Creating an Inventory Management System using VBA for a small Vietnamese enterprise

Case: company A

Tam Nguyen

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Abstract:

Inventory control is an essential activity for product-based companies like company A – a small manufacturer of fabricated metal products in Vietnam. The company's inventory control practices are currently based on mere human's estimation, without theoretical base and depends on inefficient manual processes to manage their inventories. Based on Inventory Management theories: Just-In-Time (JIT) and Materials Requirements Planning (MRP) as foundation knowledge, the thesis project examined the company's inventory activities and developed a computer-based inventory solution. Constructive action research approach was conducted via virtual meetings and discussions with the company to investigate their current inventory control practices and to construct a suitable inventory solution; and thus, the project created an Inventory System using VBA-Excel spreadsheets to help replace current manual inventory work. The application solution will be publicly shared to other small businesses which do not have sufficient resources to implement an inventory software system.

Keywords:	Inventory system, inventory control, MRP, VBA, manufacturing business, SME, Excel spreadsheets, MTO
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Abbreviations

JIT: Just-In-Time

MRP: Materials Requirements Planning

SME: Small Medium Enterprise

BOM: Bill of Materials

1 INTRODUCTION

1.1 Background and motivation

Small and medium sized enterprises (SMEs) hold a significant position in Vietnam's economic landscape as they make up for 98% of all businesses, contribute 40% of the country's GDP, and provide employment to 50% of the labour pool (Koushan, 2017). Holding a significant weight in the country's economy, non-state companies, however, only invest about 3% of their budgets in Research and Development (R&D) and that causes unnecessary costs and inefficiency (Koushan, 2017).

It can be said that private sector firms, particularly small local businesses, with limited financial and talent capacity, either do not realise the benefits of R&D or cannot afford investments in R&D. Their business decisions are merely based on human's estimation and experience. They are likely to lack theoretical base, thus being not optimised and bound to induce extra costs. In the era of digitalisation of businesses, this negligence on R&D and digital advance may disadvantage small businesses greatly and make it more challenging to compete and keep up with demands of markets.

Company A – established in 2002, as in Vietnamese Governmental Decree No. 39/2018/ND-CP (Vietnamese Government, 2018), has been categorised to be small company with less than 50 of headcount and annual turnover below EUR 1.8 million. This is a small local business, in Bac Ninh Province - north of Vietnam, that manufactures fabricated metal products such as ventilation systems and electrical cable trays for industrial buildings. Their products are completely customised, so each ordered product is different from one another. Being a product – based company, this Make-to-Order (MTO) manufacturer relies on raw materials to manufacture finished products and only start production once customers' orders are confirmed.

1.2 Problem formulation

Although the company has been in the market since 2004, it is still in local scale and has not yet moved to business automation and digitalisation stage. From a glance at the company's operation, there seems to be a traditional practice going on when inventory replenishment decisions have been made based on guesswork and judged by sight, and documentation process is managed in Microsoft Excel application. After meeting with the company's persons, it was observed that there has been a lack of automation in company A's procedures, which include pricing and inventory management. This process is, in fact, handled in a tedious manual manner, which is primitive and inefficient, and might waste time, create mistakes and probably result in irrational business decisions.

1.3 Project aim

The project is a self-initiate from the author to reduce manually intensive procedure for the company and to introduce the company to digitalisation through a simple familiar IT application Excel. The main aim of the thesis is to tailor an Inventory System Solution using Visual Basic for Applications (VBA) in Excel spread-sheets to record inventories and automate pricing, BOMs and quotations processes. Within their limited financial capacity and low IT savviness, a proposed solution to automate their inventory management should satisfy criteria: low cost, easy to use, minimum maintenance needed, featuring sufficient functions.

The created inventory system is expected to serve the use of company A and also publicly available to be shared with other small businesses who do not have sufficient resources to invest in IT infrastructure and specialists.

1.4 Research questions

This project scope concerns specific Inventory activities of company A: inventory volumes control, replenishment practices and assessing cost efficiency. Research questions to set directions for the project are as following:

- What are the current inventory management practices in company A?
- What are the existing inventory control computer-based solutions?
- What functionalities should the proposed inventory solution feature?
- How does the solution help to mitigate costs/ inefficiencies?

1.5 Methods

The thesis project follows constructive action research approach, in which the author collaborated with company's managers to investigate the situation and develop the solution (Bryman, 2012). Data was collected from observations and recurrent meetings with managers and concerned personnel.

1.6 Key concepts

Key concepts to be discussed are:

- Inventory: "include raw materials, component parts, work in process, finished goods, packing and packaging materials, and general supplies" (The Editors of Encyclopaedia Britannica, 2017).
- Inventory control: generally concerns what point inventory should be restocked and quantity of reorder (The Editors of Encyclopaedia Britannica, 2017).
- Inventory costs: include holding, storage and order costs (Kenton, 2020)
- Just-In-Time method
- Materials Requirements Planning

2 THEORETICAL FRAMEWORK

This chapter provides background understanding of inventories and why businesses hold inventories. The chapter also discusses Pull/Push and Just-In-Time (JIT) theories on which company A is operated, and Materials Requirements Planning (MRP) to back the development of the proposed inventory solution.

2.1 Understanding of Inventories

2.1.1 Definitions and classification

Stock is defined as the collection of "all the goods and materials that are stored by an organization. It is a store of items that is kept for future use"; and an *inventory* is "a list of the items held in stock" (Waters, 2003, p. 4). In accounting, inventory is understood as "the monetary value of the company's stocks and is written as current asset in balance sheet. Nevertheless, in logistics, the two terms *stocks* and *inventories* are often interchangeably used, and both refer to all products, unfinished products, and raw materials that belong to a company.

Stocks are classified among three types: raw materials, work-in-progress (WIP) and end-products. Raw materials are ingredients that are used to produce finished or end-products; Work-in-progress are items that are being worked on; and finished products are articles that are complete and waiting to be delivered to customers.

2.1.2 Why holding stocks?

According to Waters (Waters, 2003), the prime reason of holding stocks is to have a "buffer" between demand and supply. Demand or supply could be uncertain, in which case, extra stored stocks could be used to immediately meet demand to a certain extent. Take a typical cafeteria as an example, the owner can hardly know exactly how many cookies will be ordered within the day and it takes time to make cookies from scratch. In case a customer comes in and order some cookies, it is the best if the staff have some already made cookie in the shelves to that the customer can immediately be served, instead of having to wait for cookies to be baked. The already made cookies in counter are "buffer stocks" that can be sold instantly, during the time the staff make new cookies to fill the shelves. Extra cookies in inventory serves the same purpose when there is an issue with supply. If delivery of fresh ingredients arrives late, new cookies production is delayed. Stocked cookies can be sold to fulfil customers' orders, and to give the staff some extra time before stockout happens. Therefore, holding stocks is to cushion the risks of demand and supply uncertainties.

Waters also mentions in his book that some companies hold stocks for other reasons: in speculation of future increasing prices of materials or goods, in emergency scenarios, to optimize full delivery loads and to acquire discount benefit of large orders (Waters, 2003).

2.1.3 Independent versus dependent demand

Stocks can be in either independent demand or dependent demand. Demand for a certain type of stock is independent when such demand is not affected by or associated to demand for other items; whilst demand is dependent when it is resulted or derived from demand for other items (Langley, et al., 2008). Thus, in manufacturing companies, demand for components and raw materials is dependent on demand for final products; meanwhile, demand for final products is independent. Raw materials and component parts are only needed when customers order end-use products. When demand for end-products is high or low, demand for raw materials varies accordingly.

Since demand for raw materials completely relies on demand for end products, it is more relevant to forecast demand of end products rather than demand of raw materials (Langley, et al., 2008). Demanded quantities for raw materials can be calculated once customers' orders arrive.

2.2 Inventories control methods

Inventories are considered "the life wire of any manufacturing organization" (Unyimadu & Anyibuofu, 2014), and raw materials are "at the heart of a manufacturing firm" (Benton & Shin, 1998). The significant role of inventories for a manufacturer has been confirmed. Inventories as raw materials are the inputs, the essential of a production line to make end-products ready for sales, which brings revenue to the company. Without raw materials, manufacturing simply cannot proceed and that leads to the delay of processes and probably prolongs production lead time. Therefore, it is highly important for firms to employ effective and efficient inventories control methods, which is a "crucial factor in the success or failure of any manufacturing concern" (Unyimadu &

Anyibuofu, 2014). The following part explains common methods that are used in manufacturing industry: Pull and Push system, Just-In-Time (JIT) approach and Material Requirements Planning (MRP).

2.2.1 Pull and Push Inventory systems

Pull and push are the two basic types of inventory systems. A pull inventory approach is also called a responsive or reactive system, which reacts to customer demand; whereas, a push approach refers to a proactive system, which uses "inventory replenishment to anticipate future demand" (Langley, et al., 2008). In a pull system, production is triggered by customer orders, and materials and products are "pulled" through a logistics system. As an example, a bespoke tailor shop is typically run on a pull system, in which tailoring only proceeds after a customer places a customised suit order. On the other hand, push systems, like H&M shops, have production going on to keep products ready in their storages or warehouses and always push items to display shelves.

The pull system is used by many Make-to-Order companies, which sells customised products as excess customised products can hardly be sold to other customers and become wastes. Furthermore, a pull system also helps general companies to avoid excess inventory and save resources. A pull system responds timely to a sudden fall in demand, so the company can adjust their level of production accordingly and, consequently, reduce unsold goods, save time, materials and labour. However, this system might suffer when peak demand arrives and places pressure on production. It is possible that production lead time is significantly prolonged to fulfil large quantity orders.

