between centers, thus allowing tangible transportation benefits as well as a reduction in warehousing time and costs within the entire Supply-Chain. A strong synergy with the Truck Platooning technology could arise especially for medium-high levels of market penetration, thus allowing the platoon formation through an on-the-fly solution that bypasses the development of a dedicated Platooning Service Provider (Mauro et al., 2017).

Fig. 7. Hub&Spoke network compared to Point-to-point network

The Hub-And-Spoke (H&S) Network, compared to the traditional Point-to-Point (P2P) network and given the same number of nodes to connect (n), clearly distinguishes itself by the lower required number of links connecting different nodes:

$$H\&S = (n-1) \text{ links compared to } P2P = \frac{n*(n-1)}{2} \tag{1}$$

This allows the optimization of transportation costs along the reduced number of links, by enhancing Primary Transportation costs along the routes between different hubs, according to the following function:

$$FTLC = f(F_{km*t}; d_{hub \to hub}; SZ; SH) \tag{2}$$

Where FTLC is the Full Truck Load Transportation costs, F represents the Fare depending on kilometers and time, d represents the distance to cover between two different Hubs, SZ represents the shipments size within the single truck and SH the number of shipments. A stronger role of Logistics operators and freight forwarders is therefore reasonable as they focus on these technologies as their core business. Moreover, the continuous flow of information will reduce the total amount of stocks needed within the S.C., as well as inventory carrying costs affecting the Inventory policy of the Logistics of the Total Landed Cost Model, and allowing for a just-in-time delivery planning along the entire S.C. Considering last-mile deliveries, they will be operated by smaller and eventually hybrid vehicles that, travelling in a context of smart cities or suburbs and exploiting CV2I communication, can benefit from more intelligent routings that decrease traffic and facilitate delivery processes. According to this perspective, the Distribution Network redefinition will also lead to a reduction of the externalities linked to the current concept of mobility and links within a Distribution Network: a lower fuel consumption implies lower emissions in the environment, together with a reduction in the number of circulating vehicles, possibly thanks to their smarter utilization.

5. Final Remarks

The aim of this study was to assess the impact of C-ITS services and new technologies on the Supply-Chain logistics. The results show that, even if the subject is constantly changing and developing, some numerical evaluations can be drawn. First, clustering the C-ITS on the basis of the benefits for Supply-Chain logistics, Travel time appears to be the main source of benefit, in particular for the freight transport system. In the future, research may focus on the estimation of the Travel time value for the various types of freight transport (e.g. On time delivery based, schedule based, etc.) and on the impact of the C-ITS services on each one of them. As a general magnitude of the economic benefits arising from the Travel time estimation, the mean value of 21.44 \$/h (Zamparini, Reggiani, 2007) for the travel time savings is used as follows:

$$Economic\ benefit_{Travel\ time} = 21{,}44\,\frac{\$}{\mathrm{h}} * 2\ billion\,\frac{h}{year} = 42{,}88\ billion\,\frac{€}{\mathrm{year}} \tag{3}$$

Safety benefits can also be projected to assess the economic benefits deriving from a reduction both of injuries and deaths, and of material damages (the weight of which is strongly related to the shipment). This study aims at providing all the stakeholders involved in the supply chain with a literature basis to evaluate the effect that C-ITS services can have on their organization. The second contribution of this paper is related to the particular V2V solution that is Truck Platooning (which is going to be implemented in the same time horizon as C-ITS Day 1 services). As stated above, Truck Platooning can impact similar areas, such as Travel time, fuel consumption and safety, thus actually creating a synergy with C-ITS services to transform Supply Chain logistics, from storage to sea port activities. Again, rather than a quantitative estimation, the aim of the work is to show its possible application to provide the involved stakeholders with all the tools needed for the evaluation and the design of a targeted cost-benefit analysis.

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