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SUPPLY CHAIN MANAGEMENT (SCM): A NEW APPROACH FOR THE DIGITAL TRANSFORMATION OF SMALL AND MEDIUM SIZED ENTERPRISES (SMES)

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The digital era and the globalization present several opportunities and challenges for the manufacturing industry: digitalization is changing the business structures in profound ways, product development and manufacturing cycles are constantly decreasing, actual innovations are deep technological disruptions that change the world as we know it. Big manufacturing companies have been investing billions of dollars to transform old productions into digitalized and automated shop floors. On the other hand, SMEs often do not have the resources to look into the eyes of every single technological disruption, but they must regardless be flexible and able to quickly adapt to new technologies. In order to take advantage of the opportunities presented in the digital era, SMEs need to step up their development of new strategies and organizational structures. The transformation could be difficult and pricey if it is done as a single solution for every SME. Therefore, a new approach for the digital transformation of SMEs based on a new SCM's software solution and organization is proposed.

Keywords: digital; transformation; SME; SCM; supply chain

GESTIÓN DE LA CADENA DE SUMINISTRO (SCM): UN NUEVO MÉTODO PARA LA TRANSFORMACIÓN DIGITAL DE PEQUEÑAS Y MEDIANAS EMPRESAS (PYMES)

La era digital y la globalización presentan diversas oportunidades y desafíos para la industria manufacturera: la digitalización está cambiando las estructuras empresariales, los ciclos de desarrollos de productos y de producción son cada vez más cortos, las innovaciones tecnológicas actuales son de tal calibre que cambian el mundo tal y como lo conocemos.

Grandes empresas productoras llevan años invirtiendo millones para transformar antiguas plantas de producción en modernas, informatizadas y automatizadas áreas de producción. Por otro lado, las PYMES no tienen tantos recursos económicos a su disposición para implementar las mismas transformaciones, pero al mismo tiempo se espera de ellas una gran flexibilidad y adaptación al cambio. En el ámbito productivo actual, las PYMES deben adoptar determinadas estrategias y cambios de estructura para poder competir con éxito.

Ello quizás no tiene sentido de una manera aislada, por lo que se propone un nuevo método para la transformación digital basada en la consideración de un nuevo software y una nueva organización para la SCM.

Palabras clave: digital; transformación; PYME; SCM; cadena de suministro

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1 Introduction

The manufacturing sector plays a crucial role in Europe, serving as a key driver of economic growth and accounting for 80% of all exports, 25 % of the GDP and 65% of all innovations (Savastano, Amendola, Bellini, & D'Ascenzo, 2019) (DG Trade Statistical Guide) (European Commission, 2020). Likewise, SMEs are essential contributors to the GDP in Europe, accounting for 66.6 % of total employment and 56.4 % of value added (Annual Report on European SMEs 2018/2019, 2019).

Europe, as well as other economies like United States, Japan or China rely on their manufacturing sector, to continue the economic expansion and to ensure the well-being of their citizens.

SMEs are facing tremendous challenges since 2011 due to the 4th Industrial Revolution, in the form of emergence of digital transformation and its applications for the industrial sector (Barcus, 2017) (Bundesverband der Deutschen Industrie e.V., 2019).

Professor Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, introduced the phrase the 4th Industrial Revolution in 2015, in an article published by Foreign Affairs (Schwab, The Fourth Industrial Revolution, 2015) , which was also the subject of his book published in 2017, in which Schwab highlights a grave concern: organizations might be unable to adapt (Schwab, The Fourth Industrial Revolution, 2017).

SMEs need to adapt to the digital transformation, but digital transformation is not about technology, it is about strategy and new ways of thinking (Rogers, 2016), otherwise the concern from Schwab would become a reality.

The disruptive digital transformation is the key element of the Industry 4.0. Without a well-planned and deliberate digital transformation, the SMEs will encounter extraordinary challenges in an aggressive technological and digital driven future.

SMEs in the industrial sector must rethink their supply chain organization for the digital age.

The supply chain organization is a multifunctional and complex enterprise, which comprises several departments and roles: manufacturing engineering, operations, quality control, finished goods, planning, warehouse, management, customers relationship, sales, lean & innovation, etc. Oracle, SAP and Microsoft, among other companies, have been providing Enterprise Resource Planning (ERP), including Supply Chain Management (SCM), solutions for decades (Oracle, 2019).