Unlike the pull system, the push system, driven by sales forecast, produces goods to meet projected demand. This model is usually applied by high profitable segments or scale economies, with complex products and long lead times (Industryweek.com, 2017). Employing this method, companies tend to constantly have goods available to quickly fulfil orders, but might face high level of inventory, which incurs various costs and even waste.

2.2.2 Lean philosophy and Just-In-Time method

Lean mindset is a management philosophy that is recognised to enhance operational performance by trimming costs such as inventory, space, labour and space. Lean manufacturing is defined as "a process for measuring and reducing inventory and streamlining production" (Encyclopedia.com, 2020). The philosophy was first adopted by Toyota Motor Corporation in 1970s as "Kanban", in the context that Japan was a small country with minimal resources; being economic and minimising waste motivated the development of Lean principles. This methodology has significantly contributed to the success of Toyota and was emphasised in the book "The Toyota way". The approach was recognised to help several firms across the globe survive the early 1990s' recession (Womack & Jones, 2003). A research in 2003 among 1757 US manufacturers also showed that there was a correlation between lean practices and higher efficiency and performance (Shah & Ward, 2003).

Lean management or "Just-In-Time" (JIT) approach, an Americanised term, can be applied to various fields like JIT manufacturing process, JIT inventory or a delivery scheme, which are all based on the core concept of "Leanness". A JIT inventory management suggests that inventories should be available just when needed, no earlier or later. This is to ensure that inventory and holding cost be minimised or eliminated, but production can still proceed in a timely manner (Waters, 2003). In order to keep operation flow with a minimal level of inventories, JIT systems strictly trust short stable lead times (Langley, et al., 2008). When a new order arrives and requires more materials than the amount available in warehouse, inventory needs to be restocked immediately. Replenished materials are expected to arrive and move exactly when needed so production should constantly smoothly flow.

Additionally, JIT method embraces zero or minimal inventories as inventories are standing capital that incur interest costs and holding costs, occupying space (Singh, et al., 2013). Author Waters also argued in his "Inventory control and management" book that inventories, unless being held to buffer uncertain and varying demand and supply, "serve no useful purpose" but only reflect incompetent management resulting underutilised resources (Waters, 2003, p. 344). He believed excess inventories does not

motivate managers to speed up production and materials flow. Materials being circulated is a sign of progress and generates cash flows. Non-moving inventories can be an investment without returns, which is not a healthy term for businesses. Unused inventories can become obsolete, not usable and become waste, not to mention the extra space occupied by them.

Nevertheless, a JIT system might pose disadvantages to companies. Holding minimum level of stocks together with relying on consistent and quick responsive supply could put businesses under challenge of unexpected prolonged lead time and/or irregular demand (Waters, 2003). In case suppliers cannot fulfil replenishment orders on time, low or zero inventories might not be able to cover peaking demand, which results in delay in production, and thus, decreases performance. Consequently, end-products cannot be finished and delivered on time, which might be detrimental to customer satisfaction. Secondly, as a JIT system is reactive to each customer order, firms usually make small batch replenishment just to meet a specific demand and minimise inventory costs. This might cause purchasing orders to be under-optimised and increases costs (Waters, 2003).

2.2.3 Material Requirements Planning

Materials Requirements Planning (MRP) method, which was first developed by Joseph Orlicky (Orlicky & W. Plossl, 1994) as a computer-based system to plan production, is applied to ensure the production run smoothly by giving users information on what materials and how much is needed to manufacture end products, and when to replenish inventories.

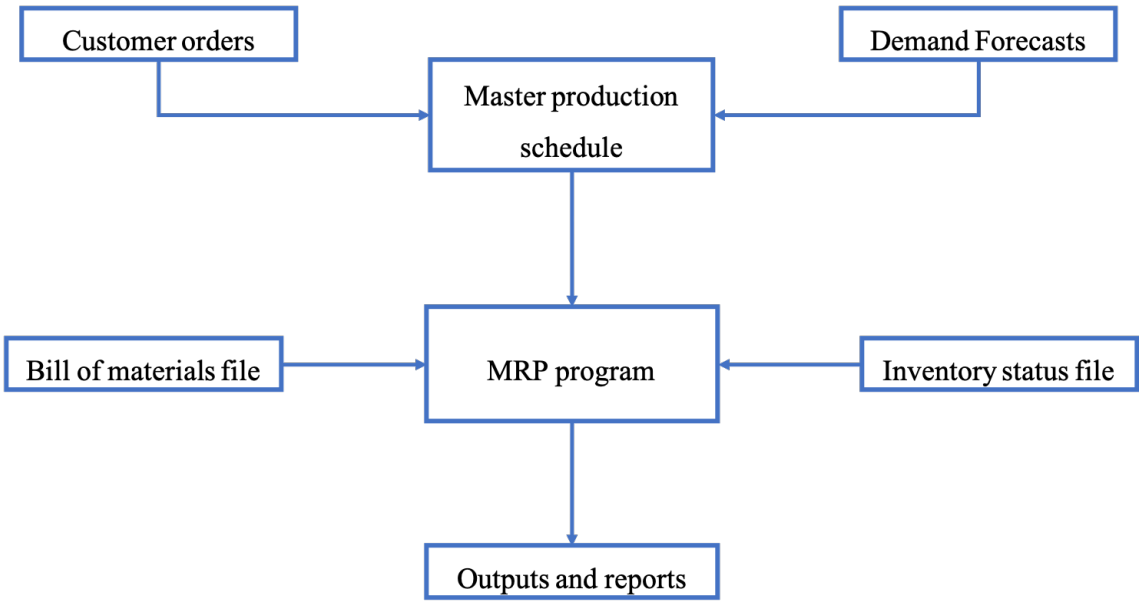


Figure 1 An MRP system (Langley, et al., 2008)

An MRP program is driven by "Master production schedule" which has Customer orders and Demand forecasts as inputs. Customer orders feed the system with details of end-products to be manufactured and customers' information. Master production schedule, based on forecast sales and real demand, can propose a plan on quantity, subassemblies, and time frame for business to follow.

Bill of materials file is a crucial input of an MRP program. It is a list of resources that are needed to manufacture an end-product. Those resources include raw materials, components, labour, finishing work, and exact respective quantity required. When a customer order is received, and the user creates a bill of materials for each end-product, the system can calculate total quantity of raw materials needed for production.

Inventory status file is a file that keeps track of list and level of inventories. With Inventory status file, the system knows if inventory needs to be replenished to fulfil production requirement. The system automatically measures shortage of inventory and recommends an amount of reorder so that there are sufficient materials for production to proceed and to produce stocks to meet forecast sales. This is why MRP is usually used in a push system.

Outputs and reports generated by MRP system can be Quotations, Reorder notes, Delivery notes, Invoices. The system automates documentation and calculation processes so users can reduce manual and "guess" work in deciding reorder amount, for instance.

The concept of MRP has been utilised in designing Enterprises Resources Planning (ERP) systems by world famous information system and software companies like Oracle and SAP (Monk & Wagner, 2009). As a marketed MRP system is computer intensive, it is costly to purchase the application and maintain it. Thus, it seems not a good deal for a small business like company A given its limited financial capital.

2.2.4 Safety stock

As companies might face uncertainties in demand, supply or lead time, safety stock adds a "margin of security" to companies' inventory (Waters, 2003). Safety stock, or buffer stock, is a reserve of stocks those usually sit in warehouses and are only used in case of emergencies or uncertainties like variable replenishment lead time or variable demand.

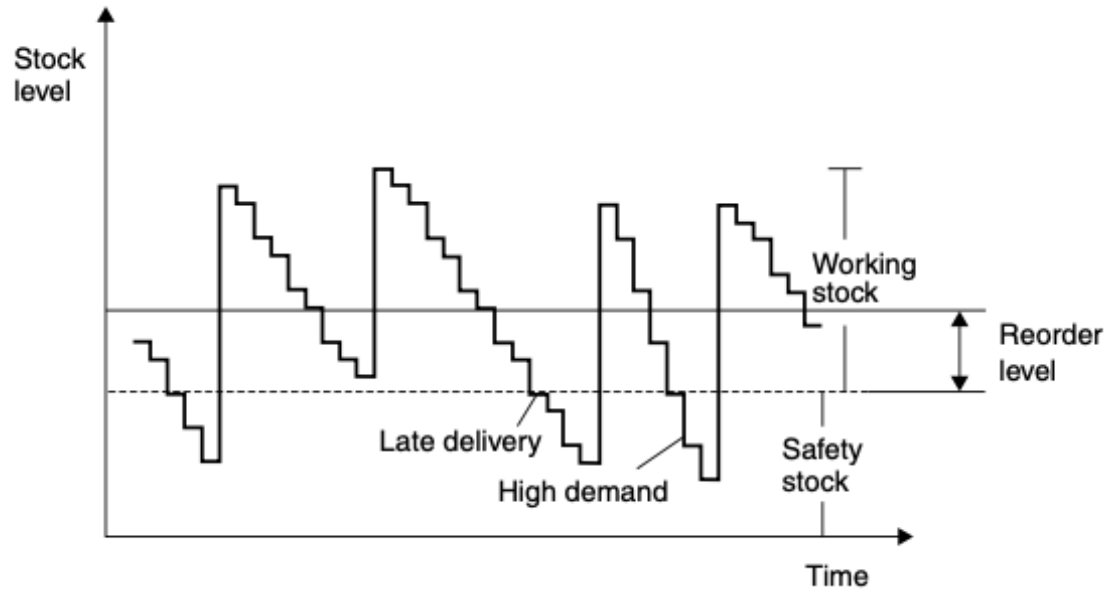


Figure 2 Safety stock in uncertain events (Waters, 2003)

In case replenished stock arrives late, some part of safety stock can be utilised to continue production. Similarly, when demand unpredictably goes up and more raw materi-

als are immediately required, companies can use safety stock as inputs to ease the strain on production.

