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The implementation of a Warehouse Management System at small and medium-sized enterprises: Developing an automated warehouse management system at Sindatex

MALEK KHOFFI

Work project carried out under the supervision of:

Professor Alexandre Dias da Cunha

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Abstract

A combination of research methodology approaches has been employed in this paper. This includes a theoretical framework that elaborates the problem identification and the existing supply chain process for introducing an automated Warehouse Management System, followed by a detailed literature review regarding the complemented supply chain software and hardware to ensure the success of the new architecture within the warehouse. The work project involves the critical success factors as well as the key challenges towards a smart Warehouse Management System. A practical application of a Tunisian medium-sized textile company illustrates the logistics dynamics after integrating the new management process.

Keywords:

warehouse management system, enterprise resource planning, small and medium sized enterprise, order fulfillment, supply chain, barcodes.

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1. Introduction

Throughout the course of the three-month internship, the author had the opportunity to focus on a particular topic consisting of "The feasibility study of integrating an automated Warehouse Management System". The company is thinking about investing in a software application where the goods can be automatically distributed over the warehouse to optimize its supply chain operations. This paper comprises an academic literature review associated with the key challenges and critical success factors of the implementation of an intelligent Warehouse Management System as well as the practical application of this approach for inventory control and tracking using barcode scanning.

1.1 Company Overview

SINDATEX is a medium-sized textile company located in Tunisia, more precisely in the industrial zone of Tunis, with about 35 employees[1]. Since its foundation in 1994 by Hamdi Khoffi, the company is still managed by the first generation and reckoning more than 26 years of experience and expertise. The activities of the business incorporate different ranges of clothes, furnishing and dressy wholesaling. With a customer base of 537 clients, Sindatex has achieved a diversified set of clients such as retailers, wholesalers, tailors, hawkers, interior designers, and decorators. Referring to appendix 2, the organization's operating revenue counts for approximately two million Tunisian dinars (DT)[2] in 2019.

At the beginning of the 90s, the imports triumphed in Tunisia. Therefore, it was the peak of all the industries and the gap of opportunities that have been spurred by. According to Word Integrated Trade Solutions, France, Germany, Belgium-Luxembourg, and Netherlands were the top partner regions from where Tunisia imported textiles and clothing. Consequently, the

[1] Please see Appendix 1 for further information about the organizational chart of Sindatex.
[2] An amount equivalent to 614,039.69 €.

owner has decided to differentiate himself among his rivalries and discover the Asian market. In 2005, Hamdi Khoffi definitely shifted his suppliers and only focused on the Chinese market. Despite knowing that this market was challenging to access, he overcame all the faced drawbacks, whether in terms of language or regarding the governmental challenges and restrictions within both China and Tunisia. In 2009, the well-known Turkish market, with its prominent history of textile manufacturing dating back to the Ottoman Empire, made a big appearance within the textile Tunisian market. Therefore, Hamdi Khoffi decided to explore the Turkish market and fortunately succeeded in building a harsh network of Turkey suppliers. At the moment, Sindatex is entirely operating with 4 Turkish suppliers for furnishing fabrics and 10 Chinese companies for wholesaling clothes fabrics.

1.2 Company's supply chain

Sindatex' warehouse is situated in Charguia where the allocation of goods is processed and fabrics' wholesaling occurs. The location of the warehouse is advantageous for Sindatex because it alters transportation facilities between retail stores and is near the highway. Besides, three different retail stores situated downtown, main Avenue Bourguiba Street, operate in the retailing of fabrics. In 2020, no less than 60 containers are supplied from China and Turkey. Depending on the type of the fabric weight, the number of rolls[3] per container can range from 1,000 to 3,200 SKUs. The average number of rolls often available in the warehouse can vary from 10,000 to 25,000 SKUs.

The generic supply chain of Sindatex is divided into two parts which are the inbound and the outbound logistics. The inbound logistics starts with the sourcing of suppliers (e.g. lower cost, better quality, fabric weight) whether in China or Turkey. Then follows the extraction of the

[3] A cylinder formed by winding fabrics around a tube, one roll can unfold between 18 and 58 meters, please see appendix 3 for further information.

most demanded types of fabrics in the Tunisian market. For Sindatex, there is a selection of 70 types of fabrics. After the order's placement, the supplies are filled by a third-party logistics (thereafter 3PL) to ensure that the available quantity and quality, as well as the industrial packaging, are adequate to the order accuracy. Besides, the logistics provider in the foreign country is in charge of the shipping of goods and the flow of financials for Sindatex's. The total lead time for order transmittal, processing, and preparation is agreed upon one month for China and two weeks for Turkey. There is no other way to alternate the maritime procurement of fabrics in order to reduce the lead time. Using another mode of transportation will eventually optimize the inventory levels, but it will further increase the shipment costs. Once the goods are received, a Tunisian 3PL is responsible for this part of activities regarding the transportation and information-based documents (freight insurance, consulting, and advisory services in the harbor). Then proceed with the outbound logistics when the order is received in the warehouse. Eventually, an inspection of items according to the packaging list of suppliers is completed. Later comes the materials handling of the goods within the warehouse of a 3000 square feet of three-floor plan featured by two mechanical hoist escalators of 15 square feet. This logistics activity includes equipment such as a forklift truck and a pallet (See appendix 4) for the placement of goods from storage to order-picking areas and finally to dock areas to the trucks that are next delivered to retailers.

1.3 Problem identification

After scrutinizing all the company's strengths and weaknesses during the internship, the author identified an over-exhaustion of the employees and an accountability towards managers that created conflicts at work. In addition, multiple problems were observed such as: (i) mistakes in order fulfillment every so often which lead to customer dissatisfaction, (ii) an inadequate inventory levels and accuracy, and (iii) an ambiguity in the decision making related to the

choice of the most demanded fabrics. Most of the identified issues seem to be related to the integrated outbound logistics.

In the following, the author thoroughly explains the problems faced by Sindatex:

Firstly, Sindatex uses a software called "Exclusive Commercial Management" (thereafter "ECM"), written in the Java programming language for Enterprise Servers. "ECM" provides all the information related to the payments, discounts and commercial invoices. It is perceived to be quite old compared to the newly released programming languages. The issue is that "ECM" hasn't been updated since it was last integrated in 2007. Even the calculations of the number of rolls by each fabric type's price (See appendix 5) are performed manually and have to be twice checked, which can take more than 45 minutes until the invoice bill is prepared. When many customers appear, the waiting time rises hence the employees in charge of the tasks have to rush. In consequence, a large margin of errors emerges, which is chaotic for Sindatex if there is a misleading of the types of fabrics. As long as the prices of the 70 types of fabrics per meter vary within an interval of 3,800 (DT)[4] and 18 (DT)[5], one error in the price of fabrics when multiplied by thousands of meters, can cause a loss of millions of Dinars. Besides, it is unethical to inform the customer about the missing fees. In the worst scenarios, if the amount is higher than 1000 (DT)[6], managers have to contact the client, that eventually leads to customer dissatisfaction. Unfortunately, the encountered losses due to miscalculations are often estimated to be up to 100,000 (DT)[7] per year which is equal to 5% of the total revenue in 2019.

