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TOWARDS A CONNECTED, EFFICIENT AND SUSTAINABLE SUPPLY CHAIN INTEGRATING THE RISK FACTOR

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Abstract- The current economic context requires companies in different sectors to thoroughly study their strategies before implementing them. Modelling the supply chain is among the first decisions to be taken in an industrial context. An optimized industrial supply chain will achieve the desired performance, then, if necessary, improvements and adjustments can be made from time to time. An analysis and review of available studies on flow connectivity in industrial chains show that this topic has often been approached from different points of view and considering different constraints, and has therefore taken a variety of senses. This makes us wonder, what is connectivity and what are its aspects in the industrial context. The literature mentions some work dealing with modelling the connectivity of industrial supply chains, in order to achieve a predefined objective. However, little work focuses on the analysis of connectivity and modelling of the global supply chain, taking into account all aspects of an industrial chain. Based on a literature review, this paper intended to complement existing studies by analyzing connectivity from a cost perspective (cost savings) quality perspective (increasing performance) or lead time perspective (decreasing lead time). The result of our study, will help interested parties to better model an industrial chain by taking into account existing constraints and challenges as well as to orient future research in this domain.

Keywords: Connectivity, Modelling, Supply Chain, Industry.

1. INTRODUCTION

At the beginning of the industrial revolution, companies were mainly interested in increasing their production in order to be able to meet the needs of their population. Today, with globalization, competitiveness and variety of customer's requirements, mass production is no longer the only guide to achieving performance. Customer satisfaction is nowadays at the crux of a company's interests because it's the key of efficient management. A satisfied customer will certainly renew his orders and therefore more business for the company. It is true that performance targets for external stakeholders must be met, but not at the expense of the company's internal interests. It is necessary to find the means to succeed and to be efficient while guaranteeing the gains and profits of the company to ensure its continuity.

Manufacturers currently orient themselves to collaborate in order to be able to respond to the customer demands respecting the requested cost, quality and lead time. In this sense, the configuration of a supply chain is a crucial strategic decision, it concerns the choice of partners, the location of production sites, the modes of management of physical and IT flows, the modes of transport between factories ... etc. [1, 2].

These parameters differ from one sector to another depending on the constraints imposed by the market. The newspaper industry is characterized by a production and delivery limited in time with no inventory system because it needs to follow the current news to be shared [3]. Regarding the agri-food sector, food storage and safety constraints as well as the volatility of raw material prices are to be taken into account. The telecom and automotive industry, as for them, are characterized by a large number of customers spread over different countries and continents: different cultures, different purchasing powers of different centers of interest, all this needs to be considered [4, 5]. Adding to the above the political and governmental constraints of each country.

A study of previously existing research dealing with the topic of supply chain modelling shows that there are a variety of definitions of connectivity and that it can be approached from different perspectives. Through our paper, we aim to see all studied aspects of industrial chain connectivity from a quality perspective, a cost perspective or a lead time perspective as well as political perspective. The outcome of our paper is to help decision makers better model their chain and guide future research in this topic.

This paper is organized as follows: section 2 presents the different meaning of connectivity found in the literature it presents also the results of our review; section 3 lays out an analysis and critique of the results of our review; and section 4 presents a conclusion and perspectives of our research.

2. BIBLIOGRAPHIC STUDY

The study of the connectivity of flows in the industrial sector has begun for a while, since the companies have

seen the interest of optimizations of flows and its impact on the performance. A literature review was conducted on electronic-library studies dealing with connectivity in the industrial sector; a variety of definitions were found: Physical, IT and financial flows along the supply chain are all factors that define connectivity in industrial chains [6].

A supply chain is a network of business units linked together to supply products to consumers. To be more effective and efficient, all actors must be integrated and connected to foster collaboration [7, 8].

The industrial revolution is the result of innovations and technological improvements that have taken place. This is clearly perceived by industrial development, we are now talking about industry 4.0: the 4th industrial revolution characterized by the integration of new techniques in order to organize the production process, where digital and robotic innovation forms the basis. The goal through these technologies is to increase the efficiency and effectiveness of industrial processes, less human intervention and thus increase productivity while reducing costs and energy consumption.

Among the technologies widely used in the industry is the Internet of Things, it is a technology that has swept all economic sectors: industry, health, transport ...it allows a more precise exchange of information at the right time.

The logistics and supply chain sector has not been excluded from this revolution, as a result of competitiveness, the use of new technologies has become paramount. In this case, the impact is clearly perceived through the sharing of the necessary information concerning the goods in both upstream and downstream flows. The coordination of these technologies applies not only in the plant, but also between plants, we speak of logistics 4.0.

A connected supply chain gives rise to a transparent network. This transparency contributes to increasing efficiency, protecting information, and anticipating disruption through analysis of instantly shared information.

