

MODUS OPERANDIS

REVISTA CIENTÍFICA MULTIDISCIPLINAR

VOLUME 1
1.ª EDIÇÃO

2024

ISCIA

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e Desenvolvimento
Tecnológico e Humano



9 - Lean management boosted by Value Stream Mapping

ISCIA / AVEIRO
Nº1, Vol I, Dez/2024 – Pp. 174-193
ISBN: 2975-9773

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Resumo: O ambiente em constante mudança exige cada vez mais estratégias de gestão eficazes e eficientes. A redução de custos, seja de que tipo for, é extremamente importante nos atuais tempos macroeconómicos que enfrentamos, para que as empresas se mantenham competitivas. Tendo em conta a necessidade de manter um desempenho competitivo, os princípios lean são analisados para compreender como os Value Stream Mappings são capazes de fornecer *insights* relacionados com a melhoria do fluxo de informação e de materiais, para reduzir o tempo de espera e de desperdício. A flexibilidade é extremamente importante, de modo a manter os clientes satisfeitos, preservando os fornecedores atuais, pelo que os resultados desta investigação podem ser replicados a outras necessidades industriais, assim como a organizações de serviços, através da implementação de um Mapeamento do Fluxo de Valor para evidenciar o fluxo de materiais e de informação de uma forma melhorada.

Apesar de os impactos da abordagem Lean já terem sido bastante estudados, esta investigação continua a acrescentar valor a esta área, ao apresentar um estudo de caso concreto da indústria automóvel e os seus resultados relacionados com o mapeamento do fluxo de valor e de materiais. O objetivo da investigação é duplo, ou seja, analisar e mapear o fluxo de materiais pode contribuir para a melhoria contínua, reduzir o desperdício através do mapeamento dos custos que empurram a produtividade para baixo, para o baixo desempenho, de modo a determinar as etapas de implementação realizadas.

Palavras-chave: Filosofia Lean; mapeamento do fluxo de valor; competitividade organizacional; fluxo de materiais e informações.

Abstract: The ever-changing environment increasingly demands effective and efficient management strategies. Cost reduction in any kind is extremely important in the current macroeconomic times we face, so that companies can remain competitive. Bearing the need to keep competitive performance, lean principles are analyzed to understand how Value Stream Mappings are able to provide insides related to information and material flow

improvements, to reduce waiting and waste time. Flexibility is extremely important, in order to keep customers satisfied while preserving current suppliers, so the outcomes of this research might be replicated to other industrial needs, so as to service organisations, by implementing a Value Stream Mapping to highlight the flow of material and information in an improved way.

Despite of lean impacts being already richful studied ground, this research is still adding value to this area, by detailing a concrete Case Study of automotive industry and its outcomes related to the mapping of value and material flow. The research aim is twofold, namely to analyze and map flow of materials can contribute to continuous improvement, to reduce waste by mapping the costs which push productivity down, to underperformance, so as to determine the performed steps of implementation.

Keywords: Lean philosophy; value stream mapping; organizational competitiveness; material and information flow.

1. Introduction

Lean philosophy has achieved considerable interest from Industrial Management in recent years, mentioning that the first VSM value stream mapping (Value Stream Mapping), was created by Taichi Ohno at Toyota, and over the years there have been numerous followers who have added improvements to the original model. Lean philosophy is concerned with process and operations management and is uniquely combined with a focus on people, culture, and leadership (Solaimani et al., 2019).

Womack et al., (1990) refer that the VSM technique was one of the most significant within Industrial Management, because it allows managers a comprehensive view of the flow of information and processes from the supplier to the end customer. Through this circuit the entire value creation circuit is detectable. This mapping can be carried out on a scale, according to specificity, and may encompass the entire production process or only a segmented process. The primary step is planning, according to Jakšič et al. (2011) and Bogataj et al. (2005) assuming a crucial role in favor of production and logistics efficiency.

There are still considerable advantages inherent to the application of the methods, because through the correct mapping of the flow of information and materials, costs inherent to the processes can be reduced (Nicholas et al., 2018). These may consist in the reduction of lead-times for the transformation of raw materials into finished products, transit times, and inventory levels of raw materials, work in progress, and finished products. Naturally, based on these reductions, it may even be possible to reduce the human resources allocated.

In the current macroeconomic context, that continuous improvement is asserting itself in a more solid and robust way in the markets, and consequently, within the respective industries (Madhani, 2020). It becomes imperative to have well allocated tools, in order to meet and preferably exceed customer expectations, thus creating more added value, allowing differentiation between competitors. Nevertheless, the relevance of costs always appears as a parallel figure to continuous improvement, i.e., the intention is on the one hand to maintain or preferably exceed the level of quality, productivity efficiency, allowing lower costs inherent to inventories, labor and waste. Naturally, costs are allied to all this continuous improvement, because the profitability of the company is crucial to its development and economic and financial sustainability. In this way, it is intended to combine the continuous improvement ordered by highly demanding customers, with the possibility of cost reduction, eliminating all activities inherent to the flow of information and materials, considered muda, that is, waste, without added value. The well-known VSM tool, which had its origin in the automobile industry, at Toyota, is analyzed around this efficiency achievement, in favor of continuous improvement (Womack et al., 1990).

This study aims to determine whether the mapping of value and material flows can effectively lead to continuous improvement in an automotive industry, thus the following research questions are posed:

Can material and information flow mapping contribute to continuous improvement, namely waiting, transit and lead-times?

This research aim afford an in-depth analysis, in order to understand by direct observation, the information and material flow, so as to complement this method by interviews in-depth Case Study was performed.