One commonly used safety stock formula is one that factors both lead time variability and demand variability (Brown, 1977):

$$\text{SS} = \text{z-score} * \sqrt{\text{avrg(LT)} * \sigma_{DD}{}^2 + \text{avrg(DD)} * \sigma_{LT}{}^2}$$

Where:
z-score: a statistical figure, "a number of standard deviations from the mean that correspond to the specified service level" (Waters, 2003) (Appendix 1).
LT: lead time
DD: demand
σ_{DD} : standard deviation of demand per unit time
σ_{LT} : standard deviation of lead time

This formula assumes that both lead time and demand are normally distributed and independent of each other. Z-score is a factor that is statistically analysed and corresponds to a certain level of service (Appendix 1). For example, if a company has 95% of service level, i.e. 95% of confidence level to meet demand, z-score equals 1.65 and the company needs to carry extra inventory equal to 1.65 standard deviations of demand variability (King, 2011).

3 METHODS

3.1 Constructive Research Method

In the era of growing digitalisation and technology, small companies like company A have been facing challenges in terms of limited technological and financial capacities versus the need to upscale to survive competition. It raises needs to apply theoretical knowledge into practice, to developing solutions to real industrial challenges (Hyötyläinen, et al., 2014). Constructive method is an approach that, according to

Kasanen (Kasanen, et al., 1993), applies theoretical knowledge to help solve problems, creating new and innovation “constructions”.

With the purpose of creating an inventory control system to reduce manual and “guess” work during inventory activities for company A, this project is conducted following a constructive method, which is "managerial problem solving through the construction of models, diagrams, plans, organizations, etc." (Kasanen, et al., 1993). This method has been widely applied in broad fields such as management accounting (Kasanen, et al., 1993), in logistics (Lukka, 2003), higher education (Ritchie, 1995) and computing and technology (Dodig - Crnkovic, 2008), highlighting the following structure:

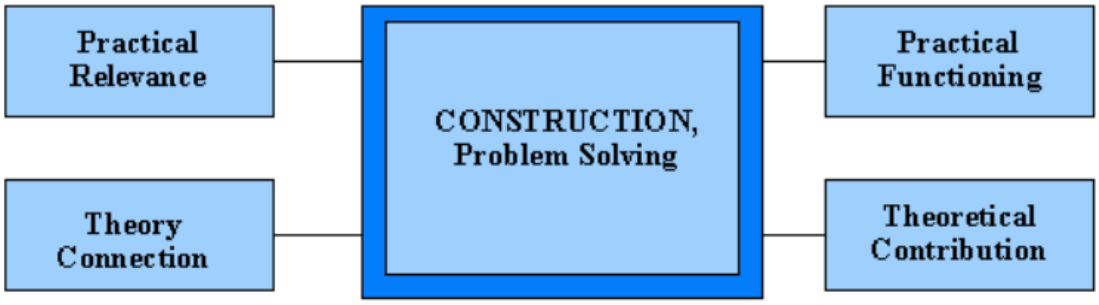


Figure 3 Four key elements of a Constructive Research (Kasanen, et al., 1993)

These four major elements of a constructive research are among a six-phase research process (Kasanen, et al., 1993):

- Finding out the practical problem
- Studying theories to inquire understanding of the topic
- Development of a solution
- Implementation of the solution
- Exploring theoretical and research contribution of the project
- Evaluation of applicability of the developed solution

3.2 Participant Observation Method

Participant observation is a method in which participant observers are in the context of the study, watching the situation, noting observations, listening to conversations and

collecting information via discussions with participants (Bryman, 2012). This method is a subordinate of "ethnography" which refers to both the observation and the written output of it. Thus, in practice, participant observation is not merely observation, but participant observers do also field notes and gather data by being involved in conversations, interviews and/ or collecting documents.

According to Alan Bryman (Bryman, 2012), there are two types of settings on which a participant observation can be conducted: open/public setting and closed setting. An open/public setting can be communities, societies, publics and so on; whereas closed or non-public settings include private premises, companies, schools, and similar kinds. It depends on the type of context being public or not, how to access the setting via overt or covert role is decided accordingly. If one takes overt roles, they open up about their researches with the organizations and negotiate to gain access; while in covert roles, researchers do not reveal their researching purpose and usually can access the setting without some hindrances.

In this project with company A, participant observation method was used in several steps of the project: in data collection stage to identify the existing practice and problem, and in evaluating the applicability of the developed solution. The setting is non-public between the author and company's staff. Nevertheless, the author faced no challenges in setting up meetings and observations with the selected participants, aka key informants.

4 PROJECT PROCESS

The overall project process followed Constructive research methodology which is explained earlier in Section 3.1 Constructive Research Method. Among those steps, problem identification, solution development and implementation steps were conducted in Action Research approach, which is a collaboration with the company to collect information and data to develop a solution for an existing issue (Bryman, 2012). This research method was incorporated in the above-mentioned Constructive framework, in order to gather data from the company A, to pilot the developed solution to a certain extent.

Following Constructive framework and with reference to Alan Bryman's design (Bryman, 2012), this project research consisted of four stages: Theoretical framework study, Investigating current practices and practical issue, Development of solution, Piloting and evaluation of the developed solution. As theoretical framework study has been shown in Chapter 2 of this report, the following parts of this report lay out the remaining 3 stages which were practical collaboration between the author and the company.

Before starting the practical parts, research questions were built up, backed by theoretical framework, to set direction for the research and to help the author to stay on track focusing and connecting relevant theories with the proposed solution.

Four research questions to be answered during the course of the project are:

- What are current inventory management practices in company A?
- What are existing inventory control computer-based solutions?
- What functionalities should the proposed Inventory solution include?
- How does the solution help to mitigate inefficiencies or costs?

4.1 Investigating current practices and practical issue

In studying the company's present routines and existing issues, the author collaborated with the company's employees to collect and exchange information that is related to inventory management topic and to answer the research question "What are current inventory management practices in company A?".

Participants to have meetings with were selected based on their job responsibilities surrounding the topic. Inventory controller was first approached, and the author was, afterwards, introduced to approach Business and Pricing manager and accountant for further useful information and documents.

4.1.1 Discussions and participant observations with key informants

Primary information was collected in forms of virtual discussions and participant observations with the company's employees. Due to geographical distance, all discussions were conducted virtually via TeamViewer application, phone calls, video calls, messages and emails. The setting was in friendly manner, so as to give possibilities to open questions and informative discussions. Participant observation fields notes were taken during each meeting in a project journal (Appendix 4). As this is a constructive action research, conversations with the company occur recurrently until the final solution is delivered and piloted.

The first discussion was conducted on 15 July 2020 with inventory controller via a phone call to get detailed information on inventory control activities. The inventory controller confirmed not tracking of stocks in and out in any software; and in fact, the routine was taken care of by financial team who is based in another city.

The second meeting took place on 17 July 2020 with business and pricing manager. The conversation was via a video call and participant observation via screen sharing in Team viewer software. In participant observation, the manager demonstrated pricing file, BOM and quotation processes; while the author being the observer taking field notes. It was observed that the process was heavily manual, manager using Excel functions like Sum() and vlookup(); the Excel sheet was filled with both drafted calculations and actual values. The manager expressed his need for a more compact and simple solution or interface to reduce the hassle of BOM and pricing process.

As introduced by the manager and inventory controller, the company's accountant was contacted to obtain inventory entries documents. Inventory report documents were extracted from the accounting system Misa.

4.1.2 Findings and Reflection: Company A's current inventory practices

After discussions with the inventory controller and business manager, obtained information on the current process in company A is demonstrated in Figure 4 below:

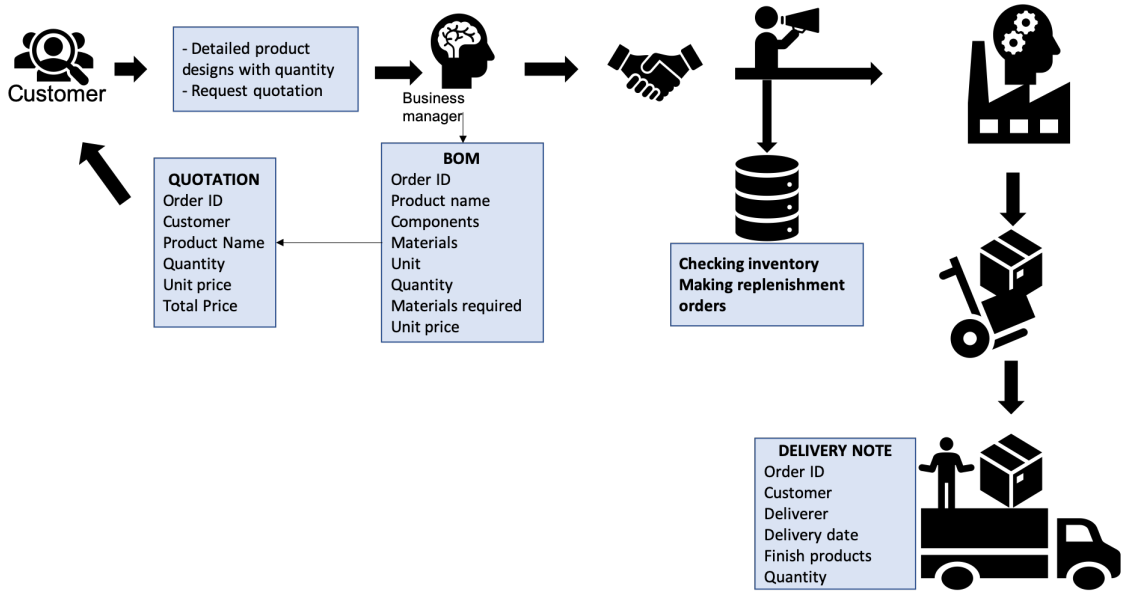


Figure 4 Inventory processes of company A

A customer first sends the company a list of products with detailed designs and requests a quotation from the company. Business and pricing manager, after receiving quotation request, starts to create detailed BOMs, calculating amount of materials needed to produce each unit, and price of each component, and thus, price of finish products. Pricing manager then does "copy and paste" work to transfer product names and corresponding prices to a quotation template, which is, afterwards, sent to the customer. After negotiation and reaching agreement on terms and conditions (prices and delivery date), customer and company A sign a contract. The business manager estimates amount of total materials needed to fulfil the order.