The paper "Internet of things and the next generation of supply chains" Christian Capadrutt & Marcus Ljung; June 2020 [9]; demonstrates the role that the use of new technologies has played in improving performance and satisfying the consumer. The research was interested on the impact of connectivity and visibility on supply chain network, and how using iot technologies affect the global supply chain performance in such contexts. The study was conducted from a holistic point of view, and it covers an end-to-end automotive supply chain network.

The performance of the industrial chain consists in the ability to ensure the customer need in quantity and quality demanded and at the precise moment, it also consists in minimizing the cost of the products and services offered [10]. To measure performance, the authors consider the key performance measures proposed by Gunasekaran et al. (2001) on their paper: Performance measures and metrics in a supply chain environment.

In this model, the authors consider industrial performance spread over five phases:

- Plan performance: this is the performance of the planning it can be followed by indicators such as the accuracy of the forecasts, the time of the orders, the coverage of the stock, the adequacy of the planning in relation to the needs…
- Source performance: it is the performance related to the supply, it can be measured through: the supplier performance and its service rate, its responsiveness to supplier lead time and quality problems...
- Production performance: this is the performance of production operations: production cost, rate of return, compliance with schedule, inventory reliability…
- Distribution performance: this is the performance related to shipments: delivery lead time, cost of shipments, number of compliant deliveries…
- Customer satisfaction: This is the measure of performance from a customer point of view: responsiveness to additional requests, service rate, Number of complaints and their seriousness...

A combination of data collected from the case company selected and information provided from a third-party solutions vendor allowed a coherent understanding of the topic which is how improving visibility and connectivity of the global supply chain improves performance and customer satisfaction?

The goals of the company are:

- Sharing accurate information with dealers to avoid late arrival of products
- Monitor trucks in real time
- Optimize vehicle yard management: Get the location of the right vehicle to be shipped.

By using IOT technologies such as: GPS, RFID, smart vision camera … information needed will be shared at the right time. This information is several: real time location tracking, estimated time of arrival, invoice information, quality and security of products, inventory information, reverse logistics information (empty packaging status) … This digital network will allow a more efficient and consumer-oriented supply chain and subsequently will contribute to improved performance.

While the digitalization of the industry has had a positive impact on the company's productivity and performance, it is not the only area to improve in order to achieve logistics excellence. There are other points to consider such as market volatility, the economic circumstances of countries and regions that are part of the chain to model.

The paper "Designing the right global supply chain network" [11] focuses on the impact of the political and economic strategy of the countries in the modeling of an industrial chain, while considering the internal profits of the different actors of the chain. The constraints to be taken into account are how to link the customer need to the demand, to answer this question, it is necessary to determine the physical and cash flow, the capacity of production and storage, the necessary technological investments. This will allow to define the cost of the product and then decide on the validity of the chain modeled or not.

The study also emphasizes the consideration of the commercial and political constraints of the countries and that will permit to decide which product and in which location.

These constraints may be related to import and export requirements, financial and treasury constraints imposed on investment credits, all limitations imposed by government policies. However, companies are currently moving towards reshoring and restriction of outsourcing with more interest on product quality.

The study also demonstrated the impact of the use of new technologies on overall performance such as blockchains and their impact on improving processes even if its value is not totally proven.

The paper drew attention to the importance of examining market balance in addition to other constraints generally taken into account.

The overall goal of this study is to achieve the desired performance. this performance according to the literature as mentioned by Annelie I. Petterson & Andres Segersdet in their paper: To Evaluate Cost Savings in a Supply Chain : Two Examples from Ericsson in the Telecom Industry [5], can be completed through a focus on cost, customer service and inventory focus or flow focus. This performance in its traditional definition consists in reducing the induced costs as mentioned by Shapiro (2001) [12]. Different types of costs are defined in the literature, but generally that supply chain cost (SCC) is divided into six main categories covering different phases of the chain: Manufacturing, Administration, Warehouse, Distribution, Capital and Installation costs [13, 14]. Referring to SCOR model, SCC is defined using two kinds of costs: the first is the cost of buying raw material and producing part, the second includes all costs of different phases of supply chain processes.

The paper focuses on achieving performance by reducing cost related to flow. For that, a study was conducted on a company operating in the telecom sector. After defining the supply chain to study, measured the supply chain cost and customer service measures of the current state, two flow modification studies were launched to choose the optimum flow allowing a gain for the enterprise. Two examples have been considered: the first is to remove two storage rooms from the value chain of the finished product, the second is to change the place of production to low labor countries. After remeasuring, the first example allowed the reduction of the warehouse cost and therefore supply chain cost and lead time, the second model has been discarded as the SCC has increased. Therefore, we can deduce that a cost optimization study of the supply chain can be based on the modeling of the chain by considering all the stakeholders and all the costs involved.