The solutions are very capable and cover every single area of the supply chain (logistics, manufacturing engineering, planning, purchasing, management, customers relationship...), offering software solutions for several purposes, e.g.: creation of bill of materials, management of warehouses, creation of work instructions, selling and tracking of spare parts production, takt-time management, etc. but the complexity and costs have been increasing over the time and those solutions have become a double-edged sword.

On the one hand, they are powerful tools able to solve every single issue, on the other hand, the complexity of the tools does not allow different departments in the supply chain to interconnect and the companies have to invest big amounts of money to provide the tools to all employees, which hinder the access to the SMEs (Barcus, 2017).

Integrated management software solutions for ERP and SCM are key elements of the digital transformation and SMEs should not wait any longer to embrace those solutions and enter the digital era. In addition, the global COVID-19 pandemic has shown the importance of companies embracing remote working (Thomas, 2020). In order to enable remote working, the information and resources of the company must be available in an integrated management software.

1.1 SMEs in Europe

The European Commission defines three SME enterprise categories (European Union, 2003):

Table 1 – Commission Recommendation concerning definition of SMEs

Enterprise Category	Employees	Turnover
Micro SME	0 to < 10	< €2 million
Small SME	10 to < 50	< €10 million
Medium-sized SME	50 to < 250	< €50 million

Source: Created by the authors based on (European Union, 2003)

There were slightly more than 25 million enterprises in the EU-28 in 2018, of which 93% were micro SMEs and 5.9% small SMEs. The SMEs generated 56.4% of value added and 66.6% of employment (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 2019). These facts show the importance of the SMEs, especially micro and small SME, in the European economy and development.

1.2 Enterprise Resource Planning (ERP)

Enterprise resource planning (ERP) is the integrated management of main business processes, often in real time and mediated by software and technology. Companies are using this suite of integrated applications to collect, store, manage and interpret data from many business activities (Enterprise resource planning, 2020) as represented in the [Figure 1]: Human Resources (HR), Supply Chain (SCM), Manufacturing (PLM), Procurement (SRM), Customer Services (CRM), Finance and others.

Figure 1 – ERP – Modules



Source: Created by the authors using Microsoft Visio 2019

1.3 ERP & SCM – Market Share

There are two big players in the ERP and SCM market: SAP and Oracle. The two together control approximately 30-40 % of the market (Pang, Markovski, & Micik, 2019) (ERP systems (world market), 2019) (Columbus, 2018).

Figure 2 – ERP Market Share

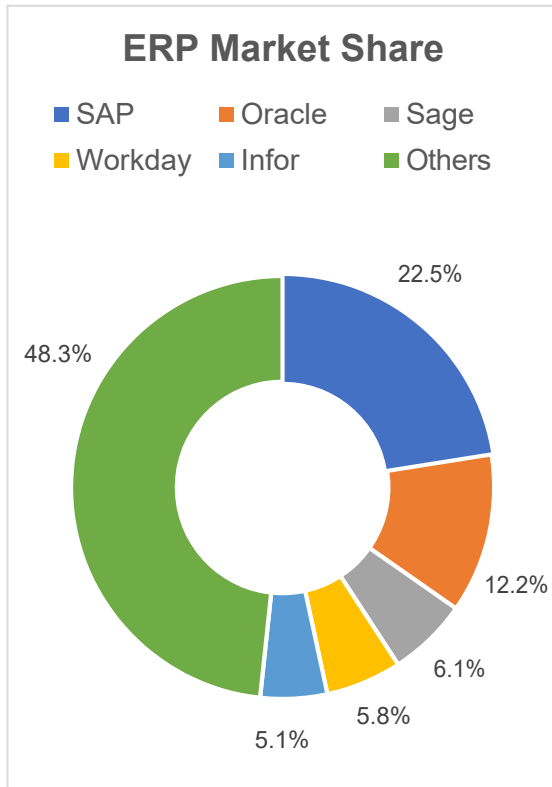
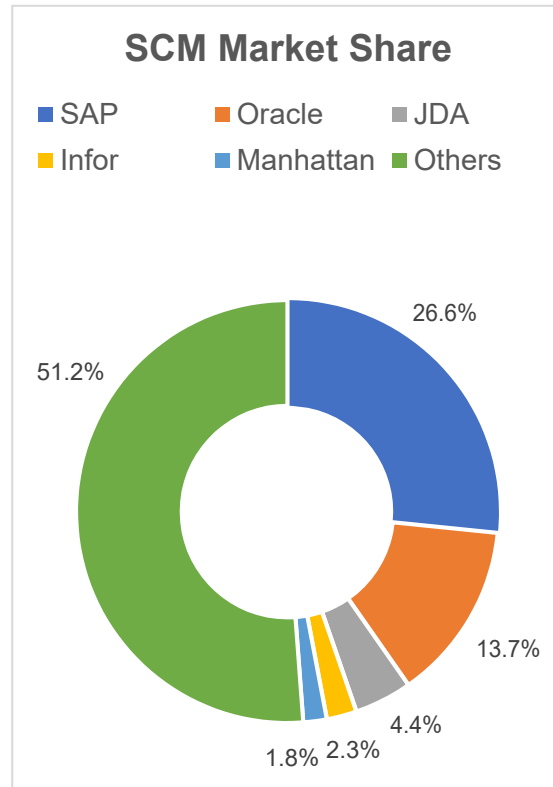