2. Value Stream Mapping (VSM) and Lean Thinking

Organizational environments request quick answers to just-in-sequence demands, based on the large fluctuation and unpredictability of customer orders, in the automotive industry, it becomes inappropriate to mass produce according to Henry Ford's theory. According to Taiichi Ohno's theory, production should be conducted in such a way that it is "pulled", rather than placed in the company's warehouse, at the customer's disposal. Taiichi Ohno called this new philosophy just-in-time production (JIT), because it resembled the supermarket philosophy of placing small quantities on shelves and replenishing them as they are consumed (Ohno, 2019). Products that have a higher turnover are placed in larger numbers, called "high-runners", while products that are consumed less regularly, called "low-runners", are available to the customer in smaller numbers. This philosophy acts as a buffer, allowing the company to be controlled more efficiently, avoiding unnecessary costs for raw materials, work in progress, and finished products. Stavrulaki & Davis (2010) intend, that high volume and low-level products are grouped and coordinated with production and logistics processes. In this way, a combination of efficient and flexible processes will be achieved (Stavrulaki & Davis, 2010).

Lean Management uses less of all components when compared to mass production: half the human resources, half the production space, half the investment in tools; half the engineering times and therefore produces in half the time. Womack and Jones (1996) state that there are three primary steps to flow:

- 1 - Focus on the actual product, and the specifications of the order itself;
- 2 - Removal of all impediments and barriers to the entry of the philosophy, flow;
- 3 - Redefinition of specific practices, in order to eliminate returns, backflows.

The below referred steps must be exercised sequentially and together for the sake of success. Table 1 summarizes previous research on the topic under review.

Table 1
Summary of main themes and authors

Theme	Author
The VSM as a centerpiece of Lean philosophy	Acharya, 2011; Al-Aomar, 201; Alvarez, 2009; Braglia, 2006; Singh and Garg, 2011
The customer-oriented VSM	Agyapong-Kodua, Ajaefobi and Weston, 2009; Chen, 2011
Joint methods:	
VSM and Milkrun	Domingo and Alvarez, 2007
Methods and times	Edtmayr and Kuhlmann, 2011
The role of systems and information in VSM and Lean thinking	Cottyn, 2011; Leu and Huang, 2011
The role of VSM in cost reduction and waste elimination	Ross, 2011; Lu and Yang, 2011; Lummus and Vokurka, 2006; Sahoo and Singh, 2008; Stefanic and Gjeldim, 2010
The flow of materials and information as a tool for waste elimination	Teichgraeber and Bucourt, 2012; Alvarez, 2009; Forza and Salvador, 2001; Jonsson and Mattsson, 2008

Source: own elaboration.

Wee and Wu (2009) state that, as far as the practical implications are concerned, VSM can undoubtedly be considered one of the best tools for supply chain management. They mention that the success of the method had its beginning in the implementation of Lean production in the Toyota Production System (TPS). It should be noted that competing companies, despite having similar tools, have not obtained the same results, so there seems to be a hidden/understood "ingredient" on the part of Toyota's competitors.

Porter and Millar (1985) divide a company's activities into primary and secondary activities. Primary activities comprise a direct connection with the production or distribution of a good or service, these being defined as: Supply Logistics; Production; Dispatch Logistics; Marketing and Sales; Customer Service. Secondary activities, in turn, include support activities, which assume an important role, composed of Organization Infrastructure; Human Resource Management; Technological Development; Procurement / Acquisition of goods.

Likewise, Ashayeri & Lemmes (2006) highlight the relevance of a joint effort between processes such as logistics, marketing, sales and top management sustained by successful policies, in order to build an efficient order plan. It is imperative to be able to count on the help of all processes, bearing in mind that the objective is to quantify the impact of planning on the supply chain.

All processes are relevant, however, Bogataj et al. (2005) reveal, that production and logistics services, comprise the origin of the supply market within the chain. According to Acharya, (2011) the primary objective lies in process improvement, based on Lean principles, and the VSM has been considered, as fundamental to the development of material flow.

A measure of operational complexity should be created to be applied before and after the supplier-customer incorporation. Efforts and investments are required to develop internal production capacity, in order to enable the production of the right product at the right price at the right time. Additionally, there is the imminent risk of raw material shortages, which must be circumvented with caution to avoid supply disruptions. The path to success, according to Chen and Blue (2010) consists of a coordinated flow, combining information, materials, resources, inherent processes and services. Singh et al. (2011) state that using VSM, information is captured on each process, showing productive times, such as cycle-time, up-time, changeover time, as well as products being manufactured and the exact human resources required.

Al Aomar (2011) mentions that the triangle that serves as the foundation of Lean focuses on productivity, cycle time and the inventory of products being manufactured. Additionally, value-added activities are highlighted, contrasting with non-value-added activities, in favor of efficiency. Through this tool, Lasa et al. (2008) state that an innovative graph can be built, helping to redefine processes in need of improvement. Whenever an analysis of this magnitude is prepared, the result is certainly the reduction of muda, meaning waste, because managers must eliminate all activities without added value.

It is notorious, that Lean implementation is solidified beyond industrial borders, being applied in several organizations of different activities, including in the services area, recognizing the importance of the power of this tool (Tyagi et al., 2016). Enabling excellent innovation at the service level, lacking fewer intervening human and technological resources. In this way, service providers acquire greater availability for customer service, being more flexible, for additional consultations, not requiring prior scheduling in case of urgency. However, there are some smaller companies that are willing to implement Lean with the objective of quick return, and there are even clinics linked to health, implementing the Lean philosophy, using the VSM, in order to identify the flow of information and material, allowing a subsequent reduction in costs and waiting times (Tyagi et al., 2016).

There is a high level of uncertainty about the actual orders, based on forecasts, referred by Chen and Blue (2010) referring to the "bullwhip effect". The main objective in supply chain management is to deal with future orders and forecast uncertainties, as

mentioned by (Jakšič et al., 2011). In order to be able to rely on additional information, managers should try to obtain capacity forecast information, related to future supply/production capacity, from their customers and suppliers. In addition, it is favorable to conduct regular inventory reviews, relying on an efficient ordering policy, interdependent on stock level/inventory security policies, considering, that the level operates, depending on the forecasts. According to Jakšič et al. (2011) models can be developed based on very specific assumptions.