Following Lean principles, the manager tends to keep stock level lowest possible and replenishment orders are only made if needed, with order quantity approximately being the sum of the additional amount needed to fulfil the order and safety stock level (= Demand - current quantity + safety stock). At the same time, operation manager starts to "pull" production. Those materials are stored at low level but adequate for production to start immediately when order is confirmed, while more materials are on the way to arrive. In this way, the company can keep production flow smoothly and avoid holding too much materials in storage. The company also reflects their JIT and Lean philosophy

when trusting short and stable replenishment lead time, so usually purchase refills when orders are confirmed.

In a Make-to-Order business model like company A, finish products are highly customised, so it is impossible to forecast demand of finish products. These finish products have independent demand, whereas major raw materials like metal sheets, coating powder, bolts and nuts have dependent demand. According to the manager, they are main ingredients to produce cable ladders – the company's mostly ordered products. To maintain production flow, the company keeps a minimal stock level of these materials.

Inbound logistics: incoming materials ordered by business and pricing manager are received and counted by inventory controller based in manufacturing site; and updating of inventory status is done by finance and accounting team in Misa software (an ERP accounting and bookkeeping software) based in an office in another city. Inventory controller occasionally keeps track of bolts and nuts stock in own Excel files.

Outbound logistics: when ordered products are ready to be delivered, inventory controller sends "Delivery note" to truck driver and products are transported to customer. Inventory control records the number of bolts and nuts used in own Excel files.

Current routines and files to manage inventory in the company are basically following the MRP structure Figure 1, though they are poorly maintained in Excel application. Necessary elements of an MRP system do exist in company A's processes: BOM files, inventory status file, customer orders, output files (quotation, delivery note) but maintenance is irregular and inconsistent. Therefore, there is a need to reconstruct the inventory management system for company A, making these processes more smoothly connected and efficient.

4.1.3 Trustworthiness of research discussions

Since the research was conducted with the company to build a solution to benefit the company, respondents were assumed to provide truthful answers. Discussions and meetings were conducted independently so that participants' responses were not affected by

each other. Certain questions were posed to both participants (business/pricing manager and inventory controller) to check the consistence and accuracy of collected data.

Questions and conversations were kept in a neutral environment, without interference of any unconcerned individuals.

4.2 Existing solutions and the chosen solution

In answering the second research question "What are existing inventory control computer-based solutions", information on existing computer-based inventory solutions was collected via desktop research. With current limited resources and scalability, the company hopes for a solution that is cheap and simple easy to use and requires minimal IT maintenance work. Thus, the desktop research should give results that can satisfy these criteria: low cost, easy to use, a solution for small manufacturing businesses and easy to maintain. The author then used these keywords "free inventory system", "inventory system for small business", "MRP for small business" in search engine.

Three inventory systems were selected for this research and data was collected following a template in Appendix 3, which would be used to analyse and compare selected systems so that the most suitable one can be selected.

A few potential solutions were found and compared in Table 1. They are Misa software, Odoo software and Microsoft Excel spreadsheets.

Table 1 Potential Inventory solutions for company A

Criteria	Misa	Odoo	Excel spreadsheet -VBA
Cost	VND 2mil /month/user (about EUR 72)	EUR 42/month/ user (Odoo, n.d.)	Free
Features/Functions	Accounting, inventory	Inventory	Can be tailored to fit users' needs
Maintenance work by IT specialist or expert	Yes, contacting service provider in Vietnamese	Yes, contacting service provider in English	Self-maintaining

From the comparison, it can see that Excel spreadsheets - VBA is the most beneficial solution for a small local company like company A at the present because it is cost-free, flexible and convenient. The company staff can have the full control over the software and it does not require an external party for the solution maintenance and development.

Excel spreadsheets - VBA solution used Excel spreadsheets and Visual Basic for Applications (VBA) to build a customised Inventory solution. In the solution, Excel spreadsheets display data and user interface, while VBA - a programming language developed by Microsoft - writes commands to automate several functions and processes.

Furthermore, Excel-VBA based Inventory System solutions have been implemented in small-scaled businesses like in J&B start-up (Freeman, 2011) in the state of Mississippi - the USA, and in Material Requirements Planning spreadsheets in aircraft maintenance (Friend & Ghobbar, 1999), as inexpensive solutions to effectively monitor inventory list, stock volumes and values, and reorder point. Thus, given its widely application and proof of success, this solution in Excel-VBA is the choice for company A.

4.3 Functionalities of the proposed Inventory solution

The proposed solution should provide main functionalities that serve the jobs of inventory controller and business manager: creating BOMs, generating quotations and delivery notes, tracking inventory status, and updating inventory.

A detailed description of these elements will be given in the coming sections, explaining how their functionalities and characteristics have been tailored for company A.

Before going into the description of each element, a high-level description of the system is required to get a correct understanding. In Figure 5, the schematics of the system is presented, which lays out the relationship and interfaces between each element.

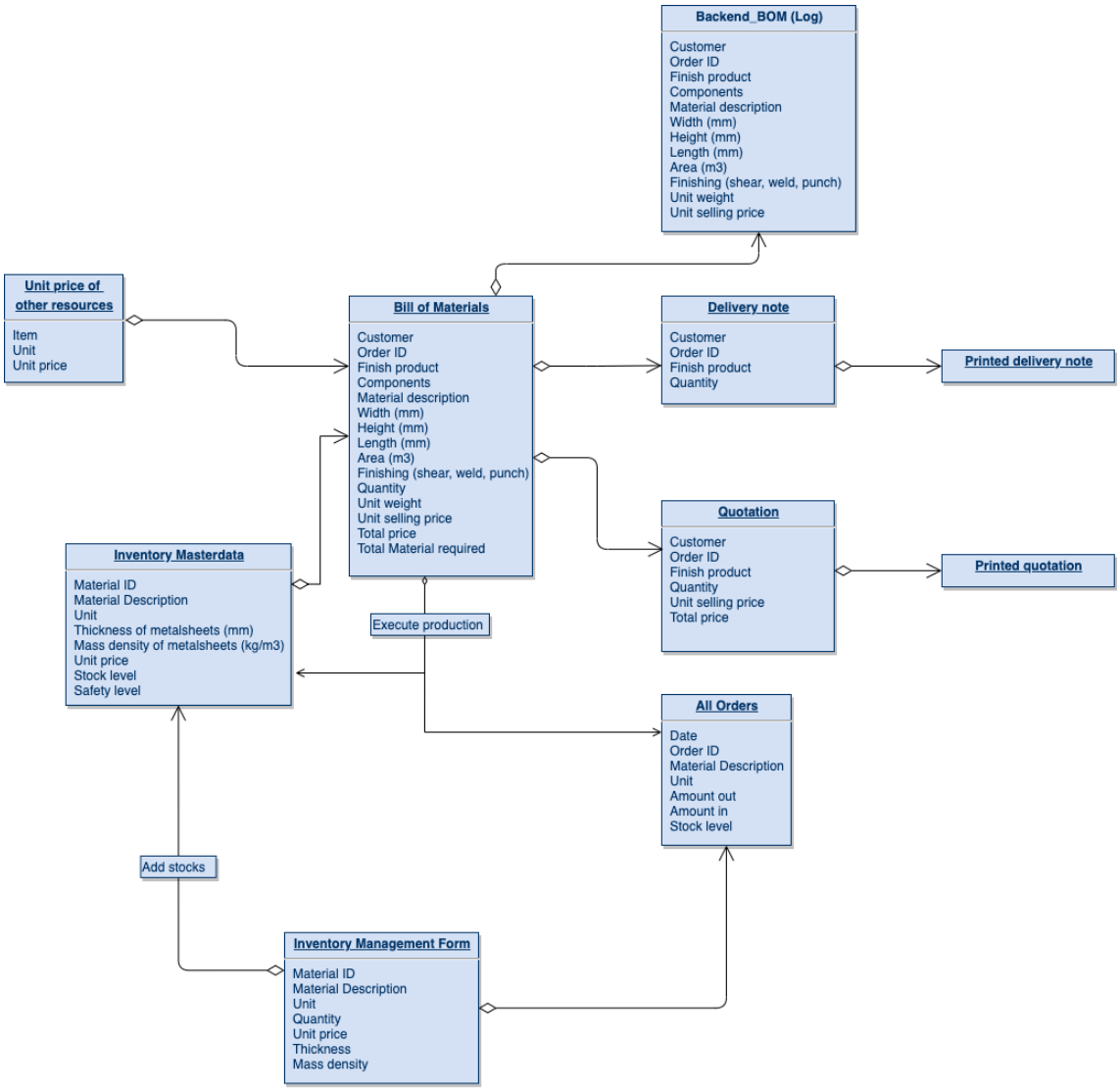


Figure 5 Structure of company A's Inventory system

This software was designed using the *Master data* as its central element. This Master data sheet can contain all items on-hand. To achieve a record integrity, it is necessary this database be up to date at all time. For this reason, every order or change in the inventory is registered in the database directly in *All orders* backlog.