Figure 3 – SCM Market Share



Source: Compiled by the authors based on (ERP systems (world market), 2019) (Columbus, 2018)

1.4 Pricing analysis

At first it is important to say that pricing for the different ERP & SCM solutions is in most cases not provided by the vendor. The companies require first a consultation with some business specialist in order to create a customized offer, which makes it difficult to compare the different alternatives before decision making.

The cost analysis presented in [Table 2], based on a research of the resources in the Web, which could be not completely precise due to the privacy mentioned before, of the different products offered by SAP, Oracle, Sage, Microsoft Dynamics and Infor for SMEs presents a revealing conclusion:

Micro and small SMEs cannot purchase the SCM solutions because of the minimum user's requirement. And even if it were possible, the micro SME (5 employees) willing to implement a SCM solution would need to invest at least monthly > \$ 1700 (Microsoft, 2020). This without considering some hidden costs like training, testing, customization, integration, employee resistance to adopting a new ERP...

Table 2 – Pricing analysis of some ERP & SCM solutions

Vendor	Product	Pricing (per user/month)	Minimum of users
Oracle	Supply Chain Planning	\$ 2425	10
Oracle	Logistics	\$ 1575	10
Oracle	Inventory Management	\$ 350	10
Oracle	Order Management	\$ 625	10
Oracle	Procurement	\$ 625	10
Oracle	Product Lifecycle Management (PLM)	\$ 350	10
Oracle	Manufacturing	\$ 350	10
Oracle	Maintenance	\$ 350	10
Oracle	Product Master Data Management	\$ 350	10
Oracle	Supply Chain Collaboration and Visibility	\$ 625	10
Oracle	AI Apps for SCM	\$ 1150	10
Oracle	NetSuite	*	*
Oracle	E-Business Suite	*	*
SAP	SAP Business One	\$ 3213	*
SAP	SAP Business ByDesign	\$ 1647	*
SAP	SAP S/4 HANA	*	*
Sage	Business Cloud X3	*	*
Infor	M3	*	*
Infor	LN	*	*
Infor	CloudSuite SCM	*	*
Infor	CloudSuite Industrial (SyteLine)	*	*
Microsoft	Dynamics 365 – Project Service Automation	\$ 95	20
Microsoft	Dynamics 365 – Supply Chain Management	\$ 180	20
Microsoft	Dynamics 365 – Business Central Essentials	\$ 70	20

Source: Created by the authors based on (Microsoft, 2020) (Oracle, 2019)

*Note: Information not available, not publicly published by the vendor.