Nowadays, companies are already more flexible to react, being able to anticipate orders, relying on greater supply capacity. It should be noted that most benefits are considered in an aggregate and interdependent way. Wadhwa et al., (2007) state that agility is central to supporting enterprise-wide integration. Allocating their flexible resources and the entire core components, so that they can offer value-added products and services. Flexibility is seen as a core competence, with regard to resources and processes, exercising for the sake of time and costs. The development of agility is extremely difficult, due to the tacit and multifaceted interrelationship, surrounded by system parameters.

Critical success factors lead to high performance in the chain, highlighting customer and supplier interconnections, as well as communication, information, and technology. They also benefit material flow management, corporate culture, and performance quantification. Thoo et al., (2011) state that managers need to update Supply Chain Management (SCM) strategies based on missions and competitive advantages.

Market Orientation (MO), combined with the implementation of the JIT strategy and Total Quality Management (TQM), allow a broad, macro vision, according to Zelbst et al., (2010). There are effectively programs developed to assist Business Management, focusing on market orientation, as well as direct relationships with the JIT philosophy, TQM parameters and agile manufacturing, in order to achieve success in operational and logistics performance. Market-oriented management strategies have a positive and direct impact on JIT production, and consequently on the quality of production, enabling effective logistics performance. This rigorous analysis requires valuable interaction from all stakeholders, starting with Process Control, Logistics and of course top management.

Over the last decades, almost all large companies have tried to become lean, aiming to be able to add value to customers in a responsible way, looking for new techniques to identify waste. However, several smaller companies, have not yet proceeded to implement this methodology due to the costs, as well as, the physical and human resources, associated with the implementation (Chen & Blue, 2010; Lummus et al., 2006; Rathke et al., 2012; Seth & Gupta, 2005).

Given the current macroeconomic environment, many companies are having to implement lean strategies in order to remain competitive in the marketplace. Lead-times have to be shortened and final costs implicitly reduced. Implementation aids include case studies, interviews, and on-site observations. According to Aguado et al., (2013) the Lean strategic implementation represents a robust contribution on the way to operational excellence by reducing non-value added activities, essentially contributing to industrial performance. VSM is considered the first tool for effective implementation, often coupled with kanban (means card in Japanese and is used to signal production flow) and milkrun techniques (delivery planning by transportation companies). Lean implementation is usually accompanied by VSM techniques, kaizen continuous improvement on visual boards. It is essential that the entire process from the supplier to the customer is investigated based on a thorough coordination and control analysis. The various sectors/processes inherent in a supply chain must be taken into consideration (Aguado et al. (2013).

The overall performance is determined by the interrelationship and interaction of the integral performance. It is extremely important, that this analysis embraces the entire flow, from the suppliers to the final customer. When it comes to production development,

performance is crucial, based on costs, lead-times and wait-times. The main objective, according to Green et al., 2010; Pattanaik & Sharma (2009) is to reduce waiting times, queues, movements and administrative times, leading to reduced delivery times for the customer.

Regarding the layout (arrangement of work cells), during the Lean implementation process, it can be in line or cell. Cell production is extremely pertinent to Production Management, allocating machines in several cells, with production distributed according to a specific group/family, in order to make cells independent from each other (Pattanaik & Sharma, 2009). In this way, the handling of materials is significantly faster, the products being manufactured are reduced, along with the set-up time (time needed for the change of machines and tools), obtaining a developed production and an effective operational control. The next step is to distinguish product families in order to allocate products to the appropriate cells. Lean implementation concepts should be harmonized, using takt-times, (useful production time/customer order time), optimizing production and the flow between cells, reducing non-value-added actions, optimizing material handling, avoiding bottlenecks, i.e., production with interruptions called bottlenecking and consequent waiting times.

Leu et al., (2011) analyzed e-logistics implementation management models, knowing that this management model quickly shows results, so it should be analyzed in 1st "1-tier" suppliers. Despite its limitations, regarding the impossibility of updating production and logistics in an automatic and dynamic way, the VSM tool assumed a fundamental role in management a few years ago. Thus, Leu et al., (2011) tried to adapt VSM so that it could be used in simulations, allocating objects, and in the future could be applied in industrial companies. In addition to these innovations, algorithms were allocated for data transfer, as well as information from VSM to tables.

2.1. The role of systems and information in VSM and Lean thinking

VSM is a tool focused on the overall flow of production processes. The mapping should also involve information flow, in order to be able to signal and control production. The first step should be to obtain information, through mapping, prior to implementation. The goal is to reduce inventories between processes, promoting productivity and lead-time reduction. The primary step in Industrial Management and Service Provision should consist of obtaining process information through VSM (Danese et al., 2012). Consequently, inventory levels will be reduced, promoting production, avoiding errors or possible delays.

The VSM tool considers all processes covered, mapping the flow of information and materials from all components within the flow, including production, suppliers and their customers (Braglia et al., 2006; Forno et al., 2014). VSM is remarkably efficient because it includes in addition to production processes, the information flow that controls and commands production (Braglia et al., 2006). Cottyn et al. (2011) state, that in the past, the possibility of joining information technology to Lean principles was considered unsustainable. However, nowadays this junction is crucial to good production performance, so that nowadays they go "hand in hand".

Organizations that implement lean principles do have considerable advantages, with regard to costs and quality, when compared to mass production (Kumar et al., 2006). The innovative production method is an evolution in the production strategy, according to (Hodge et al., 2011; Lu et al., 2011; Mahapatra & Mohanty, 2007) aiming to achieve efficiency, focusing on: waste reduction; production evolution (elimination of non-value added activities); the reduction of instability regarding suppliers and customers; providing managers with a real vision, so that they can execute accordingly.