The main access point to this database is the inventory management form. This tool allows the user to introduce changes that happen in inventory and check inventory levels. This tool creates also an order associated to the information introduced.

In the *BOMs* feature (sheet), the user needs to input the characteristics of the final product and its elements, and the changes are calculated by the program. The BOMs sheet organizes the information of each final product as show in Figure 6.

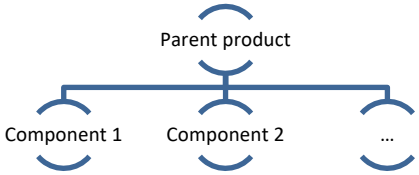


Figure 6 Product structure

Then from the BOM, a quotation document can be generated. This document is delivered to the client for him to confirm or reject the order. If the quotation is confirmed, then the manufacturing process is started. When the products are ready a delivery note is generated and shipped to the client with the products.

BOM and Quotation form sheets are to be used chiefly by Business and Pricing manager; inventory management form, delivery note, all orders backlog and master data are to be used by inventory controller.

The Excel file contains additional elements that are backup sheets. These complements are divided in different Excel sheets:

- **All Orders backlog:** This sheet contains a list of all the orders completed for company A, in and out transactions. In addition, this page can be consulted to see the evolution of the quantity on hand with each order.
- **Backend BOM:** Due to the complexity in some of the finished products offered by company A. It was necessary the creation or an additional database to store additional information for the manufacturing requirements. This way the user can have a neater BOM, where all the necessary information is presented and easy to read.
- **Analysis sheet:** This sheet is containing the calculation of safety stock. It is meant to be backend data and not used by users.

4.4 The developed solution

After sketching the schematics of the solution in Figure 5, it came to development phase. This phase followed Agile Scrum methodology to develop and pilot the solution. "Scrum" is a project development framework in which the whole journey is divided into short work events, as known as "sprints" (Scrum.org, n.d.). Each sprint is equivalent to a mini project which entails planning – developing – test and deploy (Figure 7).

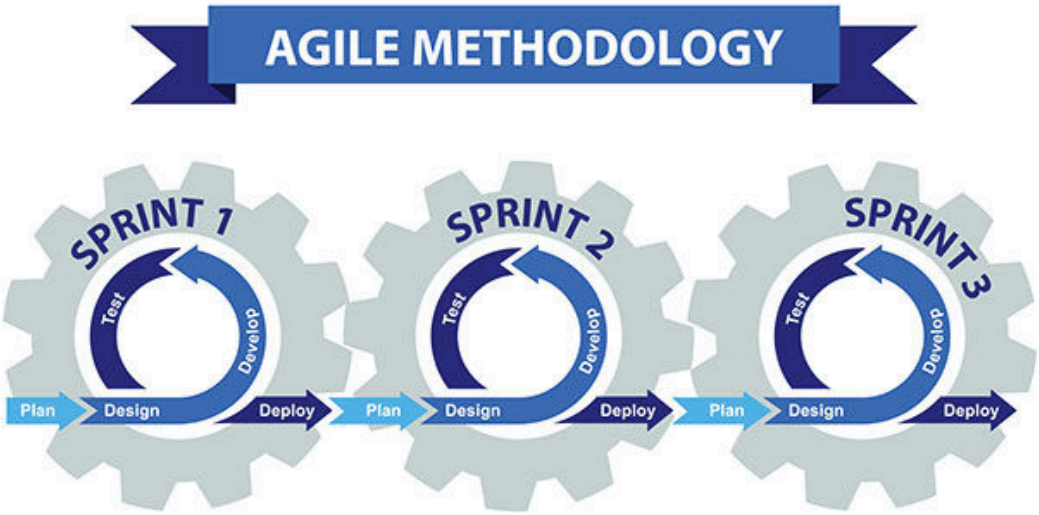
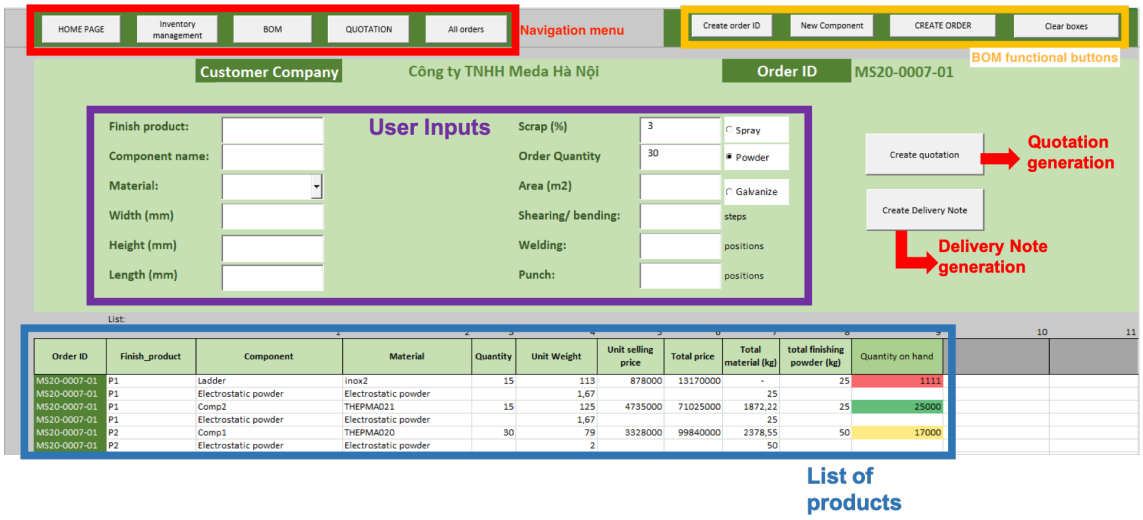


Figure 7 Sprints in an agile methodology (Sapsted, 2019)

There are three sprints in this project to automate company A's inventory practices: automation of BOM, Quotation Generator and Inventory Tracker. These three functionalities were consecutively developed and then tested by business/pricing manager and inventory controller as main users. Feedbacks were immediately inquired so that necessary modifications and improvement could happen timely.

4.4.1 Bill of Materials

In Bill of Materials (BOM) sheet, users, in this case being Business and Pricing manager, can list out components that compose a final product. The system uses input data by users (Figure 8) and retrieves necessary information like material unit cost from *Master data* sheet to automatically calculate unit cost and amount of materials required to manufacture each component.



Order ID	Finish_product	Component	Material	Quantity	Unit Weight	Unit selling price	Total price	Total material (kg)	total finishing powder (kg)	Quantity on hand
MS20-0007-01	P1	Ladder	inox2	15	113	878000	13170000	-	25	1111
MS20-0007-01	P1	Electrostatic powder	Electrostatic powder		1,67			25		
MS20-0007-01	P1	Comp2	THEPMA021	15	125	4735000	71025000	1872,22	25	25000
MS20-0007-01	P1	Electrostatic powder	Electrostatic powder		1,67			25		
MS20-0007-01	P2	Comp1	THEPMA020	30	79	3328000	99840000	2378,55	50	17000
MS20-0007-01	P2	Electrostatic powder	Electrostatic powder		2			50		

Figure 8 BOM input interface

Total cost of a parent product is the sum of material costs and subassemblies and finishing costs of its all components. Those costs include shearing/bending cost, welding and punching costs, coating cost (spray paint, electrostatic powder, or galvanization):

- Material cost = material unit cost * weight * scrap %
- Finishing costs:
  - Shear = unit price *shear acts
  - Weld = unit price * welding positions
  - Punch = unit price * punches
  - Powder = Area * powder unit price * 2
  - Spray =Area *spray unit price * 2 (two surfaces)
  - Galvanization = Weight * Unit Galvanization cost
- Total Cost = Material cost + finishing costs
- Selling price = total cost * (markup + 1)

For calculating the total cost of each component (unit price and material required) the system has implemented a series of functions that run automatically on the addition of a new component. These equations are shown in Figure 9 below.

```
'material costs
material_unit_price = Application.VLookup(Sheet2.Material_Box.Value, Sheet11.Range("material_masterdata"), 5, False)
density = Application.VLookup(Sheet2.Material_Box.Value, Sheet11.Range("material_masterdata"), 4, False)
weight = area * density * thickness / 1000
material_cost = Application.WorksheetFunction.RoundUp(weight * material_unit_price * (1 + Sheet2.scrap.Value / 100), -2)

'finishing costs
If Sheet2.opt_powder.Value Then powder_cost = area * Application.VLookup("Powder", Sheet4.Range("a1:c10"), 3, False) * 2
If Sheet2.opt_spray.Value Then spray_cost = area * Application.VLookup("Spray", Sheet4.Range("a1:c10"), 3, False) * 2
If Sheet2.opt_galv.Value Then galv_cost = weight * Application.VLookup("Galvanize", Sheet4.Range("a1:c10"), 3, False) * 1
shear_cost = Sheet2.shear.Text * Application.VLookup("Shearing/bending", Sheet4.Range("a1:c10"), 3, False)
weld_cost = Sheet2.weld.Text * Application.VLookup("Welding", Sheet4.Range("a1:c10"), 3, False)
punch_cost = Sheet2.punch.Text * Application.VLookup("Punch", Sheet4.Range("a1:c10"), 3, False)

'total costs calculation
total_cost = material_cost + shear_cost + weld_cost + punch_cost + spray_cost + powder_cost + galv_cost
selling_price = Application.WorksheetFunction.RoundUp(total_cost * 1.2, -3)
```

Figure 9 Calculating costs in VBA

Since all products are customized, each BOM is unique and belongs to a specific order ID. After a BOM is created, it is recorded in a backlog sheet as a backup.