1.5 Free and open-source alternatives

There are some free and open-source ERP alternatives available like Apache OFBiz, OpenBoxes, iDempiere and Odoo, but their market share is residual, due to the following reasons:

- Missing, in most cases, support from the software provider
- The open-source alternative is not a customized solution and therefore requires adaption, which generates new costs and demands IT-skills
- ERP is a highly complex software and the open-source alternatives have not reached the complexity and stability required

1.6 Make or buy decision

The current ERP & SCM market trend shows how big players like SAP and Oracle are widening their portfolio to let SMEs enter their business and smaller vendors like Sage and Infor are targeting SMEs offering customized accounting, finance project management, people and payroll solutions at lower prices. Another important fact is that there is an important niche for micro enterprises, due to almost any vendor offering a solution for this type of SME.

Based on the amount of solutions that are offered, most of the SMEs do not know where to start. There are several reasons preventing the buy decision: high prices, complexity, necessity of training and support after the purchase, applicability for several departments, capabilities of the solutions offered are higher than the requirements to be fulfilled... (Haddara, 2014)

Each vendor claims that using its product will give an enterprise a competitive advantage. Large companies can afford to invest in ideas that may bring them a competitive advantage. The SME does not have this luxury. They are pretty much sceptical about the change in their working style unless and until they are sure about the effectiveness of the new technology in terms of bottom line results. This causes in most of the cases a make decision; the SMEs decide to manage its supply chain using the software tools which are already available (e.g.: Excel, partial implementation of Oracle or SAP, small vendors covering some of their needs...).

1.7 Definition of research question

How to enable the access to digital transformation for SMEs providing an integrated management software solution?

1.8 Research objectives

This research has its focus on starting the development of an integrated management software solution for mainly the business activities Supply Chain Management (SCM) and Manufacturing (PLM):

- Supply Chain Management (SCM): is the handling of the entire production flow of a good or service – starting from the raw components all the way to delivering the final product to the consumer (IBM, 2020).
- Manufacturing (PLM): is the process of managing complex product information, engineering and manufacturing workflows, and collaboration (Autodesk, 2020).

The integrated management software solution attempts to fulfil the following objectives:

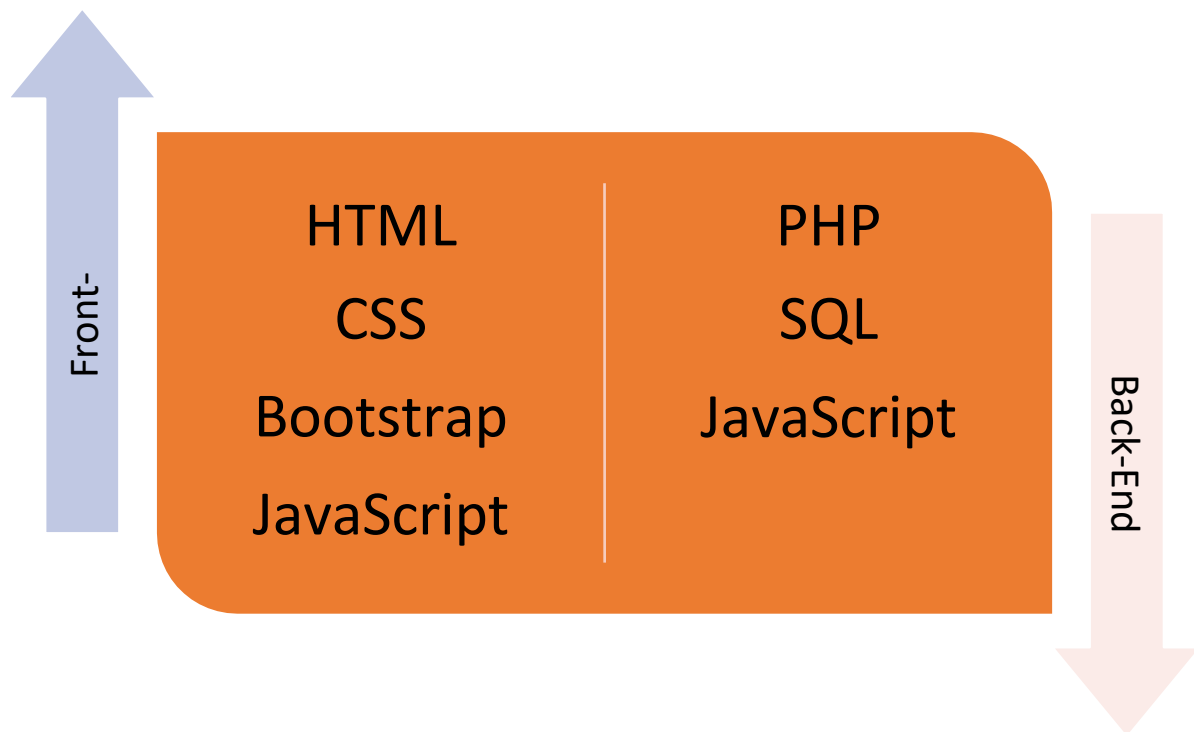
- Providing an integrated management software solution to the digital transformation to SMEs, especially micro and small SME
- Adoption of a new strategy to go paperless in order to reduce the carbon footprint
- Enhanced manufacturing collaboration enterprise-wide
- Speeding up the communication in the supply chain
- Providing the capabilities to the user of a micro enterprise to perform 80 % of his SCM and PLM activities in the Supply Chain Hub
- Embrace the development of a remote working environment
- Real-time enterprise analytics for better decision-making