The second concern is the allocation of rolls in the shelves of the warehouse, which are sorted out randomly, without any track or a linear barcode system, so the employees who are responsible for the allocation of goods had to memorize all the locations within 200 shelves for

[4] An amount equivalent to 1.17 €.
[5] An amount equivalent to 5.53 €.
[6] An amount equivalent to 306.97 €.
[7] An amount equivalent to 30,528.06 €.

70 types of fabrics. Therefore, the placement of rolls is not running optimally for the company's health and will pilot poor traceability within the inventory management system. Accordingly, there will be terrible consequences in terms of customer service since the improper location of goods often does not meet the customer's order requirements. The total waiting time for order fulfillment that customers face can go from 45 minutes to 90 minutes. Referring to the waiting period, the order processing should be correct to meet customer demands. Nevertheless, this is not the case for Sindatex since there is always misinterpretation of the types and quantities of fabrics. Therefore, the resource misallocation will lead to loss of sales and customers. Last but not least, it will further guide the way to the inaccuracy of inventory management as long as the order fulfillments are frequently wrong.

The third concern is the insufficiency of the inventory accuracy, the registration of inventory levels in Sindatex' information system often does not coincide with the physical state of the rolls. This leads to the point that there is frequently an inventory overload or the other way around, an inventory stockout since managers didn't acknowledge additional safety stocks and didn't manage uncertainties in the long term. Those kinds of incidents make it more complex to keep a high level of inventory and to meet customer demands. Finally, before the execution of the order in China or Turkey, a lot of meetings are scheduled to forecast customer preferences. The author has attended several discussions that were time consuming because the customer mindset in the time-sensitive textile market is changing fast hence the employee’s sourcing of the last trends of fabrics could be inaccurate. On that account, a statistical forecast using a knowledge base and simulation modeling could alter those kinds of decisions validly.

To conclude, the absence of an efficient Warehouse Management System regarding inventory levels and allocation of resources over the depot have been identified. Thus, a new state is needed to create an arrangement of the supply chain processes.

2. Literature Review

2.1 Definition of Warehouse Management System

The Warehouse Management System (thereafter WMS) is a revolutionary tool in scheduling, planning and tracking inventory (Min, 2006). A more comprehensive definition comes from Apak, Tozan & Vayvay (2016), who point out that WMS is a system that controls all the movement of goods within the company and is used to (i) reduce inventory and labor cost, (ii) improve storage capacity and inventory accuracy, (iii) prosper customer service. Therefore, an implementation of WMS will lead to the rejection of order fulfillment errors since it will improve the total order-picking process by reducing the search time by 30% (Broulias et al., 2005). Last but not least, according to the Technical White Paper, this integration aims to maintain an optimum space utilization as well as knowing where exactly all the goods are stored at any given time (2013). On the whole, WMS can be an excellent investment for companies to gain a competitive advantage and enhance inventory management.

2.1.1 The importance to choose the right WMS

When it comes to implementing new technology, small and medium-sized companies often choose an innovation that does not suit their business's goals and needs, leading to significant financial losses or bankruptcy in the worst scenarios. According to Apak et al., (2016), the implementation of WMS is a very puzzling and expensive task. Hence, firms have to assess their systems with significant criteria and implement them suitably to improve performance efficiency. It is crucial to examine which WMS types to select because such execution will have a huge impact on the long-term' operations. Thus, it is of utmost interest to scrutinize what is the added value of the software. "The most important part of the software selection process is defining the processes within your organization and determining functionality that is critical to your operation" (Piasecki, 2012, para. 5).

2.1.2 A generic distinction between the types of WMS

The majority of the literature papers about WMS such as (Ramaa et al., 2012) and (Faber, 2015) still use the three classifications of WMS of Dusseldorp (1996):

(1) Basic WMS: supports stock and the allocation of supplies. The identification of goods is possible by using scanner reading tools. The system can register the data and generate the storing and picking processes. This type focuses mainly on throughput.

(2) Advanced WMS: has the same features of the basic WMS, but more than that the advanced WMS can master resources and synchronize the flow of goods.

(3) Complex WMS: is used to optimize the difficult operational process. This type can interface with different technical systems (e.g. robots, Radio Frequency identification).

Into that bargain, Rogers (2011) details further on the first and second types of WMS. He states that a Basic WMS assists daily functions whereas the Advanced WMS supports replenishment, cycle counting, productivity and above all the automatic identification and data capture.

2.2 The definition of Enterprise Resource Planning

The coalescence of the WMS is only efficient when it is combined with Enterprise Resource Planning (thereafter ERP). According to Haddara (2014, p.395), ERP is an integrated all-in-one management process for the organization's information-processing needs that can standardize information flow across all the departments. It allows the company to (i) integrate the business process, (ii) share the real-time data across the entire enterprise and (iii) use a common language and file to be understood by the integrated systems (Rogers, 2011). All the movements executed in the WMS are updated in the other modules of the ERP system (De Assis et al., 2018). Finally, yet importantly, the system optimizes stock based on real-time information by using Automatic Identification and Data Capture, which is a fundamental technological attribute for better traceability and tracking (Ramaa et al., 2012).

2.3 Automatic identification and Data Capture Technology

Automatic Identification and Data Capture (thereafter AIDC) is one of the most useful technological advancements that businesses have exploited over the last decades. Moreover, AIDC is an automated process that managers use to collect tasks in which sensor systems, repeatedly manipulated by humans, are used to identify objects and accumulate data from items, images, or even voices (Gunter et al., 2009). Consequently, the collected data are automatically saved in the WMS, where it is afterward classified and aggregated. This technology is practiced to oversee inventory, assets, files, and security. AIDC involves distinct technologies such as barcodes, biometrics and Radio Frequency Identification (thereafter RFID) (Whitman et al., 2007). One example of a biometric device is the infrared cameras that capture objects from a determined distance. According to Williams et al. (2017), infrared cameras are used to identify products, locate their placement, count the inventory facings, and even identify the missing items. However, RFID and barcodes are auto-ID technologies that aim to anticipate fast and reliable goods identification and tracking capabilities (Kim et al., 2013). On that account, companies have to choose the best AIDC technology to capture their product identification database depending on the type of sector and the size of their business.

3. Implementing a successful WMS at Sindatex

According to Moore et al. (2009), small and medium-sized enterprises (thereafter SMEs) play a major role in the world economic development as they account for more than 70% of the world's production. Shibin et al. (2018) take the view that innovation and sustainability are closely connected and in order to develop durable business, SMEs should be able to overcome problems by effectively managing knowledge and technology which influence the feasibility-oriented innovation in the supply chain process. Nevertheless, to support the long-term sustainability, SMEs have to absorb change agilely to remain strong in a stormy environment

through a full commitment and acceptance of the new situation. With this information as inputs, the author assessed the key challenges and success factors of integrating an automated WMS for Sindatex referring to evidence from SMEs. Furthermore, an interview with the CEO of a textile retail company was conducted to oversee the possible functionalities and challenges of applying this new structure.