From another point of view, there are studies that are interested in modelling the sustainable supply chain, we are interested in this case in the establishment of a supply chain considering the use of natural resources to both protect the environment, to ensure economic growth and social equity. These aspects have to be connected [15]. The paper "Simulation Modeling of the Sustainable Supply Chain" [15] is interested in the modeling of a sustainable supply chain and its benefit on economic and environmental aspects using a simulation model. As technology evolves, companies are interested in adapting more easily to the needs and production processes, which means that we need to be faster to avoid slowing down production and downtime.

This new system has a particular impact on transport companies, which must be reactive and keep up with demand, and hence a large number of trailers on the road, energy consumption and high pollutant emissions, hence the environmental impact. The study presents the advantages of order consolidation and how it reduces the number of trucks on road, and subsequently its impact on the environment and the economy. An example was presented for study and simulation using FlexSim software. The built model used some entry information:

- Order information: Quantity of pallets to be transported, and number of vehicles to be used.
- Vehicle information: type of vehicle, fuel consumption, work cost
- Fuel cost
- Time of realization of transport order: between loading and unloading pallets
- Load and unload points, and distance between each point.
- Number of pallets per order which need to be load in each load point or unload in each unload point.

Sixteen experiments were made, analyzing their obtained results, the cost of operations and the number of polluting emissions has decreased, therefore it can be deduced that the consolidation of orders positively impacts the environment and the economy, it also makes it possible to reduce the number of vehicles circulating and therefore potentially a low risk of accident subsequently a positive social impact.

3. DISCUSSION

The various studies available dealing with the connectivity of industrial flows are mainly concerned with finding the best organization to improve performance. The studies chosen for our paper are proof of this. Performance in this case means achieving customer satisfaction at a lower cost.

To achieve this objective, research focuses on the following areas:

❖ Increasing productivity and decreasing lead time
❖ Reducing induced supply chain costs
❖ Building a transparent network, through improving the sharing of information needed at the right time
❖ Focusing on environment impact by reducing energy consumption and exhaust emissions

The taking into account and application of these constraints differ according to the chain to be modelled: is it a reconfiguration of a production chain within a company, or is it the modelling of the end-to-end supply chain:

✓ Within a company, work is often done on the arrangement of machines in order to increase the production rate and reduce the mudas of unnecessary

movements. To do so, we can rely on modelling the production unit using different models available, such as the EPC (Event Process Chain) model which aims to reduce lead time by focusing on production processes; ACM model (Activity Chaim Modeling) aiming to optimize use of resources [16]; DES (Discrete Event Simulation) which considers the supply chain as discrete event subsystems each event arrives at a given moment and modifies the state of the system; SD (System Dynamics) which is used to model a complex system in a global way without too much detail and ABM (Agent Based Modeling) a system is modelled by agents. Each agent assesses their situation individually and makes decisions based on a set of rules [17].

✓ if we consider the end-to-end supply chain, several aspects are treated:

➢ Analyzing the different steps through which a product passes before being delivered to the customer: production site, storage site ... What stage of the chain can be eliminated? What gains can be generated?

➢ Establishing the chain's strategy: which product and where to be produced? in this case the transport costs generated, the labor cost, geographical distribution of customers by area are taken into account, this step comes in the first phases of the establishment of a supply chain.

➢ Data flow processing: what information to share and how? what technologies to use?

Considering government-imposed constraints: benefits and facilities to perform import, export and customs clearance operations.

4. OUR VISION

In an increasingly connected and globalized world, the setting up of efficient production lines to meet the needs of customers at the best possible ratio: quality, cost and lead time, is a complex strategic issue for the different industrial sectors. It consists in establishing the necessary connection between suppliers, producers, transporters, warehouses and customers in an efficient way that enables customer satisfaction. Supply chain connectivity aims to make trade, physical flow and communication between different network collaborators more fluid [18].

Existing studies show a strong focus on the design of a logistics chain to improve performance by focusing on

➔ The reduction of global supply chain costs, which will allow financial gains for companies in the chain;

➔ The reduction of the lead time which will allow to respond to the customer more quickly;

➔ Instantaneous sharing of information, which will make it possible to anticipate any disruption that may occur.

Taking into account the economic and political constraints imposed by the various countries is essential before deciding on the geographical location of the various companies in the chain.

However, few studies focus on the risks associated with the modelled chain and that can destroy it, on the resilience of this chain following the various changes that may take place. The 2020 Covid-19 health crisis demonstrated the fragility of several industrial sectors facing different changes that can occur during a crisis.

The Figure 2 below shows us some risks that can be faced by an industrial logistics chain. To address these risks, supply chains must be prepared and adapted to such circumstances. The management and management of risks is an essential aspect not to be neglected for supply chains. We have proposed a 4-pronged prevention model to facilitate the management and prevention of industrial risks, as presented in Figure 3.