2 Methodology

2.1 Development of the integrated management software solution

The integrated management software solution receives the name Supply Chain Hub and it is a full software stack (Front-End & Back-End). For the Front-End Development the following programming languages were used: HTML, CSS, Bootstrap and JavaScript [Table 3]. The Back-End Development is developed using the programming languages PHP, SQL and JavaScript [Table 4]. The full software stack structure is shown in the [Figure 4].

Figure 4 – Front-End and Back-End Development overview



Source: Created by the authors using Microsoft Office 2019 (SmartArt)

The source-code editor used for the development was Visual Studio Code, which is the most popular developer environment tool, with 50.7% market share in 2019 (Developer Survey Result, 2019).

The development has been performed locally on a laptop, local test server, without interaction with a live server, therefore the usage of a web server solution stack package has been necessary. XAMPP is the solution stack package that has been selected and consists mainly of the Apache HTTP Server, Maria DB database and interpreters for scripts written in the PHP and Perl programming languages (Apache Friends, 2020).

The desktop web browser used for the trials was Google Chrome, which is the most popular desktop web browser worldwide, with 70 % market share in 2019 (Desktop Browser Market Share Worldwide, 2020).

Table 3 – Front-End Development Programming Languages

Programming Language	Usage in the Supply Chain Hub
HTML	Standard markup language for the development of a Web Page
CSS	Describes the style of the Web Page
Bootstrap	Framework for developing responsive, mobile-first websites
JavaScript	Programming language of the HTML and the Web

Source: Created by the authors

Table 4 – Back-End Development Programming Language

Programming Language	Usage in the Supply Chain Hub
PHP	Is a server scripting language and a powerful tool for making dynamic and interactive Web Page
SQL	Is a standard language for storing, manipulating and retrieving data in databases
JavaScript	Programming language of the HTML and the Web

Source: Created by the authors

2.2 Level of user expertise

The Supply Chain Hub is designed as an easy to use integrated management software solution for non-developers. It keeps clear of classifying the users into beginners, intermediate and experts. Everyone who is able to open Google Chrome and visit a Web Page, should be able to fully use the capabilities of the Supply Chain Hub.