3.1 Critical success factors of implementing an intelligent WMS at Sindatex

There are countless advantages of integrating an automated WMS, especially in today's world. We sat foot into the industrial revolution 4.0, where a shade of technology tingles every aspect of our lives. As a matter of fact, Min (2006) and Hamdy et al. (2018) have identified the critical success factors of implementing an intelligent WMS which are:

1) Increase labour productivity by controlling and prioritizing tasks:

Fortunately, the implementation of WMS will bring benefits to the top managers since it is a system that records the specific time and the exact performance that the employee devotes for a given task (De Assis et al., 2018). During the internship, the author observed whether an under or over performance of the employees. Notwithstanding their commitment and devotion to Sindatex, not all the workers are considered efficient and productive. For example, the accounting supervisor is often held responsible for all the mistakes of the order fulfillment, whereas she has no relation with this part of logistics. Keeping that in mind, she performs multiple tasks that are not related to her responsibilities such as the supervision of the movement of goods. With an automated WMS, the tasks of each employee will be aligned and prioritized and everyone will be held in charge of his/her work .

2) Eliminate order fulfillment errors:

A Cycle Counting (thereafter CC) is an inventory procedure, where a group of elements, in a specific location are counted on at any given period of time (Apak et al., 2016). Thus, it

monitors inventory levels continuously. For Sindatex, the inventory is counted manually. First came the storage of goods by colors, then a verification against the suppliers' packaging list and lastly the insertion of all the rolls into "ECM". The fact that the rolls are introduced without any details is perceived as an issue. For example, when a customer orders 120 and 80 rolls of respectively red and blue Fibranne[8], the order is inserted into the ERP system without identifying the colors, such as 9,600[9] meters of Fibranne. Therefore, this structure will further increase order fulfillment errors by ignoring the number and quantity of rolls left per color by each fabric type. The company also encounters a considerable margin of error in terms of inventory accuracy[10]. On that account, the WMS could be strengthened by using AIDC[11] that identifies the exact rolls automatically and updates them into the system.

3) Increase space utilization:

With the new architecture of the system merged by a scanner reader, the rolls are pinpointed to exact their locations. There is a lot of wasted space in the warehouse as aforementioned in section 1.3. According to Richard (2017), “Many managers will say they are running out of space, yet when you walk around the warehouse, you may see obvious signs of waste”. Thereby, the automated WMS can arrange the total floor space utilization directly, which will result in a better shelf replenishment of pallets and consequently in a worthy use of the available warehouse space. Hence, Sindatex won’t pay for additional storage expenses.

4) Reduce errors by decreasing paperwork:

The process of only one container of 20ft or 40ft requires more than 300 sheets of operational and administrative documents to process manually into “ECM”. The number of rolls per container varies from 1,000 to 3,200 depending on the fabric weight. The huge amount of files will lead to the misinterpretation and confusion of data since employees are

[8] A type of fabric of clothes.
[9] (120+80)rolls*48 meters.
[10] Described in section 1.3.
[11] Definition in the Literature Review in section 2.3.

exposed to thousands of numerical evidence and countless variety of fabric's colors and types[12]. For example, the employee responsible for counting the received goods could be misunderstood by the person that is writing the number of meters for each roll in the inventory report. The mistaken numbers will be later inserted into "ECM" and create confusion in the system. Therefore, the implementation of a smart WMS will remove the traditional paper-and-pencil approach which will lead to a paperless environment that ease the transfer of data, hence it will diminish the number of errors related to the inserted files.

5) Decrease counterfeiting, fraud and theft:

Sindatex had noticed a great deficiency in their financial performance 12 years ago. The owner had to wait several months to detect which employee was responsible for this theft. Eventually, one of the top managers had stolen an amount of approximately 120,000 (DT)[13] over an interval of four years, so he won't get caught short. Back then, it was a huge turmoil for Sindatex in all terms. Consequently, an advanced WMS will ensure the automatic updating of the overall information and will hinder every tentative of theft or counterfeit.

In general, WMS can pilot a 25% gain in warehouse productivity, an inventory accuracy of approximately 100%, an improvement in floor space utilization of 10 to 20%, and a decrease in safety stocks by 15 to 30% (Autry et al., 2003, Smith 2003). The mentioned critical success factors, especially the accuracy of order fulfillment (no.2), will lead to an impulsive improvement of customer satisfaction. Finally, implementing an advanced WMS needs factors to ascertain that this new philosophy will be fully internalized within the company. The factors that could push the change consists of empowering the managers through keeping and engaging the employees informed of the new benefits of a smart WMS. By doing so, a decrease of skepticism towards change by all individuals in the company will be observed.

[12] 70 types of fabrics: there is a range of 10 to 15 colors for each fabric.
[13] An amount equivalent to 36,842.11 €.

3.2 Key challenges of introducing an intelligent WMS at Sindatex

Despite the rosy picture illustrated in section 3.1, WMS implementation is quiet a challenging task. The first and most important problem is the cultural shock that employees will face when such changes will take place within the organization. The workers in Sindatex have a powerful explicit and implicit knowledge about every organizational aspect and production process. In particular, they approximately know every single piece of information related to more than 300 clients. Additionally, and as aforementioned in section 1.3, the software hasn't been updated since 2007. Therefore, the traditional mechanism of the company has strengthened their memory and their commitment. On that account, they are very skeptical towards any form of change, fearing that the introduction of an automated WMS will lead to discharging employees, therefore to lose their jobs. Moreover, they are reluctant to break their routine tasks, habits, and daily process. In consequence, the introduction of an intelligent business system may be threatened if employees won't make an effort to effectively understand the intricacies and complex features to make it work. This is a matter of a simple keystroke that can cause ambiguity within the whole organization's logistics. On that account, the author had the opportunity to visit an automated textile company called "World Trade Textile," to interview[14] its owner, Slim Trabelsi. They operate in commercializing the furnishing fabrics and are the first textile retailer to implement a barcode on WMS in Tunisia. Despite a long workshop that has lasted almost one month to provide employees with continuous updates and guidelines regarding the theory and practical application of the WMS, Slim pointed out that there was permanent ambiguity and breakdowns of the system. Therefore, he had to pay the software vendor an additional 3,500 (DT)[15] per month to be always available in case of blurriness so that employees won't generate any animosity towards the intelligent WMS. On another hand,

[14] The interview was documented using a voice recording device.
[15] An amount equivalent to 1,074.56 €.