The initial goal is to describe all steps of the current process in order to portray the current situation, called the Current State Value Stream Map. Each Process Manager is asked several questions, such as:

- Do the tasks inherent to the process add value to the customer?
- Do they produce positive results?
- Does the output maintain the desired quality level?
- Is the process flexible?
- Can production lots easily be changed?
- Is there excess capacity?

It is essential to determine whether the information received by the client, referring to a particular product, is in accordance with the objective. Timely deliveries are also subject to analysis and evidence in the information and flow map. All processes without added value should be excluded, while inefficient processes, lacking capabilities and/or resources should be developed, in order to elaborate the "Future State Value Stream Map". By comparing the current and future VSM, one can easily see the reduction of waste, i.e. non-value added activities.

According to Agyapong-Kodua et al. (2009) companies have to adapt to the business reality by adapting to the market, maintaining effective pricing in accordance with customer needs. The current scenario depicts constant fluctuations in the market, Mross et al. (2010) reveal that companies feel forced to keep up with progress. Under these current conditions VSM has proven to be triumphant, building on its faculties of analysis at the level of waste within production as well as in other intervening processes. Arlbjörn et al. (2011), Lummus et al. (2006) mention that the core lies essentially in reducing inventories by half, consequently eliminating waste and non-value added activities, along with reducing defects, optimizing production quantity, increasing product variety. In turn, Hodge et al. (2011) complete this reasoning by stating that Lean principles are constant, what differs are the methods of application, depending on the structure, production and internal procedures. The goal is always to maximize customer satisfaction.

Also Tenent et al. (2009) refer that the implementation absorbs immense human capital, based on the exchange of information between experts Álvarez et al. (2009), Danese et al. (2012), Lummus et al. (2006) understand that the primary implementation of the Lean Management technique descending from the automotive industry, could spread in other business areas, including the provision of services. Currently this is a reality, as the Lean philosophy is already applied also to services (Maciel et al., 2021; Morell-Santandreu et al., 2021; Nedeliakova et al., 2020).

2.2. The flow of materials and information as a tool for waste elimination

Based on this innovative form, production instructions are transmitted according to customer requirements, i.e. there is only an instruction to produce if the previous unit has been consumed, or the minimum safety stock level has been reached. Through this production theory, obsolescence is avoided, along with exaggerated stock levels, unnecessary raw material acquisition costs and labor. Achieving perfection, and maximizing customer satisfaction, through the pull strategy, which symmetries the entire process according to customer requests (Lu et al., 2011). The improvement of the internal process, referring to investments, connecting the knowledge applied to Logistics, and respective financial performance is highlighted by Birou et al. (2011) in order to produce, according to orders, MTO (make to order), or alternatively, to stock, MTS (make to stock). There is a positive relationship between internal process development, the investment of financial performance in companies with MTO orientation, because in this way they avoid exaggerated inventories, when compared with production philosophies for MTS storage. The practical aspect, highlights the knowledge of logistics activities, planned and integrated in the tacit knowledge.

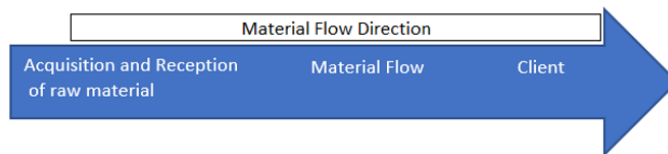
J. P. Womack et al. (1990) state that for a company to create value, it must abandon the classic work model, in which human resources were allocated by departments.

Companies become much more functional when composed of processes, in favor of the continuous flow of the product. Obeying the corporate hierarchy, in order to be able to make them more flexible and functional.

According to Womack, Jones and Womack et al. (1990) through restructuring, responsible managers are able to develop capabilities according to their ideals much more easily, because the flow of work is more direct, that is, more continuous, without structures resistant to change. It is imperative that those in charge have knowledge of the procedures and tasks inherent to the same process, so that they can ascertain the locations of the muda, that is, of the waste.

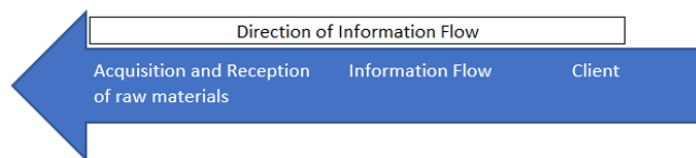
Value creation has assumed a vital role in companies, so two steps are considered the main ones, according to Esper et al. (2010): (1) obtaining information through the marketing process, and (2) ordering according to the supply chain. Thus, it is essential to pay close attention to Figure 1 and Figure 2 below, because the flow of information and materials constitute the value stream. As we can see, it is imperative to pay attention to the flow of materials, because it must be in line with the customer's request, which is received through the flow of information. The sum of these two flows will originate the global value stream, which is perceived by the customer, so it is important that the customer's expectations are exceeded.

Figure 1
Material Flow Direction



Source: own elaboration.

Figure 2
Information Flow Direction



Source: own elaboration.

In favor of the development of competitive advantage, Anvari et al., (2011) that the implementation of Lean theory allows sustained progress because it is based on an integrated socio-technological system. It can be complemented by a dynamic model, analyzing variations in production requirements, and significant reductions can be seen in lead times, work in process, and inventories. Jonsson and Mattsson (2008) highlight the importance inherent to planning methods, in order to control the flow of materials, with regard to inventories and raw material acquisition.

According to Green et al. (2010) and Rathke et al. (2012) simulations related to fluctuating requirements allow for a readjustment of the work cells. Additionally Rathke et al., (2012) refer that in a case study in the medical field, it was proven that only 1/3 of the processes revealed added value (Lu et al., 2011).

also investigated on site for several months, analyzing the Engineering procedures related to the processes adopted by a company in China. They concluded that $\frac{1}{4}$ of the activities have no added value, taking into account that many Engineering procedures showed gaps, exemplifying; the creation of drawings; the compilation of mass production documents, the checking and signing of Engineering documents, the creation of programs, the creation of packaging queues, among others. Based on VSM, Lu et al. (2011) concluded that there are two problem areas: cycle times and orders with Engineering technical changes. Trentin et al., (2011) warn, that the successful implementation of management practices, such as, just-in-time, TQM quality policies, or engineering, depend essentially on the organization of the company, and communication and information should be highlighted.