3 Results and Discussion

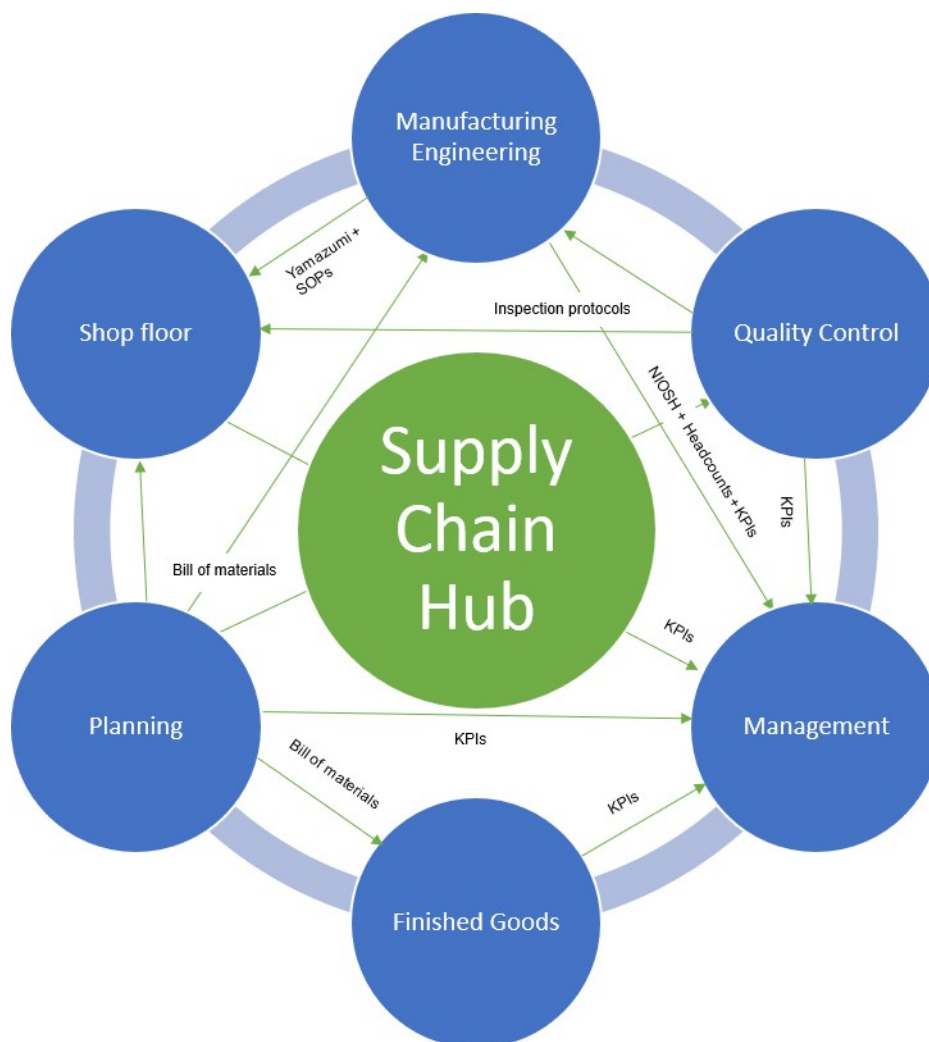
3.1 Tools

The integrated management software solution offers several tools to rethink the business for the digital age in the SMEs. The tools interconnect departments, functions and roles [Figure 5]. There is a similarity between baseball (sport) and business that has been used for several years and defines the multifunctional relationships in a business: the pitcher-catcher concept (Ghemawat, 2003).

- Pitcher: the player who throws the baseball to the catcher. The department, function or role, who creates a tool to be used by the catcher.
- Catcher: receives the ball from the pitcher. The department, function or role, who uses the tool created by the pitcher.

This pitcher-catcher concept promotes the interactions between departments and activities across the company, enhances manufacturing collaboration enterprise-wide and prevents the isolation.

Figure 5 – Different departments and roles of the Supply Chain interconnected through the Supply Chain Hub



Source: Created by the authors using Microsoft Office 2019 (SmartArt)

3.1.1 Homepage and How-to

It is the start page and describes briefly the purpose of the Supply Chain Hub. Provides access to the How-to section, which is a guideline showing some tutorials for the proper usage of the integrated software solution.

3.1.2 Yamazumi charts

The tool Yamazumi chart is a stacked bar chart that shows the balance of cycle time workloads between several operators typically in an assembly line or work cell.

- Pitcher: Manufacturing Engineering
- Catcher: Supervisor Shop floor

3.1.3 Bill of materials (BOM)

The bill of materials (BOM) is a list of materials, sub-assemblies or parts, and their quantities to manufacture and product.

- Pitcher: Planning
- Catcher: Manufacturing Engineering, Quality Control, Shop Floor, Finished Goods

3.1.4 Standard operating procedures (SOP)

The standard operating procedure (SOP) tool allows the users to create a step by step instruction designed to help the workers carry out complex manufacturing, packaging or quality operations. SOPs aim to improve the productivity and the quality of the products.