Sindatex is a family owned-business; thus, it is not surprising that there is an excessive focus on stabilizing and sticking to the traditional roots frightened by challenging the status quo. According to the research on organizational culture suggested in the book *Family Business*, the culture has to be flexible, adaptive, and agile in terms of change otherwise it will present defiances to the adaptation to changing competitive environments (Poza, Family Business, 3rd Edition, 2010, p. 223). The owner of Sindatex has a tight attachment to his business strategy and operations. Therefore, a generated sense of urgency towards reshaping the architecture of logistics is not perceived as a necessity because he is worried about the stability of the company's status quo when such change occurs. Indeed, Hamdi Khoffi is anxious about throwing his initial strategies away and that the company's operations will be blurred with such unforeseen technological implementations. The fact that he is perceived by his employees as the primary instrument of the organization is somewhat a challenge for change. They could be very influenced by his behaviors and actions. On that account, a successful implementation would require that the leader becomes less skeptical and resistant about the cultural change so that employees will be more encouraged and motivated to articulate a better vision of the company after this integration. According to Beckhard-Harris (1987), to meet the challenges of skepticism towards a smart WMS, SMEs usually use this Change Equation. Referring to appendix 6, Harris suggested that the product of (i) Dissatisfaction with the status quo, (ii) the Vision of the desired future, and (iii) the First Step of Change is greater than the existing Resistance. If any element is equal to zero or low, then the product will be null and can overcome the natural resistance to change. To prevent this, the company has to implement a clear vision, and the CEO, employees and managers have to be determined for the implementation of the new WMS. Finally, "A rule of thumb is to examine whether the WMS software contains 85% of the features that users are looking for" (Min, 2006). The software criteria differ from one company to another. WMS's success stands on the accuracy of data

supplemented by other supply chain systems. For this reason, a complete understanding of the technical features of the fully-integrated WMS paired with the extensive modifications of the ERP has to be performed by all the employees, including the owner, before the full-operationality of the system since the main goal for Sindatex' operations is "to provide a set of computerized procedures to manage the movement of inventory and orders within the warehouse, and enable a seamless link to order processing and logistics management" (Graves, 2013, p. 39). Otherwise, the misinterpretation of the software' features will lead to a continuous upgrading of the WMS functionalities. Last but not least, in many cases, SMEs consider the implementation of the WMS system as an investment and draw wrong conclusions about the high costs that it necessitates such as costs of maintenance, training and modifications.

4. Practical Application - Sindatex

After becoming acquainted with the theoretical background of implementing a fully-integrated WMS and the critical success factors as well as the key challenges of this change as the effective acknowledgment of having a smart supply chain management, the second part of the work project deals with the practical application of the design and implementation of WMS. The author of this paper was employed at Sindatex in order to facilitate the introduction of the new system by formulating specific requirements for its configuration to meet the particular needs of the company's operations. On that account, a reputable software vendor, who is specialized in developing and making customized software according to the company's specific needs, was often interrogated to support the study of the execution of the automated system. Moreover, the author has been in direct collaboration with "World Trade Textile" employees and CEO as a very helpful basis to model the integration of the systems and analyze the new situation of the implementation of WMS.

4.1. Requirement selection of software:

4.1.1 The selection of the type of WMS

The first step to assess what the features and the possibilities are to discern the best-fit of WMS is the selection of one of the three types of WMS mentioned in the Literature Review. The Basic WMS only assists the primary daily functions of throughput, whereas the Complex WMS is applicable for cross-docking[16] operations. In contrast, the Advanced WMS supports cycle counting[17], slotting optimization[18], inventory management, and AIDC technology. Moreover, this type of WMS assists the replenishment of goods by sending a notification to the operator to place an order so that the warehouse doesn't run out of supply. It also measures the productivity of employees and detects which individual is responsible for erroneous operations. Therefore, the Advanced WMS is the type of WMS that best suit the specific case of Sindatex since the emphasis is more on logistics and supply chain management rather than production. After choosing the type of WMS that combines properly with the specific needs of Sindatex, a set of alternatives for selecting the most appropriate logistics software and its vendor has been conducted[19] based on several criteria. Consequently, ScanTech is the name of the WMS software that will be used for the company, hereafter S-WMS. This system is not only an enhancement for inventory accuracy and warehouse space utilization, but rather it provides dashboards and statistics related to every single detail, such as the rate of movement of goods over time (e.g., daily, weekly, monthly, annually) and the filling rate per location (Scantech, 2014). Besides, S-WMS can structure the warehouse hierarchy according to different sets of colors, types, shelves, and zones. As stated by the software vendor, the Advanced WMS will

[16] Products are directly distributed from supplier to the end-customer without handling or storage time.
[17] Previously explained in section 3.1 (no. 2).
[18] Allocates the often-purchased rolls to the most reachable warehouse' shelves.
[19] For deeper analysis about the software and vendor selection, please see appendix 7 and 8.

cost Sindatex 45,000 (DT)[20] to purchase. The author has seen the functionalities of S-WMS when visiting the company "World Trade Textiles". The software could give an overview of the best-selling fabrics, the most present or absent clients, which state of Tunisia is buying the most, and many other functions that could deepen insight into the company's operations. Furthermore, S-WMS provides a statistical forecast of the operating revenue, sales per colors and types, the number of days for shelves to be empty for a specific type of fabric, and the list of functions goes on. However, to improve warehouse visibility, it is essential to question oneself, what should be the best tool for traceability and tracking of goods ?

4.1.2 The AIDC technology and barcodes

The success of WMS often rests with the quality and speed of data collected that are often supported by AIDC technology. As aforementioned, RFID and barcodes are the most used auto ID-technologies that anticipate fast item identification. After comparing the application areas of RFID and barcodes' systems, summarized in appendix 9, barcodes' functionalities seem to have the edge over RFID in terms of utilization and cost-efficiency. After choosing the type of AIDC technology, a distinction between 1D and 2D barcodes is assessed; the difference is the amount of data stored. However, during a meeting with the CEO of "World Trade Textiles", he points out that Code EAN 128 which is a 1D barcode is the best fit for the specific case of Sindatex. 2D barcodes are mainly used to track data, but the issue is that it goes along with complex and expensive barcode scanners while Sindatex only needs to capture a specific item with digital letters and numbers. The barcode scanner will cost the company around 2,500 (DT)[21] to purchase. On the other hand, the company has to settle a certain logic of the common language and design of barcodes with its suppliers; hence when the goods are received, the barcode scanners can easily read the QR code. Following the software vendor suggestion, it is

[20] An amount equivalent to 13,731.63 €.
[21] An amount equivalent to 762.87 €.

much easier for textile goods to implement a barcode with only 19 digits. Therefore, a set of characteristics that will ease the life of Sindatex' employees and the suppliers was prepared and introduced. As mentioned in appendix 10, the barcode includes 6 blocks of data: S represents the company's first letter, the second block is the suppliers' code, then comes the code of colors and the type of fabric, and finally the length and the serial number of the roll. Besides, a study of the number of infrared cameras according to the warehouse size has been conducted. In order to scan the rolls from all angles within a 3000 square feet plan, 56 cameras should be placed. The total cost of the infrared cameras is equal to 28,000 (DT)[22]. In conclusion, the incorporation of barcode scanning into WMS can generate synergy within inventory locations. Nevertheless, the synchronization of the overall data needs to be properly liaised with an ERP system.