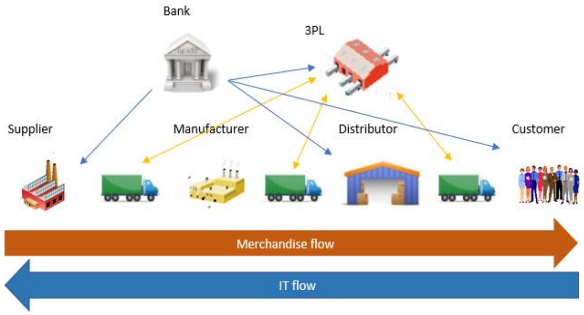

Figure 1. Manufacturing supply chain process flow studied

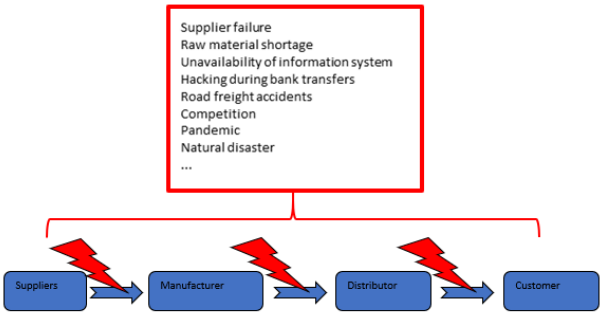

Figure 2. The potential risks of disrupting a supply chain

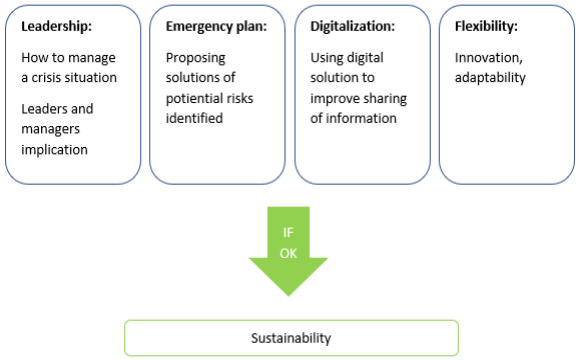

Figure 3. Supply chain risk prevention model proposed

We believe that we must be able to deal with the disruptions that may occur during a crisis situation, however, control of supply chain disruption may not always be perfect, but the alternative of having no plan or not working on the potential risks that can sustain is the worst solution. Our proposed model aims to put in place a system to prevent the effects of supply chain risks, it covers four dimensions: Leadership, emergency plan, digitalization and flexibility. These aspects can be addressed before, during or even after the crisis:

4.1. Leadership

A good leader is an essential success factor for companies. Management in times of crisis is not obvious, the role of leaders in this case is very important. The role of the leadership consists in putting in place a strategy of reorientation, a schedule to absorb disruptive shocks. More attention is required to communication and leadership support. Leaders are also brought to know the impact of the crisis on customers and employees and react accordingly.

4.2. Emergency Plan

This involves studying and identifying potential supply chain risks and implementing actions to prevent the impact of the risks raised, risks can be: operating risks, man-made risks, digital risks... Alternative tracks to propose can be set back-up suppliers, prioritize the jobs to start, define a backup process of all operations of the chain…

4.3. Digitalization

Digitalization is used for improving communication between the different collaborators of the chain, it serves also to improve visibility, transparency and a safe exchange of information. Different solutions are in place such as using ERP system, which enables the day-to-day management and monitoring of all the operational information and services of a company, IOT solutions which enables better connectivity and instant information sharing, blockchain which allows a secure exchange of data.

4.4. Flexibility

Faced with a crisis situation, the company must think of alternatives to ensure its continuity, it can be a service innovation, a diversification of production, a change of process ... we speak then of the notion of flexibility.

Once the chain has been designed and modelled taking into consideration different potential risks, what measures must be taken to ensure its durability, we are therefore talking about the network sustainability, which is also a field of research rarely considered.

The themes cited are very interesting lines of research especially in the current economic context.

5. CONCLUSION AND PERSPECTIVES

In order to guide the study of the connectivity of flows in industrial chains, we have grouped together all the topics studied in this direction through a few selected studies. For each study, we presented the idea of the authors and how it was modelled. Connectivity is generally studied to improve overall performance and reduce costs.

Different constraints are taken into account for each case, for example: the location of production sites, labor costs, economic and customs constraints imposed by countries, transport costs generated... Connectivity obviously helps to improve performance, however, if the analysis of the various risks that may arise is not taken into consideration before defining a supply chain, it can be destroyed at the first risk faced.

We therefore proposed to broaden the study and look at the resilience of the industrial chain in the face of different possible risks, the exchange of data between factories and how this data is protected, in order to speak of a sustainable supply chain.

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