- Pitcher: Manufacturing Engineering
- Catcher: Shop floor

Figure 6 – Standard operating procedures (SOP)

The screenshot displays the 'Supply Chain Hub' web application. On the left is a blue sidebar menu with options: Dashboard, SHOP FLOOR, Documents, MANUFACTURING ENGINEERING, Tools, and MANAGEMENT. The main content area is titled 'Work Instructions' and includes a search bar at the top. Below the title, it states 'Easy, smart and user-oriented tool to create work instructions'. The form is divided into two sections: 'Header' and 'Content'. The 'Header' section contains fields for 'Name', 'Group' (with a dropdown menu showing 'A-'), 'Number', 'Cell', and 'Revision'. The 'Content' section contains fields for 'ID', 'Description', and 'Picture' (with a 'Choose file...' button and a 'Browse' button). At the bottom right of the form, there are two buttons: a green '+ Add ID' button and a red '- Remove previous ID' button. The user's name 'Antonio Cotrino' is visible in the top right corner of the interface.

Source: Compiled by the authors using the software Supply Chain Hub

3.1.5 Troubleshooting

Troubleshooting is a form of problem solving, often applied to repair failed products or processes on a machine or a system.

- Pitcher: Manufacturing Engineering
- Catcher: Shop Floor

3.1.6 Takt Time

This tool allows the user to calculate the takt time, which is the average time between the start of production of one unit and the start of production of the next unit, when these production starts are set to match the rate of customer demand.

- Pitcher: Manufacturing Engineering
- Catcher: Management and Shop Floor

3.1.7 Headcounts

This tool provides a simple and fast feature to calculate the needed headcounts based on forecasting.

- Pitcher: Manufacturing Engineering
- Catcher: Management

3.1.8 Dashboard

The dashboard provides at-a-glance views of key performance indicators (KPIs) relevant to the business process, as well as some general information and updates for the employees to keep them up to date.

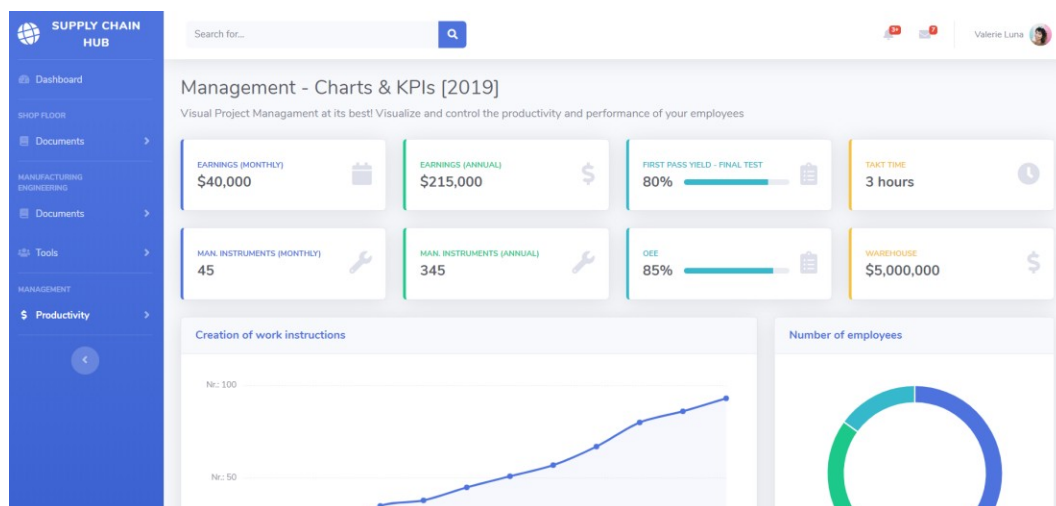
- Pitcher: Management
- Catcher: Manufacturing Engineering, Quality Control, Finished Goods, Planning, Shop floor.

3.1.9 Management

Real-time enterprise analytics for better decision-making

- Pitcher: Manufacturing Engineering, Quality Control, Finished Goods, Planning, Shop floor.
- Catcher: Management

Figure 7 – Management



Source: Compiled by the authors using the software Supply Chain Hub

4 Conclusion

Given the complexity of a complete ERP and SCM platform and the multifaceted possible tools to be developed, the results of the investigation gave some positive results and some areas to be improved according to the objectives abovementioned [1.8].