4.1.3 Systems integration

As previously mentioned, Sindatex uses "ECM" as its ERP system, the integrated management software that collects and stores the data for several functions: accounting, invoicing, and inventory management. The Advanced WMS cannot operate in isolation; it should be integrated into the present ERP system. However, "ECM" is quite old and does not meet the specific needs of the current warehousing management system. Hence, a total reshaping of the ERP system that has always been vital to the company should occur before the integration of the S-WMS. In that account, the software vendor that will execute the Advanced WMS is ideally the same that will structure the new ERP system. Nonetheless, this is quite an issue for Sindatex because the process of developing a more sophisticated and specialized ERP software has been conducted two months earlier by a different software vendor[23]. But as long as there is a synchronization of the supply chain operations where ERP and S-WMS systems complement

[22] An amount equivalent to 8,544.12 €.
[23] Changing this decision was not within the degree of freedom of the current Work Project development.

each other and the transfer of data collected by the Advanced WMS is accurately shared with ERP, that won't raise a concern anymore. Therefore, software vendors have to be flexible in the integration of both ERP and S-WMS. Otherwise, erroneous data or faulty processes introduced will lead to the total project failure. In addition, the Transportation Management System (thereafter TMS) is an operation platform in Sindatex that processes the data related to carriers, shippers and customers as well as freight and transportation reports. TMS helps the organization to make services more agile and flexible. The integration of the overall systems, described in the figure below, starts with the tracing of goods. Using a barcode scanner, the items are tracked and later stored in the S-WMS. Then the Advanced WMS centralizes the data and coordinates the inventory control management to report and introduce the updated information to the ERP system. The integrated all-in-one management process will afterward standardize information across all the departments based on the real-time environment. For its part, TMS will enhance the synergy of the outbound and inbound logistics with S-WMS and will benefit from the order management functions and detailed data about customers (e.g., transporter name, address) that arise from ERP. Thus, ERP will facilitate the preparation of shipments for TMS. On the other hand, the ERP system will exploit the data transferred from TMS to update the status of customers' orders. Last but not least, S-WMS along with barcode scanning will provide transparency into the warehouse activities and will optimize the operations as business demands change, while the ERP system will utilize all the company's collected resources to provide an integrated solution for up-to-date logistics management within Sindatex. Along with TMS, a better control of the transportation flow will occur through the real-time information fed by S-WMS. Moreover, an improvement of Customer Relationship Management within the ERP system might also result since TMS returns data to the ERP to improve the customer's orders. To conclude, all the functions involved in the integration must be aligned with the business processes.

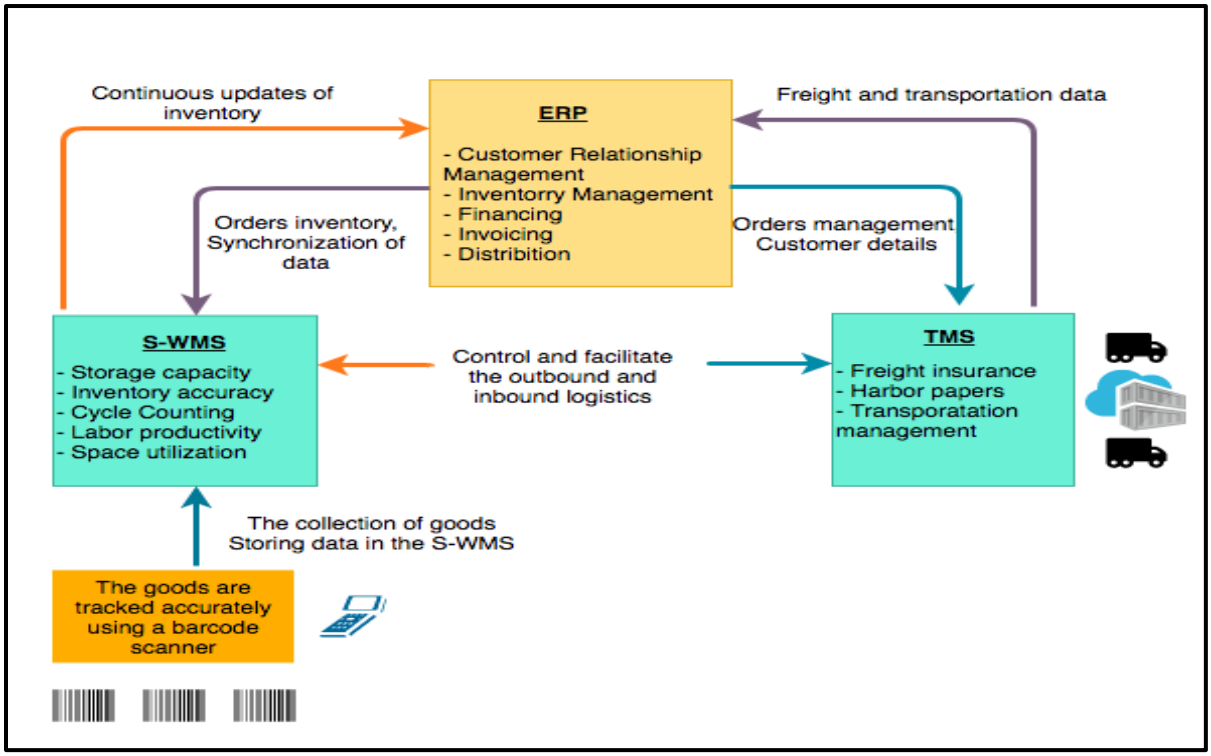

Figure 1: The integration of the Advanced WMS with supply chain systems ERP and TMS along with barcode scanning.

4.2 The logistics dynamics after WMS

The new situation differs a lot compared to the current situation especially regarding the reception and the storage of goods. Currently, Sindatex assists the reception of goods based on a hand-written delivery document to check the order's accuracy then rolls are stored randomly over the warehouse free shelves. After allocating the pallets, the administrative papers are keyed into "ECM" without identifying the colors of rolls. Regarding the outbound logistic process, to prepare an order, employees have to search for rolls over the warehouse. Once found, every picked item is written down on a report. Noting that when an item is removed from a shelf, there is no update of inventory capacity within the system. The difference between the current and new situation is the traceability of items, the automatic updating of orders and inventory level that will enhance efficiency and transparency in every aspect of the warehouse operations besides the other functionalities such as re-warehousing and cycle counting. After

having a holistic understanding of the change of the process flow and the deployment of the Advanced WMS with the supply chain software (e.g., TMS, ERP) along with barcode scanning, a total reshaping of the logistics chain will take place within the warehouse in the new situation. The inbound and outbound logistics are explained below:

The process of the reception of goods: The advanced shipment note, a confirmation for the received goods, enables the warehouse to assign location shelves so that the reception of goods is prepared in advance. Transported from the harbor, the goods enter the warehouse and are unloaded. All the information related to shipment numbers, carrier details are keyed into the TMS system. The goods are palletized and later tracked by an operator using a barcode scanner. This step will ensure that the supplier document of barcode labels is similar to the goods furnished. Therefore, when the operator scans the item, the barcodes are automatically verified and processed in the S-WMS as received items. Hence, there is a continuous updating of the inventory level. In the case of deviation in the amount of inventory against the supplier's document, S-WMS issues a threshold alert[24] to prevent errors in the received goods.