In the BOM interface, the manager can execute production by pressing “CREATE ORDER” button; and inventory controller can generate delivery note by clicking “Create Delivery note” button when finished products are ready to be delivered.

4.4.2 Quotation

A quotation is generated after pricing and BOM creation have been completed (Figure 10).

Order ID	Finish_product	Component	Material	Quantity	Unit Weight	Unit selling price	Total price	Total material (kg)	total finishing powder (kg)	Quantity on hand	Create quotation
202010-0021	Cable ladder 1	Ladder	sheet metal 0.58	132	5,0083	233000	30756000	661,0956	24,2	5000	
202010-0021	Cable ladder 1	Electrostatic powder	Electrostatic powder		0,183333333			24,2			
202010-0021	cable ladder	ladder	sheet metal 0.58	150	5	233000	30756000	661,0956	24,2	4338,9044	
202010-0021	cable ladder	Electrostatic powder	Electrostatic powder		0,183333333			24,2			
202010-0021	cable ladder	duct cover	sheet metal 1.15	150	9,93025	332000	43824000	1310,793	24,2	3889,207	
202010-0021	cable ladder	Electrostatic powder	Electrostatic powder		0,183333333			24,2			

Figure 10 BOM and prices

The creating quotation function automatically fills in the quotation form with order ID, ordered products, quantities, and prices. This function saves users from previous “copy and paste” routine. Hence, business and pricing manager can immediately print out the generated quotation or save as PDF file and send to customer.

no.	name of finish pr	Note	Unit	Quantity	Unit Price	Price
1	**Cable ladder 1**		set	132	233 000	30 756 000
2	**cable ladder**		set	150	565 000	84 750 000
	Delivery fee		lô	1	1 400 000	1 400 000
		SUB-Total (chưa bao gồm VAT)				**116 906 000**

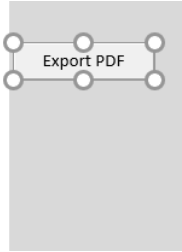


Figure 11 Auto-filled quotation form

4.4.3 Inventory Status and master data sheet

Inventory Management form (Figure 12) is the interface that users, i.e inventory controller, use to add a new stock or adjust an existing stock level. The form also allows users to track stock level of an existing material using material ID, and it suggests amount of stock to be replenished in case stock level is lower than safety stock level. When material ID is entered in the search, all information connected to that material ID (including material description, unit, quantity on hand, safety stock level) is retrieved from Master data sheet and is showed in the result box.

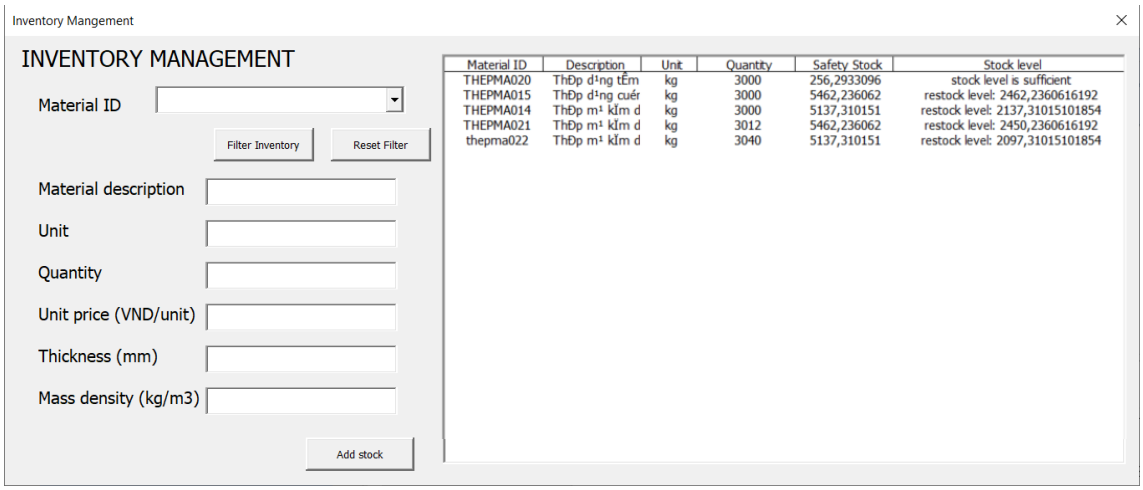


Figure 12 Inventory Management form

The result also suggests restock level when quantity of stocks on hand is lower than safety stock level. Restock amount is calculated as the difference between safety stock level and quantity on hand (restock level = safety stock – quantity on hand)

The safety stock calculation discussed in Section 2.2.4, in case of company A with stable replenishment lead time, has been simplified as standard deviation of lead time is close to 0. Since materials can be purchased from local suppliers, lead time is usually

within the day, making average lead time about 1. Thus, the simplified formula of safety stock to apply for company A is SS = z-score * standard deviation of demand. This calculation is done in the Analysis sheet within the Excel solution, and this is a backend data. Demand standard deviation of each material was derived from records of material expenses, using Excel Pivot tables (Appendix 7).

Once a quotation is accepted and the contract is signed, the company can execute production. "CREATE ORDER" button based in BOM sheet runs to calculate total amount of materials to be used and record "Amount out" in all orders backlog; at the same time reduces and updates new stock level in Master data sheet.

5 SOLUTION EVALUATION

5.1 Solution testing

The application was introduced to two main users: the business and pricing manager and inventory controller of company A for testing. Discussions and participant observations were conducted with both target users via video calls and TeamViewer software. Objectives of the discussions are to test if the application caters the needs of users, and to assess overall user experience, and to obtain feedbacks and ideas for future development.

Discussion with business and pricing manager (Appendix 4):

The business and pricing manager was invited to a video call and TeamViewer screen-sharing. Introduction of the whole system and demonstration were first given, then the manager tested out BOM and quotation form functionalities by using information of an already created component to check accuracy of VBA codes and the system. The result price was delivered instantly and matched prices that were calculated using old manual method with Excel functions. Quotation function worked smoothly; information was correctly filled in the form. The manager could immediately export the PDF file and save it in folder.

The manager compared this application to Misa software – a ERP software that the company is introduced to. This software costs VND 22 mil/ year (about EUR 800/year), and the manager was reluctant and found it "complicated". The Excel-VBA solution was said to be more familiar and flexible solution.

Discussion and observation with inventory controller (Appendix 4):

The discussion was also conducted via a video call and TeamViewer software. The controller was first introduced to the structure of the system, Inventory Management, Master data sheet and all orders backlog functions. A demonstration was first provided, afterwards, inventory controller tried to create a new material and add more stock of an existing material using Inventory Management form.

Comparing the application to Misa software – the previous Inventory System tested by the company, the controller found the application to be easy and simple to use. It was convenient as "copy-paste" work was eliminated, and files can be generated within a few clicks of buttons.

5.2 Evaluation

This section of the thesis answers the last question "How does the solution help to mitigate costs/ inefficiencies?" by evaluating the solution based on criteria: functionality, user experience, cost and time efficiencies.

Functionality: The developed solution is functional, serving all required purposes. This inventory system caters main functions: creating BOMs and pricing, generating quotations and delivery notes, and inventory management. Furthermore, the program following MRP structure – typically used in push systems, still allows the company to adhere to their Lean principles, and to run their "pull" method of working. Replenishment is suggested considering statistics-based safety stock level, which act as the cushion for the business in case there is unpredicted demand or prolonged lead time to refill materials; meanwhile production is only pulled when business manager confirms orders with

customers. This hybrid pull/push characteristic of the solution is expected to help the company maintain its leanness, low level of inventory, and also to continue smooth production when demand peaks. The application of a hybrid pull/push production system was in fact tested and proven by Markovian model to be beneficial and resulting in "lower inventory levels and better response to demand changes than the pure pull system" (DELEERSNYDER, et al., 1992).

User experience: It is also effective in removing or minimizing tedious manual Excel works for the users. In the BOM feature, calculations of costs and prices are automated so no using of Excel functions is needed. Generation of quotation and delivery note is possible with a quick button click. Conducted participant observations (Appendix 4) with the manager and the controller prove that they did not have to copy values such as item names, corresponding quantity, prices and paste in a new sheet when creating new documents. The manager did not have to do any calculations of costs and prices using Excel functions when using this solution. Thus, it is a transformation for the company, moving from primitive Excel procedures to a functional programmed system.

Furthermore, this is a centralised system that all functions exist in one file, saving users from having to manage many files and folders, which can potentially result in excessive administration work or mismatched values between customers, manager and inventory controller. Furthermore, being an inclusive system, the developed solution allows users to easily switch between features by clicking navigation buttons. It creates a frictionless experience as if this were a real well-established application. It was observed that both users met no difficulties in switching among functionalities and did not get "lost" in the system (Appendix 4).

The proposed BOMs feature has a more compact interface with fewer cells and columns compared to current pricing BOM files used by the manager before. That saves the user from scrolling the sheet and mis-looking. Automated work and neater interface could probably spare users from misalignment of cells, columns and reduce mistakes, hence, increasing work precision.