2.3. VSM - Implementation Failures

LPD (Lean Product Development) is considered one of the most powerful resources in achieving value maximization, increasing product quality, reducing lead times, so that it can provide lower PD (Product Development) product development costs (Salgado & Dekkers, 2018). However, several companies have failed to implement it, due to inherent flaws or inaccuracies. Although this Lean philosophy dates back to the previous century, this philosophy is still very current serving as a guide on the way to business success, according to

Several multinational companies have been instructed to focus on producer responsibility, with the goals being (1) to re-establish high production levels; and (2) to introduce the life cycle concept. Companies must possess their natural instincts, regarding the benefits of short-term maximization, and multi-cycle application, in order to maximize lifespan. Horizontal collaboration, or vertical integration, can decrease the effect of the "gap" (information technology failure) by sharing planning and control systems.

Through horizontal collaboration, high returns are obtained, both in terms of costs inherent in production, the detection of possible failures or improvements to be implemented, as well as demonstrable waste (Gjeldum et al., 2011). Wee and Wu (2009) wonder about the fact that Toyota has successively achieved success based on its competencies - allowing the elimination of waste according to the long-term philosophy. Wee and Wu (2009) gathered several ideas about Lean implementation and applied the theory to a case study, looking at how the supply chain affects product cost and quality. Consequently, they concluded that through VSM process indicators related to quality development and lead time reduction are evidenced, although the application is costly and time consuming.

The limitation of the use of the Lean tool in industrial companies, regarding the adoption of industrial concepts, in the face of redesign and development of production system was performed based on on-site analyses in six companies with Lean perspectives using the VSM. Serrano Lasa et al., (2009) concluded that the failures were due to inadequate application of the respective tools, i.e., they did not explore all the functions inherent in the same tool, in addition to gaps regarding the interconnection of theory and practical application. Based on these case studies, the authors conclude that, possible communication failures could be correctly overcome by the stakeholders. Top management lacked adequate preparation for the introduction and implementation of the tool. Managers, through efficient application, may verify productive gains in relation to the "output", reducing the volume of work in progress and finished product, consequently counting on greater productive gains. (Serrano Lasa et al., 2009).

The proper functioning of a supply chain needs the fundamental support of information and communication technologies, as they support the business processes inherent to the supply chain (Carvalho et al., 2010). The first organizational step should consist of an internal functional and organizational integration. Managers working with customers and suppliers must solidify external relationships to maintain equally solid and enriching internal relationships.

In fact, human capital is more critical than technology in the implementation of SCM, so the right people must be placed first and then the technologies must be allocated. The relationships between information technology and competitive advantage cannot be applied globally across divergent cultural environments and industrial settings. (Halldórsson et al., 2008; Lai et al., 2006)

Information technology (IT) concentrates a company's competitive advantage, therefore the integration of these technologies is extremely pertinent in order to align IT strategy with business strategy. Tenent et al. (2009) further elaborated on the administrative application along with the development of product-related activities from an independent perspective. IT applications are extremely relevant within industrial companies, based on the current economic situation, however, they need a detailed observation regarding the processes involved in the flow of a given company, according to Ou-Yang and Chang, (2000) and Wang et al., (2011). The main objective lies in the flow of information and material flow, along with the overall management processes.

Ou-Yang and Chang, (2000) are concerned, the most common method consists of automatic production systems, describing for this, the functions based on information processes, proposing an integrated organizational model, regarding functions and information. Along with this development, the integrated transfer was detailed during the implementation process, in order to circumscribe steps - respective steps between processes, reducing product development times. Within several companies, activities inherent in this context were investigated, and it was found that the problem lies in the coordination of product development systems, so that due diligence was taken with regard to the interaction of processes, based on a simulation process, which captures information and proceeds to interactive computerized construction.

3. Methodology

The use of the qualitative method in management control research has become common to study the impacts of globalization, particularly at the business level of multinationals Baxter and Chua, (2003) as it provides analysis of the complexity of social phenomena (Yin, 2015). Corroborating these arguments, Piekkari, R., Welch, (2009) argued that qualitative research is fundamental to the study of multinationals as it allows for interpreting and understanding the multiplicity of contexts, i.e., the organizational context, the cultural context and the institutional context, as well as, their interconnection. Qualitative methodology was adopted, namely a case study, as being one of the powerful methodology for in-depth analysis (Yin, 2015). The purpose of this process is to collect comprehensive, systematic, in-depth and robust information on the topic under analysis (Baxter & Jack, 2008).

Bearing in mind the aim of this research, namely mapping the flow of materials that can contribute to continuous improvement, mapping the information flow that can contribute to continuous improvement, so as understand, if continuous improvement helps companies reduce waste and its costs. Consequently, the following techniques: observation and interview were identified as the ones that fits research's aim. Thus, the sample was selected based on the intentional principle, i.e., it represents a convenience sample. In this company the Process Managers who manage the processes inherent to the production chain were selected. Additionally, in order to compare the data collected during the interviews, we carried out direct observation in the production sector, in four distinct periods, during the two shifts, on two consecutive work days. The direct

observations occurred at different times, in order to determine whether the production flow changes according to the shift status, that is, beginning or end of shift. Both procedures occurred during the year 2021.

Table 2
Interviewees experience

Managers	Age	Qualifications	Function	Experience
1	35	Higher Education	Production Manager	7
2	37	Higher Education	Client Manager - Finished Goods Logistics	12
3	40	High School	Packaging Manager	25
4	37	Higher Education	Cutting/Laminating/Preparation Manager	8
5	35	Higher Education	Planning Manager	12
6	43	High School	Purchasing Manager - Raw Materials Logistics	24
7	42	High School	Warehouse Manager	21
8	36	Higher Education	Unit Manager	13

Source: own elaboration.