The storage of goods: The process continues with the storage of goods as S-WMS, along with infrared cameras, uses algorithms to automatically determine where the rolls should be located among the free shelves. The items are handed over from the receiving to the storage zone. The forklift truck places the goods through the assigned shelves. The infrared cameras automatically trace the items that are placed by mistakes in the wrong shelf location. Consequently, a notification in the system representing a misallocation of goods is triggered. Finally, the amount of inventory and allocation of goods are instantly treated by the Advanced WMS when the received items are stored on their assigned shelf. There is a constant approximation of the amount shipped out and the leftover rolls in the S-WMS. Moreover, all the information are subsequently communicated with the ERP so that data are upgraded.

[24] An automated email notification.

Order fulfillment process: The order fulfillment process starts when customers enter the warehouse and place the order. The operator inserts the filling order to know exactly the quantity and the location of rolls. The S-WMS then guides the employee responsible for the order preparation to pick the materials in their respective location. When the goods are collected, the outgoing rolls from the shelves are scanned by the infrared cameras again to register the shipped goods so that the order fulfilled is removed from the inventory in S-WMS.

Production planning process: In conjunction with simulation modeling and updates forecasts of the supply chain systems, Sindatex could generate an overview of the safety stock and lead time demand. In this context, S-WMS aggregates data and exports them to the ERP system where the reassessment of inventory occurs. The missing data in the S-WMS are completed and matched with the ERP system's information that are interconnected to all the departments within Sindatex. Therefore, the replenishment of inventory is further accurate and has less chance of human errors related to fabrics' selection and sourcing. Hence, the order placement for the suppliers in China and Turkey is performed using the ERP system, an email is prepared and eventually sent whereupon all the label codes are accommodated and depicted by the quantity and colors' information.

To conclude, the new situation of logistics will solve the identified problems previously discussed in section 1.3. The activities of Sindatex are mainly managed by the Advanced WMS and the ERP system. There is no more need for hand-written documents for the incoming and outflowing rolls. This will lead to a significant reduction of mistakes concerning the inventory capacity and order fulfillment. Since the new integration helps employees prepare well-structured orders by guiding them directly to the right shelves' location, this will eventually support the way to customer satisfaction. Consequently, the lead time of order transmission, processing and shipment will be shortened. Instead of waiting 45 to 90 minutes, the customers won't exceed 30 minutes to have their orders satisfactorily fulfilled, according to "World Trade

Textile" employees. Last but not least, the ambivalence of decision-making processes related to the sourcing of fabrics won't present an issue anymore because the Advanced WMS supports the replenishment of goods. Finally, the implementation of a smart WMS reaches the needs of the supply chain operations of Sindatex, especially the functionalities regarding picking, inventory adjustment, order replenishment and cycle counting.

5. Limitations

Even though this integration is a total benefit for Sindatex, it is possible to enumerate some limitations that need to be observed. Firstly, the total cost of the implementation will approximately be around 129,400 (DT)[25]. The initial expenditures for the new system are insignificant compared to the losses encountered yearly for the company. However, the total amount for this technological development as a one-time investment could be seen as a perceived risk for the owner. The second challenge is that ERP and WMS software are integrated separately by different vendors. There should be an outstanding amount of data processing to keep both systems synchronized. Therefore, the additional cost and time of interfacing the information have to be taken into consideration. The third challenge concerns the barcode labels of the damaged pallets during the transportation process. The labeling of the rolls can be error-prone. With that in mind, a barcode printer should be purchased. Otherwise, the rolls cannot be tracked by the barcode scanner and cannot be allocated to their assigned shelves. Last but not least, the lengthy implementation of the WMS and the time-consuming requirements for modifications can alter some difficulties within the current situation of Sindatex since employees are mainly focused on the transition of the business supply chain and tend to forget to focus on the daily-solving problems.

[25] An amount equivalent to 38,987.64 €, for further information about the total cost of the implementation, please see appendix 11.

6. Personal reflection and conclusions

The integration of an automated WMS is a great opportunity for Sindatex to encounter a reliable and efficient inventory management along with good traceability within the warehouse. Nevertheless, one should keep in mind that the execution of such a change after 26 years of stability and continuity is way more difficult than its planning. The reality is always more complex than presumed. Especially in family owned-business where the owner is often worried about throwing away his initial decision and where the strong culture, that shapes how employees and managers behave when challenged with decisions and choices, may present issues in the face of innovation. Moreover, the power of habits, behaviorism and learning cannot be underestimated. The main ingredient that could help to break old habits is the belief that change is feasible. Moreover, the theory indicates that employees should be motivated by maintaining a constant exchange of knowledge with managers to be familiarized with the new WMS features. However, the practice shows that cramming a high amount of information can lead to employees' anxiety and depression. Building on the status quo is vital but it requests too much time to insert a routine of the new way of processing supply chain operations. Therefore, introducing a new system within Sindatex requires effort, commitment and patience among all individuals involved. In the end, the key success factors of implementing an automated WMS overlap the challenges. It anticipates many advantages for logistics operations and brings great competitiveness. In fact, Sindatex needs a project manager that will guide the process of understanding the cultural change and overcome the existing mindset of the organization. Finally, to become an agile organization, SMEs have to consider their set of resources and capabilities to support the viability of an innovative process. The practice of technological development is often more deeply explored in the execution phase especially at changing times.