Time efficiency: As a result of smooth user experience, it is a time-saving solution for the company. On average, the manager spent about 10 minutes on a typical cable 4-component ladder product (including doing BOMs, calculating costs and price, transferring values to quotation form). From the solution testing and observation with the manager (Appendix 4), it was observed that it took only 4 minutes on keying in details of that product in BOMs feature, and all other steps were completed with a button click. The process got 2,5 times faster, meaning work productivity increasing 250%. Similarly with inventory controller, the usual routine to transfer information from quotation to a new delivery note costs about 3 minutes per small-sized order. With pressing only one button "create delivery note" in the new solution, a new delivery note now can be instantly ready and 3 minutes is saved.

Monetary cost: this solution is built on existing Excel software that is being used in the company. It requires no IT experts from any external service provider to maintain or develop. Thus, no extra cost is incurred. Revealed by the manager, an ERP software called Misa has been marketed to them and it costs about VND 22 mil/ year (about EUR 800/year) for subscription and maintenance fees. The manager is considering the cost and is reluctant as that software is inflexible and unfamiliar for them (Appendix 4). Thus, this proposed solution can definitely save the company that amount of money, and is a flexible program that is based in the traditional and well-accustomed-to Excel.

To objectively assess if the proposed solution is better than the current procedure, Weighted Sum Matrix is used to weigh the two options, with evaluation criteria being functionality, user experience, time saving, and money saving. The business and pricing manager, being the decision maker and more significant user of the solution, gave a weight for each criterium: Cost – saving 35%; functionality 25%; user experience 30%; time efficiency 10% (Appendix 4).

During the meetings, the two users the manager and inventory controller were requested to grade the solutions by each criterium, following scoring scale 1 to 5. (1 – very bad; 2 – bad ; 3 – neutral; 4 – good; 5 – very good) (Appendix 4). The calculated result is presented in
Table 2:

Table 2 Weighted sum matrix - Evaluation of proposed solution

		Business manager				Inventory controller			
	%	New solution	weight	Old practice	weight	New solution	weight	Old practice	weight
Cost saving	35	5	1.75	5	1.75	3	1.05	3	1.05
Functionality	25	5	1.25	4	1	5	1.25	1	0.25
User experience	30	4	1.2	1	0.3	5	1.5	1	0.3
Time efficiency	10	4	0.4	2	0.2	5	0.5	2	0.2
Total weighted sum			4.6		3.25		4.3		1.8

From the table, it is seen that the proposed solution overweighs the current practice and is more highly graded by both users. In total, the developed solution scores 8.9 whereas the current one scores 5.05. Thus, it is evident that the inventory system in Excel – VBA is a suitable solution that should be employed by the company to improve the efficiency of its inventory process.

5.3 Future development and improvements

The application received good feedbacks from main users being the business and pricing manager and the inventory controller of the company, and it showed positive prospect. Nevertheless, more features could be implemented to make the application more well-rounded for the company specifically, and other similar businesses.

The manager also suggested Customer Management and Special Discount for specific customers or bulk orders could be added (Appendix 4). With customer management function, company can keep a master data of its clients and designate a specific code or ID for each client. Using customer codes, order IDs could be automatically generated following format MSyy-cccc-nnnn (where yy is order year, cccc is customer code and nnnn is order number). Special Discount feature can decide how much discount is given to certain customers or if a customer makes a high value order.

An inventory dashboard or summary page could be added to the application so that inventory controller can have a quick look at the overall inventory status and recognize low stocks at a glance. It will save the user from having to track individual material status, so replenishment could be made timely.

One challenge of the application is that it is a desktop-based software so the 2 main users could not use the application simultaneously. The master data sheet is the central of the application and both users need an updated master data to do their jobs. For the data to be synchronised and updated, the Excel file should be emailed back and forth as the company is of small-scale and financial capacity to have its own intranet. However, this is not a convenient solution and different versions of this Excel file could be mixed up. It is recommended that the company stores the file in Microsoft drive so both users can have access to it and use at their own convenience.

Another drawback of the solution is that when BOMs or orders accumulate, after a certain time, Excel can run out of cells and the system can slow down or lag. A feature that can automate archiving and clearing of long past data will be added to keep the file neat and light.

5.4 Learning outcomes

It is learnt that there is a huge gap in digitalization between Vietnamese local companies and bigger sized ones and that gap is not easy or even impossible to close. The primitive run-by-gut-feeling way of operating is still prevailing; and accepting to kick-start transformation and automating takes great courage from company's leaders. They are pulled back by limited financial resource, and by their concern of not being able to adapt and keep up with updated technology. It is a vicious circle for local businesses when they are too small to afford investment in modern digital/automating programs, which is one way that helps boost productivity and efficiency, so they can scale up; as a result, they stay small sized and even get left behind in competition, which hinders them further from obtaining enough revenue to re-invest in automation projects. The solution for them could be that they have to take a leap of faith to at least slowly change in their vi-

sion and mentality, willing to accept the fact that sooner or later automation and digitalisation is a must to survive.

A Make-to-Order business like company A meets many challenges in their production planning as simply there is hardly a fixed plan when all products are bespoke and every single order is different from one another. Automation process for such local company will probably require a large amount of resources in terms of time and money. In order to create a pricing tool and a material planner that work precisely for products of all shapes and sizes, coming in either hand-drawn/sketchy or computerised designs, it might need some algorithm to do so. It might not be rocket science, but definitely a hard brain work that is a challenge for small enterprises. Therefore, manual process sometimes is unavoidable, and this developed solution might not promise to be a working-for-all-products tool.

A hybrid pull/push production system that utilises advantages of both seems an advisable for small Make-to-Order companies. With this method, they still pull production when there is demand, so can save resources by avoiding waste and extravagance; also holding a reasonable level of safety stock for main raw materials can help when facing unpredicted peak demand.

6 CONCLUSION

As digitalization and automation have become an inevitable process for businesses nowadays to gain scalability and efficiency, many Vietnamese local SMEs face challenges and are on the verge of staying behind due to lack of advanced digital solutions. An automated solution that is cheap or free, can be "home-made", and can serve basic functions is a significant assistance for SMEs with low level of financial capacity and IT-savviness. Inspired by this, a simple Inventory management system was developed to specifically fulfil the needs of company A – a local manufacturing business in Vietnam.

The solution, created in Excel spreadsheets and VBA, was tailored to replace the current manual tedious inventory works in the company A. It can give its users, be the business

and pricing manager or the inventory controller, a smooth and time-saving experience. The developed inventory system has three key features being BOMs, quotation generation and inventory management form and status file, and potential future development features. It is expected to provide the company with a functioning tool now, and a more comprehensive solution in the future. The solution does not only improve the company's processes, making them more automated and time-saving, but also is cost-free. It is a do-it-yourself cheap solution and can spare the hassle of contacting external IT helpdesk.

This paper provides a working code and an inventory system that is used by company A, yet it can be applicable to other small Make-to-Order businesses. This is not a perfect solution as once companies grow, it has not enough capacity to function; but it is a current solution that SMEs can take advantage of. The developed solution, for certain SMEs, might be the first step into the journey of business automation and digitalisation.

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APPENDICES

Appendix 1 Z-score and service level

Desired cycle service level	Z-score
84	1
85	1.04
90	1.28
95	1.65
97	1.88
98	2.05
99	2.33
99.9	3.09

Appendix 2 Research design

Stage	Concepts and Activities
Literature review and concepts	• Background knowledge of Inventory • Pull/push inventory system • Lean management and Just-In-Time approach • Material Requirement Planning (MRP) • Safety Stock calculation
Research questions	• What are current inventory management practices in company A? • What are existing Inventory System solutions for small businesses? What is the most feasible solution in this scenario? • What features/functionalities should be featured in the solution? • What impacts does the proposed solution make on the company's Inventory management activities?

Sampling cases	• Company A's personnel, documents and reports; emails or texts to arrange meetings • Internet & journals sources on existing Inventory solutions
Data collection	***Primary data:*** Virtual Semi-structured in-depth discussions were conducted via phone calls and video calls with Managers, Inventory controller and Accountant. • Meetings with manager were to collect information and perspectives on revenue, inventory value, issues (late or delay deliveries: causes, impacts), unsold stocks of company A. • An interview with Inventory controller to get information on how often inventory control activities and current inventory system. • Observation and taking notes of pricing, quotation and delivery note generation via screens shared in Zoom. • Inventory lists and quantitative data (2019's sales and restock records) were retrieved from the company's accountant. ***Secondary data:*** • Internet reviews on current Inventory Solutions to choose the most suitable solution • Study of similar solutions as reference
Data analysis	• analysis of meeting takeaways, reflecting on published theories • Inventory-out data in Excel find out required Safety stock, pivot table

Appendix 3 Existing inventory solutions data collection template

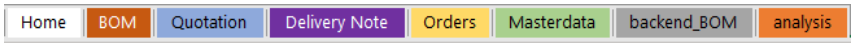
Criteria	System A	System B	…	System n
Cost				
Features/Functions				
Target users				
Maintenance work by IT specialist or expert				