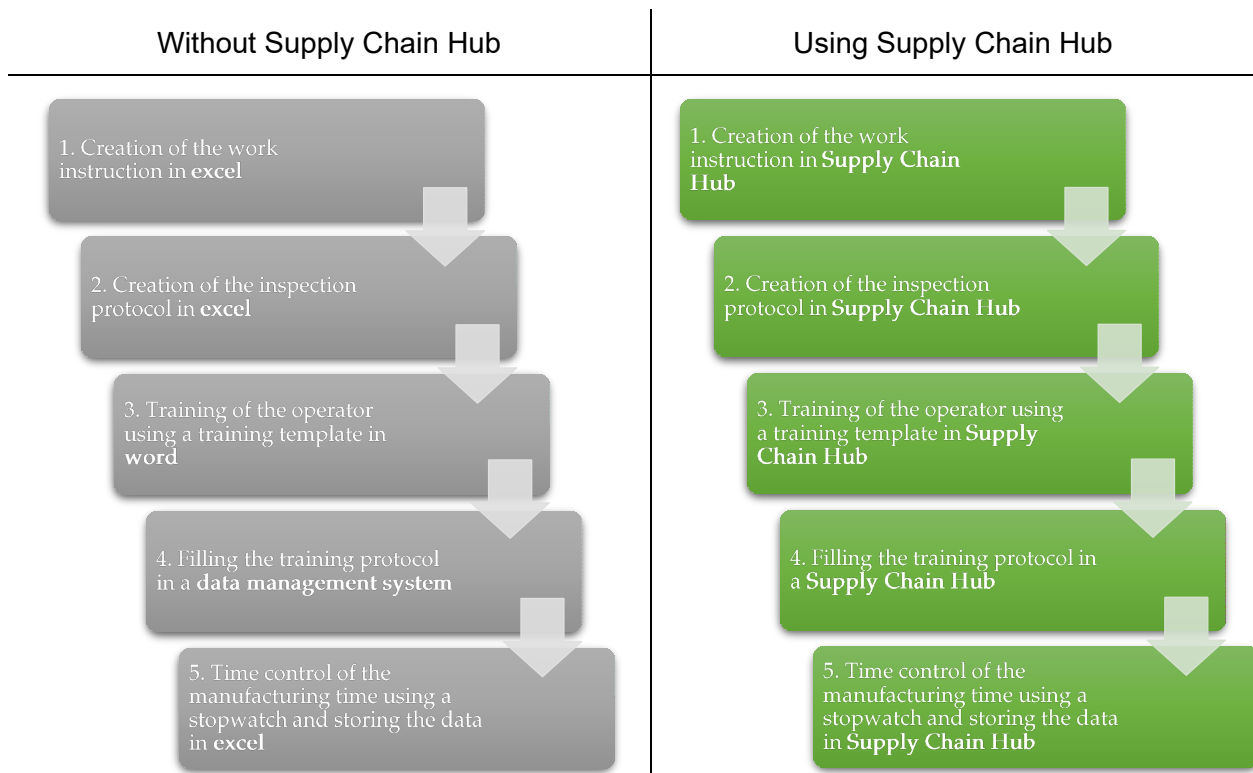
Table 5 – Conclusions – Positive results and improvements

Positive results	Future improvements
The Supply Chain Hub represents the beginning of a vision, where an integrated software solution helps SMEs to overcome the digital transformation, especially micro enterprises	The dependency from Microsoft Office (e.g. Excel, Word...) remains, due to the level of capabilities of this software has not been reached
The Supply Chain Hub could reduce significantly the amount of paperwork in every SME	Real-time enterprise analytics provide by the Supply Chain Hub are still in its infancy
Reduction of unnecessary communication (e.g. E-Mails) due to the introduction of a multifunctional solution in the supply chain	
Enhancement of the collaboration across the supply chain	

Source: Created by the authors

The great improvement using Supply Chain Hub is shown in the example below [Figure 8] because it allows the SMEs to move from old isolated software solutions and paperwork activities to an integrated software solution for the digital transformation, which interconnects the whole supply chain.

Figure 8 – Benefits of the implementation of the Supply Chain Hub



Source: Created by the authors using Microsoft Office 2019 (SmartArt)

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