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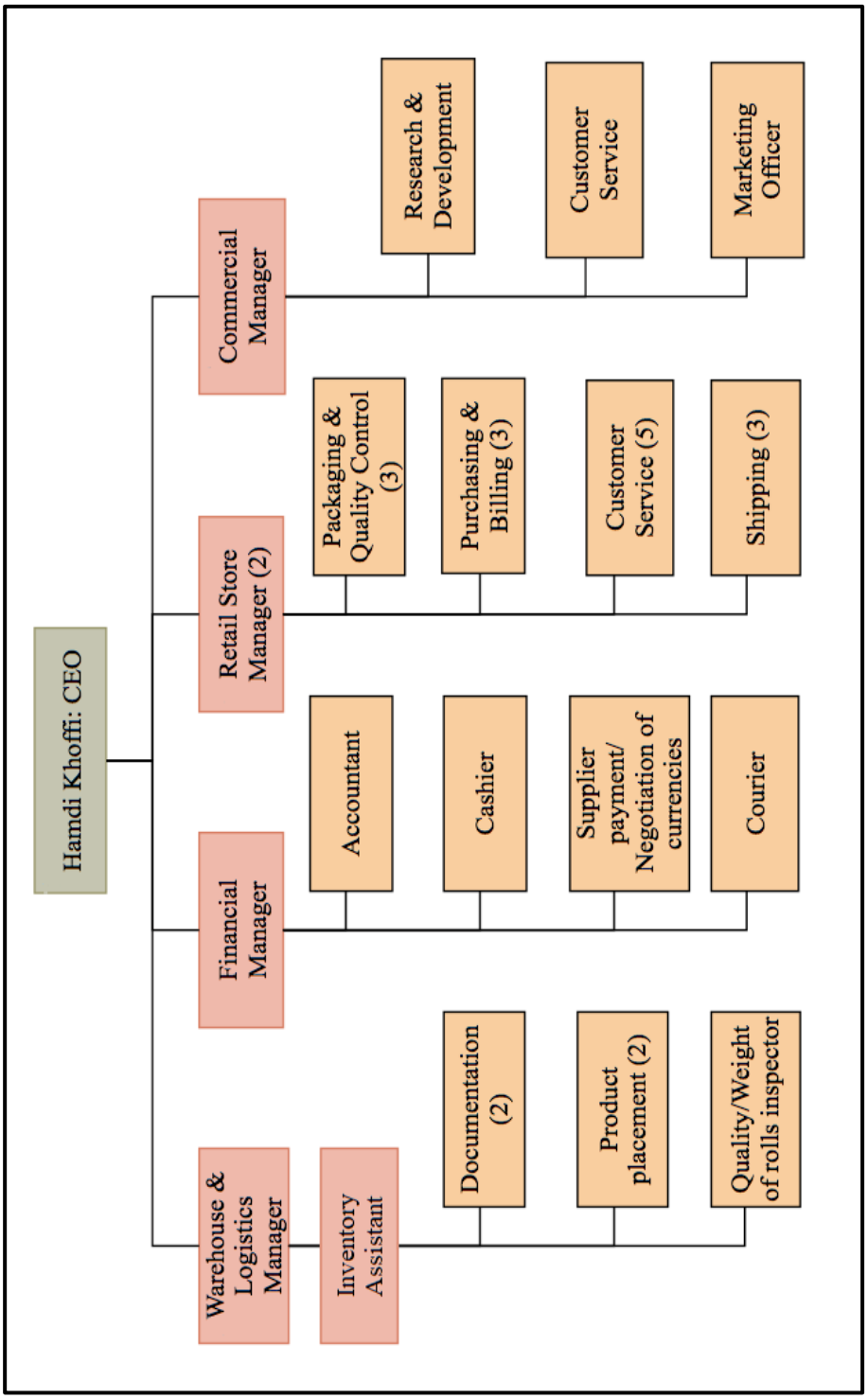
Appendices

Appendix 1: The organizational chart of Sindatex:



Source: The author

Appendix 2: The key financial statements:

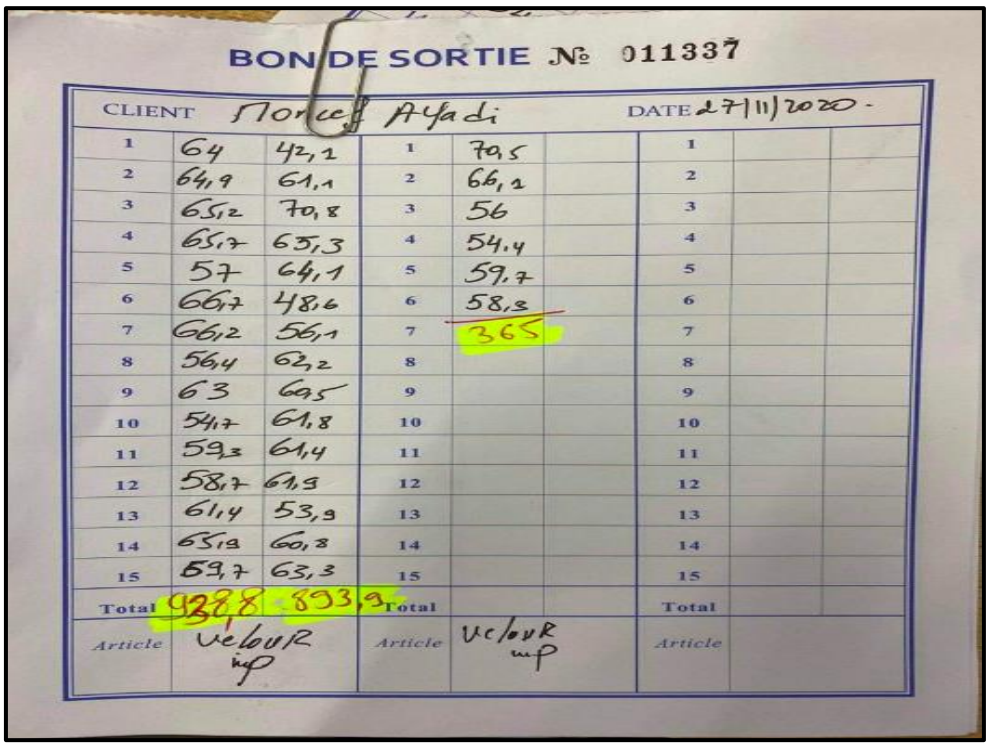
Unconsolidated Accounts	31/12/2016 (DT)	31/12/2017 (DT)	31/12/2018 (DT)	31/12/2019 (DT)
Operating revenue	1,485,960.34	1,520,087.10	2,092,640.66	1,760,988.46
P/L before tax	58,133.95	17,519.16	80,385.57	96,843.73
Net Income	42,422.20	13,139,41	60,086.32	72,388.48
Total liabilities	871,940.73	1,166,027.11	1,833,677.27	1,752,484.15
Shareholder's equity	1,070,843.61	1,378,069.39	2,105,805.87	**2,097,001.23**
Cash Flow from Operations	211,354.40	308,158.88	952,311.01	490,810.17
Cash Flow variation	205,213.99	1,118.33	19,949.12	234,893.73
Cash Flow Statement	106,336.24	105,217.92	125,167.04	360,060.76

Source: The author

Appendix 3 : Rolls

Appendix 4: The logistics equipment: the forklift truck and the pallet

Appendix 5: Exit Voucher



BON DE SORTIE № 011337

CLIENT Morceff Ayadi DATE 27/11/2020

1	64	42,1	1	70,5		1		
2	64,9	61,1	2	66,1		2		
3	65,2	70,8	3	56		3		
4	65,7	65,3	4	54,4		4		
5	57	64,1	5	59,7		5		
6	66,7	48,6	6	58,3		6		
7	66,2	56,1	7	365		7		
8	56,4	62,2	8			8		
9	63	69,5	9			9		
10	54,7	61,8	10			10		
11	59,3	61,4	11			11		
12	58,7	61,9	12			12		
13	61,4	53,9	13			13		
14	65,9	60,8	14			14		
15	59,7	63,3	15			15		
Total	9328	8939	Total			Total		
Article	velour mp		Article	velour mp		Article		