Appendix 4 Project Journal

Appendix 5 User Manual

User Manual

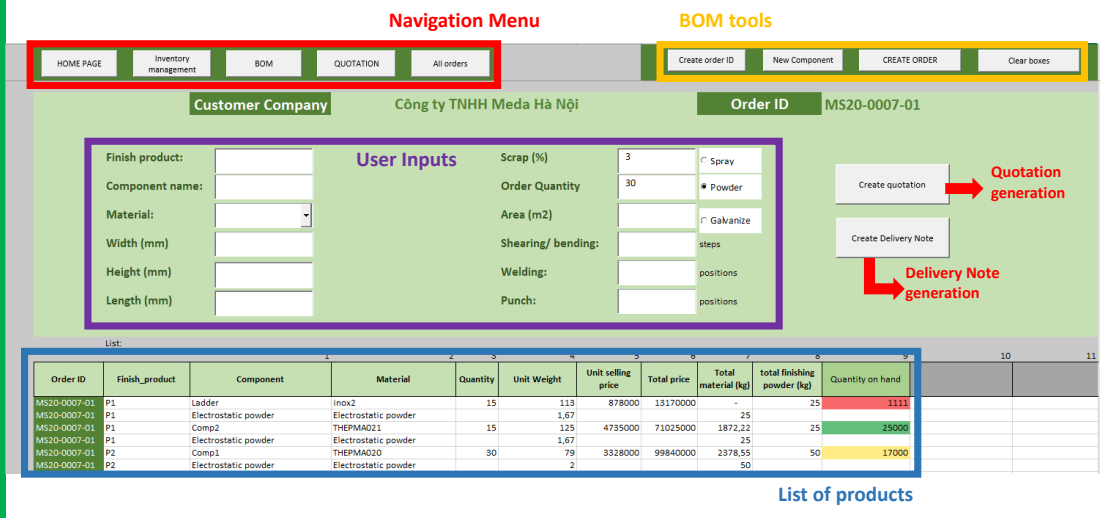
Inventory Management System



Visible elements to the user:

- BOM
- Quotation
- Delivery Note
- All orders backlog
- Masterdata
- Inventory Management
- Backend_BOM
- Analysis

Bill of Material



Inventory Management System – User Manual

Bill of Material

In this sheet the user can introduce the details for each of the final products in the user input field. The following fields are required:

- Finish product
- Material
- Dimensions
- Quantity

When all necessary fields have been filled a new component can be generated clicking in New Component button in the BOM tools.

Other BOM tools are:

- **Create order ID:** Generation of a new order ID for starting a new BOM
- **Create Order:** Generates an order for each component in the “All orders backlog” after quotation has been confirmed for the customer.
- **Clear boxes**

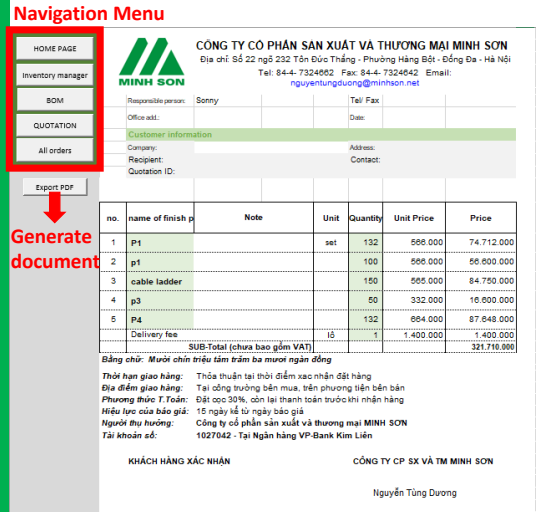
Bill of Material

The buttons “Create quotation” and “Create delivery note” generate the Excel version of each of these documents, respectively.

Below the User input, it is display the list of finish products and each of their components for user awareness. This list is read-only (cells protected) to prevent any accidental changes of data.

Inventory Management System – User Manual

Quotation

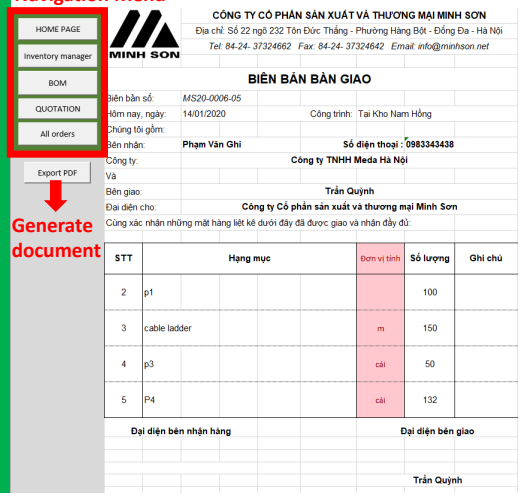


This sheet is for checking purposes allowing the user to check the final Quotation document before generating it and send it to the customer for his approval.

It is possible to add new rows and modify manually the information in this sheet. This way, the user can add additional costs that does not fall into the manufacturing chain, such as delivery fee or discounts.

Delivery Note

Navigation Menu

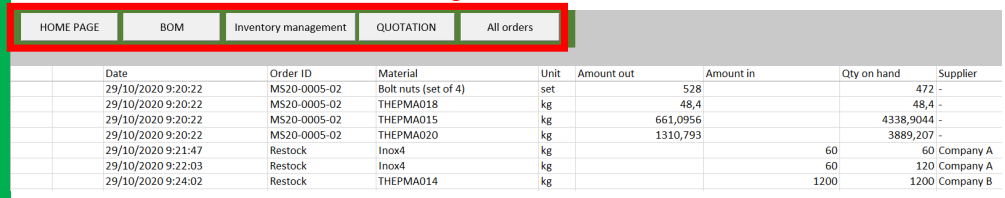


This sheet has the same functionalities as the quotation sheet, allowing the user to introduce changes manually.

Inventory Management System – User Manual

All Orders Backlog

Navigation Menu



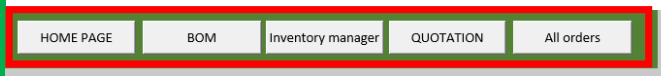
Date	Order ID	Material	Unit	Amount out	Amount in	Qty on hand	Supplier
29/10/2020 9:20:22	MS20-0005-02	Bolt nuts (set of 4)	set	528		472	-
29/10/2020 9:20:22	MS20-0005-02	THEPMA018	kg	48,4		48,4	-
29/10/2020 9:20:22	MS20-0005-02	THEPMA015	kg	661,0956		4338,9044	-
29/10/2020 9:20:22	MS20-0005-02	THEPMA020	kg	1310,793		3889,207	-
29/10/2020 9:21:47	Restock	Inox4	kg		60	60	Company A
29/10/2020 9:22:03	Restock	Inox4	kg		60	120	Company A
29/10/2020 9:24:02	Restock	THEPMA014	kg		1200	1200	Company B

This sheet is read-only. This sheet is updated every time an order is created from the BOM sheet or the “Inventory Management” is used.

It shows the history of all the orders, buy in and sell out.

Masterdata

Navigation Menu

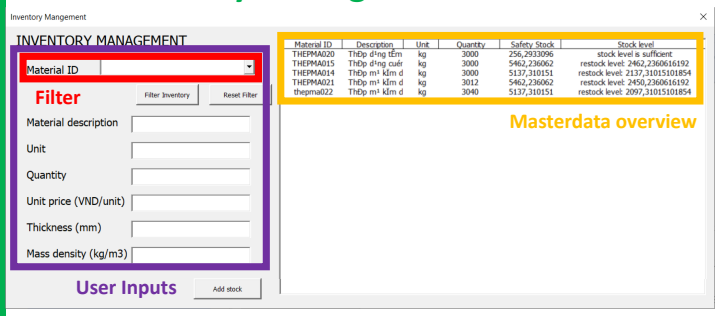


material ID	Material Description	Unit	Thickness f	Mass density (	unit price (VND)	Qty on hand (kg)	Safety level
THEPMA020	*Thép dạng tấm MSM-CC-DA 90 1.0x1219x25*	kg	1,01	7.850	25.000	3000	256,2933096
THEPMA015	*Thép dạng cuộn ZAM 1.2x1219x2500*	kg	1,21	7.850	25.000	3000	5.462,24
THEPMA014	*Thép mạ kẽm dạng tấm ZAM 1.2x1219x3000*	kg	1,51	7.850	25.000	3000	5137,31
THEPMA021	*Thép mạ kẽm dạng tấm ZAM 1.2x1219x2000*	kg	1,59	7.850	25.000	3012	5.462,24
thepma022	*Thép mạ kẽm dạng tấm MSM-CC-DA 90 1.5x1219x2500*					3040	5137,31

This sheet is read-only. This sheet is updated with every transaction that happens in the workbook.

It shows the list of all the materials that the company has on stock.

Inventory Management



The Inventory management allows the user to obtain a quick overview of the inventory available and what material should be replenished soon. This is shown in the “Masterdata overview”.

The user can filter this list by introducing the material ID of the desired material. The dropdown will show all currently available materials.

The other function of the “Inventory management” is adding new materials or directly modifying the quantities of existing ones, this changes are recorded directly in the Masterdata and by generating an order to keep track of the change.

- For adding a new material, the user just needs to write a new and unique material ID and fill the rest of the fields.
- It is possible to record a reduction of the stock of any material by simply introducing a negative quantity.

Backend BOM & Analysis

These two sheets have been introduced because of the nature of the user company. In these two sheets a detailed description of the manufacturing process is displayed. These are not supposed to be used in the daily operations. These sheets are fully user controlled but it is important to maintain the format to ensure a correct functioning of the system.

- **Backend BOM:** This sheet contains ALL the information related to a finished product and its components. It can be used as an additional record for past BOM as all of them are stored in this sheet.
- **Analysis:** This sheet is containing the calculation of safety stock, providing the user with additional information for a more efficient handling of the company A's inventory.

Appendix 6 The developed solution

Appendix 7 Standard deviation calculation