The Process Managers perceive the flow mapping as a useful tool for continuous improvement and waste reduction. However, its success may be associated with the degree of knowledge of the tool

4. Results and Discussion

Considering the research aim, namely mapping the flow of materials that can contribute to continuous improvement, mapping the information flow that can contribute to continuous improvement, so as understand, if continuous improvement helps companies reduce waste and its costs.

In order to confirm whether the mapping of the flow of materials can contribute to continuous improvement, it is verified, that although the production runs at a smooth pace, in which, there is already a stability as to the routine of tasks, the workflow does not occur without interruptions, because it is verified, for example, that the seamstresses have to get up, so that small materials can be supplied. Besides this intervention, the entire flow of material is conducted based on human intervention. It is verified that, despite the production lines integrating young employees, they are perfectly integrated into the production environment. There is a phase that precedes mass production, in which employees are prepared for the same mass production, in order to avoid possible failures or inadaptations to the environment. The wheeled carts, called pallets, are prepared by employees manually and then delivered to production by employees, called distributors. Regarding the identification of whether the mapping of the flow of information can contribute to continuous improvement, it is clear that the flow of information is coordinated so as not to disturb its proper functioning, noting, however, that the flow of information also lacks human intervention. However, it is verified, that the flow of information lacks human monitoring and indication, and it is not seen that this flow works in an automated way. Often the production manager goes to the production giving instructions, as well as, one sees the Packaging or the Magazine interacting with the Production, in order to obtain information. According to Rahani and Al-Ashraf (2012), the mapping of the material flow may contribute to the continuous improvement, which was verified in this research based

on the interview responses. Indeed, mapping is important so that the company can minimize costs and be competitive, so the same proposition can be validated.

As far as cost reduction is concerned, all the interviewees have unanimous opinions, that cost reduction is very important, and that it is necessary to invest in continuous improvement in order to be competitive. The mapping of flows may contribute to the identification of waste, including waiting times, transit times and lead-times, as highlighted by Pattanaik and Sharma (2009) and Green, Lee and Kozman (2010). It was found that managers are of the opinion that mapping enables the streamlining of work processes, allowing them to function effectively and efficiently. Also, through direct observation it was evident that, although the flow is coordinated in a structured way, it could be made more efficient, avoiding waiting times between sectors. Regarding the thought that the mapping of flows may contribute to the identification of waste, including waiting times, transit times and lead-times, it should be noted that the system is adapted to be able to correspond without the prior definition of the map of flows, working in an optimized manner, however the same process can be overcome by outlining the flows. The delivery of wheeled carts and racks (pallets) is done manually, in order to be available at the beginning of the shift, so that the supervisors can distribute the materials to the production lines, despite being a manual allocation, it does not cause any production stoppage. There are effectively the distributors present in production to supply the production lines, seeing that they put the small materials in a specific place, under the sewing table, which implies that the seamstresses get up, stop production, so that the same materials can be allocated in the proper place. Information flow mapping can contribute to continuous improvement", it can be seen that in a general way all the interviewees affirm its agreement, referring to it as extremely pertinent. This idea is completed with the statements of the Packaging Manager, and the Manager 4, who identify, that it is easier to connect and analyze the process circuit, by predefining the flow. In the opinion of Manager 5, the predefinition is important to be able to react to possible problems or bottlenecks, also allowing the identification of improvements, says the Unit Manager.

Continuous improvement helps reduce waste and its costs, for companies, it is evident that although the company is structured for human intervention, this can be made more efficient, reducing the so frequent intervention of employees, optimizing their work, reducing, in turn, unnecessary costs to the company. According to what we saw, this need to adapt to new conditions, to a possible new functioning of the flow of information and materials, does not seem to be an obstacle, despite the fact that the employees already work in a very systematic way, with a considerable manual contribution. After the production of the respective upholstery, these are placed in dedicated carts, to be collected by the magazine, for inspection and subsequent delivery to packaging. Again, there is human intervention, because these are picked up by the magazine as the magazine needs work, i.e., if the magazine has too much work, production will necessarily check more full carts waiting to be picked up. Consequently, the finished product, after inspection, is placed in white carts, in order to proceed to packaging, so that it can be packed and then shipped to the customer. According to Manager 5 said during the interview, *"it is always important to have a notion of our flows, to realize our problems, our bottlenecks, our obstacles so that we can solve them"*. Although in this productive area there is a lot of human intervention in what concerns the flow of information and materials, it is clear that the productive flow already follows a very recurrent form, facilitating the routine. It can be seen, that effectively, employees present "on the ground" production, assume a key role, because as stated by Unit Manager, *"on the ground is where things happen"*, they are the ones who interact with the other processes, and try to solve any problems, referring to the Customer Manager, "They are the first to detect any problem or failure". It is noticeable that, according to proposition number three, *"The mapping of flows can contribute to the identification of waste, including waiting times, transit times and lead-times"*, the development and application of a flow mapping of information and materials, is considered of added value, both upstream and downstream of the company, according to the words of the Customer Manager, will allow the "streamlining of all work processes" achieving a

good organization. Continuous improvement helps companies reduce waste and its costs, Manager 4, says, *"it is very important that we have a perfect idea of the flow through a VSM type diagram"*, because he says, that this way there is a better possibility of reaction.

As regards the mapping of the information flow may contribute to continuous improvement, this was validated by the answers obtained from the interviewees, which is in line with what was identified by Bell (2005). Managers consider that the predefinition is important to guide and analyze the process circuit, allowing, if necessary, to correct possible problems. It was verified through direct observation that although the company works at a continuous pace, there are certain flows that could be optimized for the sake of continuous improvement. As confirmed by Mahapatra and Mohanty (2007), Hodge et al. (2011) and Lu, Yang and Wang (2011), continuous improvement helps to reduce waste and its costs, for companies. Such a finding was also evidenced in the present study, where Managers stated that the possibility of quick responses in a timely manner leads without a doubt to continuous improvement, regarding the needs or issues faced. It was also verified that the flow depends a lot on human intervention, so that one can bet on continuous improvement in benefit of lower costs for the company.