Source: Internal documents of Sindatex

Appendix 6: The formula of change

$$C = D \times V \times FS >> RC$$

Where

C = Change

D = Dissatisfaction with the status quo, making a clear case for change

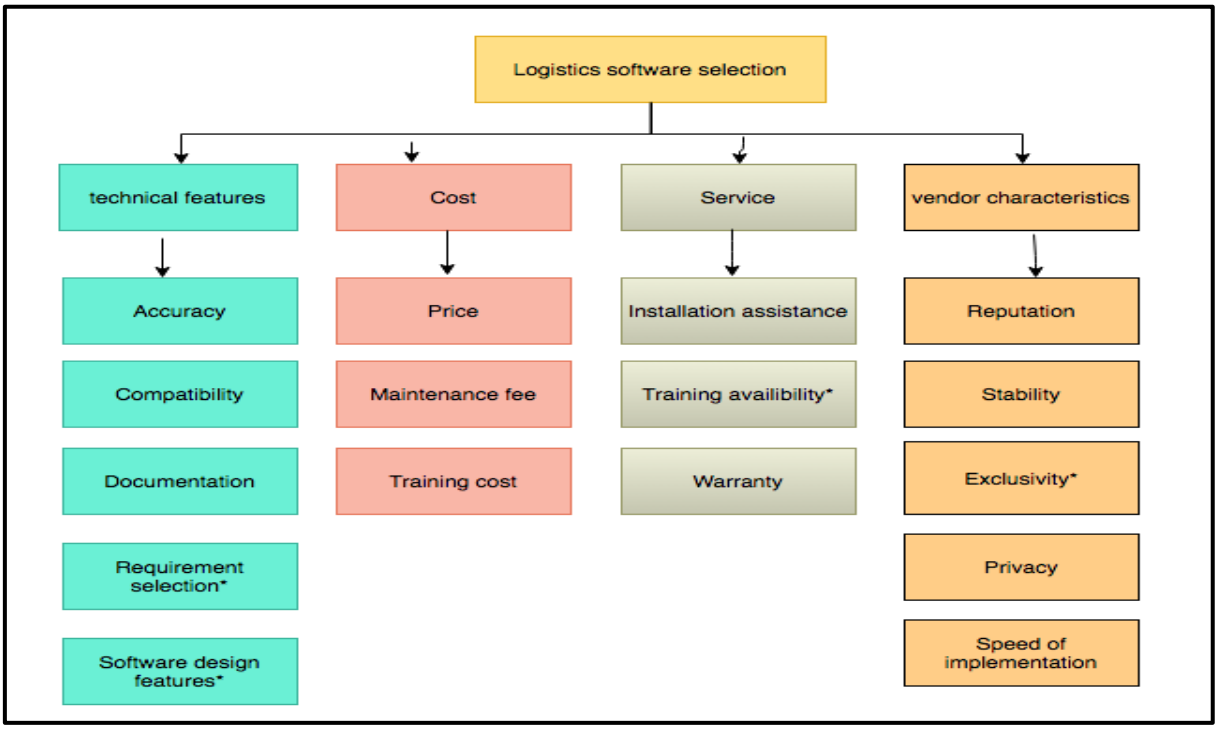
V = Vision of the desired future, providing a clear sense of direction

FS = First step from getting "here to here"

RC = Natural resistance to change

Source: Harris, R.T. and Beckhard, R., 1987. Organizational Transitions: Managing Complex Change, 2nd Edition. Addison Wesley series on organization development. Addison-Wesley Publishing.

Appendix 7: The generic criteria for selecting the WMS software and vendor:



Source: Min, H., 2006. The application of warehouse management systems: an exploratory study. International Journal of Logistics: Research and Applications, 9 (2), 111-126.[26]

[26] The market criteria are added by the author.

Appendix 8: The set of alternatives to choose the right WMS software for Sindatex:

As shown in Appendix 7, the WMS software and vendor's choice is based on criteria such as technical features, the total cost of the implementation, the service offered and the vendor characteristics. Therefore, a set of alternatives for WMS software has been conducted with the help of Sindatex's employees and managers. The selected WMS softwares are Scantech, SAP Warehouse Management, Softeon and HighJump. These four vendors have been pointed out among many other WMS software being more valid for the size of the business, the type of sector, and the implementation budget within Sindatex. However, when comparing the four alternatives, Scantech seems to outweigh all the attributes presented in terms of cost-advantage, technical features (e.g., documentation, modification), and most importantly, the degree of its compatibility with other supply chain software. Besides, the meetings with the CEO of "World Trade Textile" and the employee's point of view about their ease of use of Scantech has helped a lot as inputs to choose the right WMS software for Sindatex. Last but not least, Scantech has been making a name in the worldwide textile market in recent years in terms of functionalities that optimize warehouse operations while improving traceability (Scantech, 2014). In the appendix above, the author added the marked criteria, which are exclusivity and privacy as very significant factors for vendor selection, especially in the textile Tunisian market. Rivalries can corrupt the software vendor to collect data warehousing, leading to a huge loss of revenues and customer dissatisfaction. With that in mind, the vendor characteristics should be well-considered and scrutinized before making the decision of selecting the best vendor by the top management. Consequently, the managers have chosen a reputable software vendor who is very famous for developing WMS software based on the requirements of Tunisian warehouses and manufacturing facilities. The vendor is known for his speed of implementation as well as his accurate measures of privacy and data protection for technological developments.

Furthermore, his maintenance and modification fees are reasonable compared to other software vendors in the Tunisian market. The software vendor earn 3,500 DS (around 1000 €) per month.

Source: The author

Appendix 9: The comparison between RFID and Barcode systems:

Types	 **RFID**	 **Linear barcodes**
The amount of information stored	Different data storage capacity Forms and functions are possible depending on tag design	High Capacity of Data Storage
Installation	RFID tag malfunctions, reader problems, hardwares breakdown	Reliable
Utilization	Large warehouses (e.g. stockholding, cross-docking operations)	Small and medium warehouses (e.g. manufacturers facilities and production warehouses)
Cost	Expensive	Low
Readable Rate	Line of sight is not required	Clear line of sight is required
Materials	Adversely affected if it cope with metal and liquids	Can be printed in durable materials / Not affected by substrate materials

Source: Erkan, T.E and Can, G.F, 2014. Selecting the best warehouse data collecting system by using AHP and FAHP methods. Technical Gazette, 21 (1), 87-93.

Appendix 10: The design of barcode for Sindatex:

Source: The author

Appendix 11: the total cost of the WMS:

Fixed Cost of Software/Hardware/Devices	Cost Items (DT)	Cost Items (Euro)
Infrared cameras	28,000	8,503.12
ERP system	12,000	3,644.19
Advanced WMS	45,000	13,665.73
Modification/Debugging fee: (3,500/month)	42,000	12,754.68
Barcode scanner	2,500	759.21
Barcode printer	400	121.47
Total cost of the installation	**129,400**	**39,296.56**

Source: The author.