According to more than 1/3 of the managers, the Packaging Manager, the Purchasing Manager and the Warehouse Manager, the possibility of quick answers to the questions or needs faced, is seen as of great value. The Production Manager, in line with his colleagues, also identifies advantages, considering that it allows the company to be faster, optimizing transports and consequently reducing inherent costs. Also, Manager 5, states, *"The elaboration of an information flow mapping always brings added value"*. The idea of flow visualization, and relevance, of visual projection, is again mentioned by the Production Manager.

Collaborators that work at the shop-floor are the ones that detect firsthand possible failures or delays, so the Production Manager considers that interaction is essential, and the Customer Manager also points out that they are the first to detect any problem or failure. Referring to the words of the Packaging Manager 3 *"the employees are the ones who know the day-to-day difficulties, such as the barriers that they have to overcome, it is an asset, they are inserted in the way we want to make the map"*. The same opinion is shared by the Purchasing Manager, who states that employees should take an active role, because *"they are the ones who understand and know the difficulties that exist on the ground"*. Manager 5 shares that they should be able to interact, because they know certain details, which are usually important for the respective process and consequently for the smooth running of the company.

In turn, Manager 4 mentions that the employees present in the field should be able to participate, in order to get to the detail, as mentioned by Manager 5, however, he emphasizes that they should not be the ones to proceed with the design, because that will require other technical knowledge. Referring to the statement of the Unit Manager, it is indeed crucial that there is an interaction between the people present on the ground and the other employees of the company, even stating that *"it is essential to work, because the ground is where things happen, so for the VSM to make sense there has to be a very strong connection between the ground, and ultimately, between the person who leads this project"*.

The Process Managers perceive the flow mapping as *"a useful tool for continuous improvement and waste reduction. However, its success may be associated with the degree of knowledge of the tool"*, it appears that the managers consider that the mapping is favorable to the definition of the flow of information and materials, all interviewees state that the visualization is effectively important. According to the words of M1 *"I consider extremely important any tool that visually projects the supply chain"*, it is clear that a visualization is easier to interpret, so at the outset can be better understood, and consequently, better applied in reality. Manager 2, along with the Manager 4 and Manager 5, consider that the visualization of the operation is important because it is easy to understand and allows to create a perfect sense of the flow, allowing us to get closer to

the intended reality. Manager 6 mention that it is always favorable. The workflow can be made simpler and more dynamic, points out the Packaging Manager. Manager 8 also mentions that it provides a more systematized operation. As for the thought that Process Managers perceive flow mapping as a useful tool for continuous improvement and waste reduction, but its success may be associated with the degree of knowledge of the tool (Mahapatra & Mohanty, 2007; Hodge et al.2011; Lu, Yang & Wang, 2011), it was also found in this research. In fact, it was found that in general this tool was known by a small number of employees. The managers who were familiar with this tool knew it only from a theoretical perspective, or from its application at clients and/or suppliers. During the Interviews, this was emphasized by all the interviewees.

In summary, it can be seen that all Process Managers, although they do not have a tool like the VSM in operation, believe it to be of enormous relevance, because it allows a simplistic visual projection, involving not only a single process, but the entire plant, including customers and suppliers, i.e., the entire supply chain. They state that with the possibility of linking the flow of information and materials, the whole chain can become more productive by reducing inventory levels, intermediate stocks, raw material levels, lead-times, and waiting times. Making it possible, to make the company more competitive, based on shorter response time to the customer, being more efficient and competitive.

It was clear that during the interviews, the Process Managers mentioned that the employees present in the field are a crucial vehicle of information, so they must be involved in analysis of value and material flow, including quoting the Production Manager 1, who states: *"essential and decisive for good results. Likewise, the Unit Manager, in addition to all other interviewees, reiterates the importance of production employees, unit manager considers that "on the ground is where things happen"*.

It is noticeable that the work environment is calm and tranquil, without any abnormalities. Table 4 shows the summary of these observations made during two different productive days in different periods.

Table 3
Summary of observations

	Yes	No	Not observed
Checklist	Sum		
The production is currently working.	xxxx		
There is lighting in the workplaces.	xxxx		
There is a correct indication of the layout.	xxxx		
The sewing machines are working normally.	xxx	x	
The employees have occupation.	xxxx		
The productive environment is calm.	xxxx		
There is a coordinated information flow.	xxxx		
The flow of information runs without human intervention.	x	xxx	
The flow of materials occurs without interruption.	x	xxx	
The flow of materials proceeds without human intervention.	x	xx	x
The flow of materials between staging and production takes place without supply failures on the production lines.	xxxx		
The finished product is allocated to the appropriate location.	xxxx		
They collect the produced upholstery in a timely manner.	xxx		x
The searched finished product is immediately delivered to the packaging.		xx	xx

Source: own elaboration.

Despite the different days, the flow of information and materials occurs in a similar way in the various periods observed.

Regarding the issue inherent to the cooperation of the processes involved and their participation in the design of flows, the interviewees generally affirm, 100%, that cooperation is essential. Manager 5 also states that all processes must be involved, an opinion shared by Manager 4, who emphasizes that participation is important. Referring to the Warehouse Manager, the map has to obey to a key feature, because as the Manager

says, "the map first of all has to be dynamic". Effectively is a fundamental condition, to the correct preparation of the map, because this in no way can remain static, without updating, having to show the situation and operation of the company, and all the processes involved, according to the Unit Manager.

5. Conclusion

Considering the actual performance focus in industrial and non-industrial organizations, the focus of this research relies on value creation, based on waste reduction. To understand, if mapping materials and information flow can contribute to continuous improvement, as well as the identification of waste, including waiting times, transit times and lead-times, thus allowing waste reduction and its costs for companies. Since these propositions were verified based on the interviews with the Process Managers, we wanted to know whether they perceive flow mapping as a useful tool for continuous improvement and waste reduction. However, its success may be associated with the degree of knowledge of the tool.

Highlighting the need to identify, if or how the flow of materials helps to contribute to continuous improvement. No workflow occurs without unexpected interruptions, but the aim is to identify these, to define improvement steps, in order to minimize actions without added value, so as task, movements, or excess of workflow. Another relevant topic is to try to reduce human intervention through automatic milk-runs, for instance. All in all, on hand of a VSM, all the flows, namely material and information are gathered, presented in one chart, to allow a complete a concrete overview of organization's performance, to afterwards, identify the flows or tasks that do not create value and might be banished (Womack et al., 1990; Womack & Jones, 1996).

Propositions were analyzed based on a Case Study conducted in an industrial company dedicated to the production of components for the Automotive Industry. To this end, Interviews were conducted with the Process Managers, based on a uniform script, with semi-structured questions, and completed by Direct Observations of the production environment on two days, two shifts, as well as two distinct periods, in order to obtain a more comprehensive range of findings.

Based on the propositions initially established, intersecting all the information collected through the literature review, and seeing this completed through the case study, it appears that the propositions initially defined can be effectively validated in full. It is concluded that the correct definition of the flow of materials and information can contribute to continuous improvement. Facilitating the identification of waste, namely waiting times, transit times, and lead-times, enabling the reduction of waste and inherent costs. This relevance of information and material flow mapping is perceived by the Process Managers, considering it useful for continuous improvement and waste reduction. It should, however, be noted that its success is associated with the degree of knowledge of the tool.

Generally speaking, all companies should analyze the functioning of their processes, to avoid errors and delays in the flow of supplies. The Lean Management method is considered truly essential; however, it needs a long implementation phase and extreme rigor in its implementation. It is imperative that pre-implementation precautions are carefully followed to avoid possible failures. All cost reduction is extremely important in the current macro-economic that we face, so that companies can continue to be competitive. Likewise, flexibility is of utmost relevance today, in order to keep customers satisfied while preserving current suppliers.

The limitations of this study reside in the selected methodology, since it is qualitative, namely a Case Study, which, for this specific research, was deemed to be the most appropriate, has its limits, since it does not contain quantitative analysis, and therefore there is a limitation regarding generalization to other contexts. The Case Study carried out in an industrial company involved, based on the Interviews, all the Processes of the manufacturing unit, since they were carried out with all the Process Managers related to

the production flow. The Direct Observations, however, were only made to the production sector.

Throughout this research, themes and areas emerged that raised interest for future research, namely, in this particular case, it is considered advantageous in a future study to proceed to the Direct Observation of the Processes that directly supply the production sector, in order to analyze and compare their respective flows. Additionally, in addition to the opinions of the Process Managers, it would be advisable to involve the perspectives of employees in a more executive position, in order to be able to contrast their statements and observations. It would be appropriate to associate more quantitative research methods, in order to complete certain gaps inherent in the qualitative method, namely with regard to the Case Study.

It is also considered advantageous to include in a next Case Study a range of industrial companies in the same area, to be able to verify the applicability of the tool within the same companies, ascertaining possible divergences or gaps. Additionally, it will be advantageous to focus a Case Study in the Services area, making the research also focus on a non-industrial area, in order to be able to ascertain and compare the results obtained in different areas.

Based on this research, the application of this tool for mapping the flow of information and materials leads to continuous improvement, and therefore an advantage is evident in the application of the same in the industrial company, in which it was verified, advising its replicability to other sectors and entities.

Acknowledgements: The authors gratefully acknowledge funding received from NECE – Research Centre for Business Sciences and FCT - Fundação para a Ciência e a Tecnologia, Grant: UIDB/04630/2020, DOI: 10.54499/UIDP/04630/2020.

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Appendix - Interview script

- I. Motivation of interviewees and legitimization of the interview
 - o Informing the interviewees about the ongoing research.
 - o Ask for their cooperation, stressing the importance of it.
 - o Request permission for audio recording of the interview.

II. General data collection

o Identify the employment status of respondents

1. What is your name and position?
2. Allow me to question your age and level of education.
3. What is your professional background, and seniority in the company?
4. How has your professional path been?

III. Respondents' opinion about the value chain

o Identifying the picture they have of the value stream mapping

o Understand what role they assign to mapping the flow of information and materials

5. In your point of view, how important is cost reduction?
6. The predefinition of the flow of information and materials is vital for the correct unfolding of the processes?
7. Knows the technique of analysis of the flow of information and materials VSM (Value Stream Mapping)?
8. Understands, that the application, of a VSM mapping, is favorable to the definition of the flow of information and materials?

IV. Identify the representations of the interviewees about the involvement of the processes o Understand how the interviewees understand this progress, as being an asset.

o Identify possible strategies of articulation between intra-company processes and extra-company

9. Through the implementation of this map, VSM, all processes could be make you more productive, reducing lead times, and inventory levels extraordinary?
10. What is the advantage of the map regarding the acquisition of raw materials? Do you understand that the transport of raw materials, in groupage type transports, is favorable to the reduction of the transit-time and delivery frequency?
11. The elaboration and application of an information and material flow mapping, is considered, of added value, both upstream and downstream of the company. What are the relevance, in your point of view?
12. Inherent to each process, what benefits may follow from the implementation of VSM?

V. Respondents' representation of overall stakeholder involvement.

o To know the respondents' conceptions about the transversal application of mapping

o Identify future trends and needs.

13. The mapping status is dynamic, so it needs to be updated. Understands that Is the cooperation of the processes involved relevant in the design of the flows? The collaborators present "on the ground" should be able to interact in the design of the respective map?
14. Are there any suggestions that you would like to mention, regarding the efficient elaboration of the map value stream?