Tampere University of Applied Sciences

The value of flexible manufacturing system investment

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ABSTRACT

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Flexible manufacturing systems can increase production volumes and introduce cost savings to a metal machining factory. As a highly technological solution the investment price can be significant. Communicating the customer benefits, values and balancing them with price is a difficult but very important task for case company sales and marketing.

This paper analyses the customer value, benefits and price of flexible manufacturing investment from marketing perspective. This thesis processes the concepts of the earlier studies with sales and marketing. The goal is to develop understanding how the customer values can be communicated and how they could be used in marketing and pricing.

The academic literature focuses on flexible manufacturing systems, price perception and customer value. Flexible manufacturing systems are described in a basic level to establish basic understanding of the industry. Price and price perception are processed as the counterweight for the customer value, and are processed to support the use of results from this study in pricing.

The thesis produced an updated version of a calculation model, that will enable sales to communicate the most critical financial benefits together with the customers.

Key words: flexible manufacturing systems, FMS, customer value, pricing, return on investment, production volume, machining centre

CONTENTS

1 INTRODUCTION

1.1 Thesis background

Fastems Oy Ab is the leading manufacturer of flexible manufacturing systems in global markets. The evolving nature of modern manufacturing methods requires up-to-date understanding not only in one's own product technology but also to industry mechanics, customer values of offered solutions and latest business practices.

Fastems invests research and development resources to product hardware and software and product managers process and develop data to develop new products and support existing. A part of that product support is to understand the value those products have for the customers and how that value information should be utilized in sales and marketing.

The case company has commissioned multiple studies to understand this topic. This thesis was commissioned to take the next step in supporting the sales and/or marketing with the results from most recent studies and update data where necessary.

Heikki Hallila created a calculation model for flexible manufacturing systems for the same case company (Hallila, 2007). Calculation model created by Hallila was updated in a thesis study by Santtu Kumpulainen (Kumpulainen, 2013). Kumpulainen (2013) also examined the customer values of flexible manufacturing systems.

Both of these studies offered supporting material to sales and marketing, and could be considered as foundation for this thesis. For some reason, the calculation models created previously have fallen out of use and might be outdated. This paper examines the use of the existing calculation models, the possible need for updates, the best practices of the use of earlier versions and the use of the data from the calculation in pricing.

1.2 Research topic

This thesis studies practical ways to support sales and pricing in case company, and to communicate benefits and value more efficiently to the customer. As described in thesis background, the subject isn't new for the case company, but since the last study the calculation models are assumed to have fallen out of use and partially outdated with the new and expanded sales organization.

The study analyses the flexible manufacturing investment benefits from marketing perspective. For case company sales to succeed in communicating customer values and benefits to a potential customer, the values must be presented in easy and understandable way and as quantified, if possible. This thesis processes the concepts of the earlier studies with sales and marketing. The concept is to develop understanding how the customer values can be communicated and how they could be used in marketing.

The academic literature focuses on flexible manufacturing systems, price perception and customer value. Flexible manufacturing systems are described with industrial literature to establish basic understanding of the market. Price and price perception are very relevant to financial justification of any solution with customer value, and are processed to support the use of results from this study in pricing.

Customer value is analysed only in the key elements related to the financial justification as it has been analysed in very detailed level in the previous studies for the case company. The use of customer value will be taken further in pricing and selling aspects as well as in practical applications.

1.3 Research questions and objectives

The main goal of this thesis is to identify key price and value arguments the sales persons of case company face with their customers and update and create tools where necessary to defend these arguments. Secondary goal of this study is to identify the areas and solutions that could benefit from updated pricing methods.

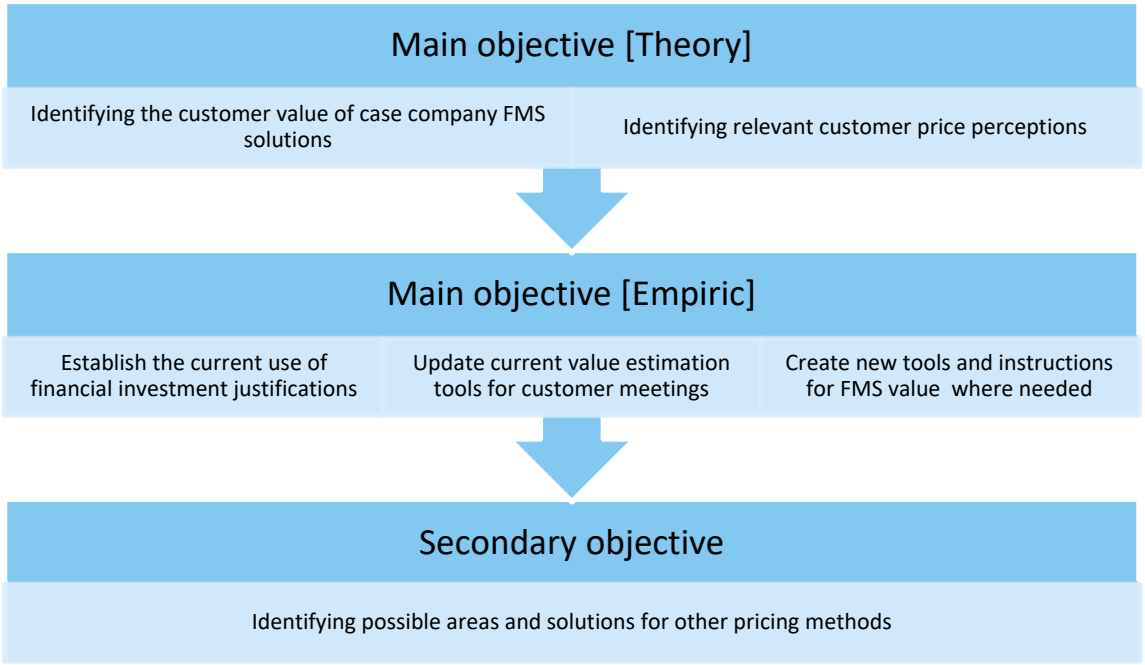


Figure 1. Thesis objectives

The thesis will study and analyse methods and practices that are already in use and have been studied before by the case company. For that reason, the first order in the empirical study is to establish the baseline and find out what needs to be improved or changed.

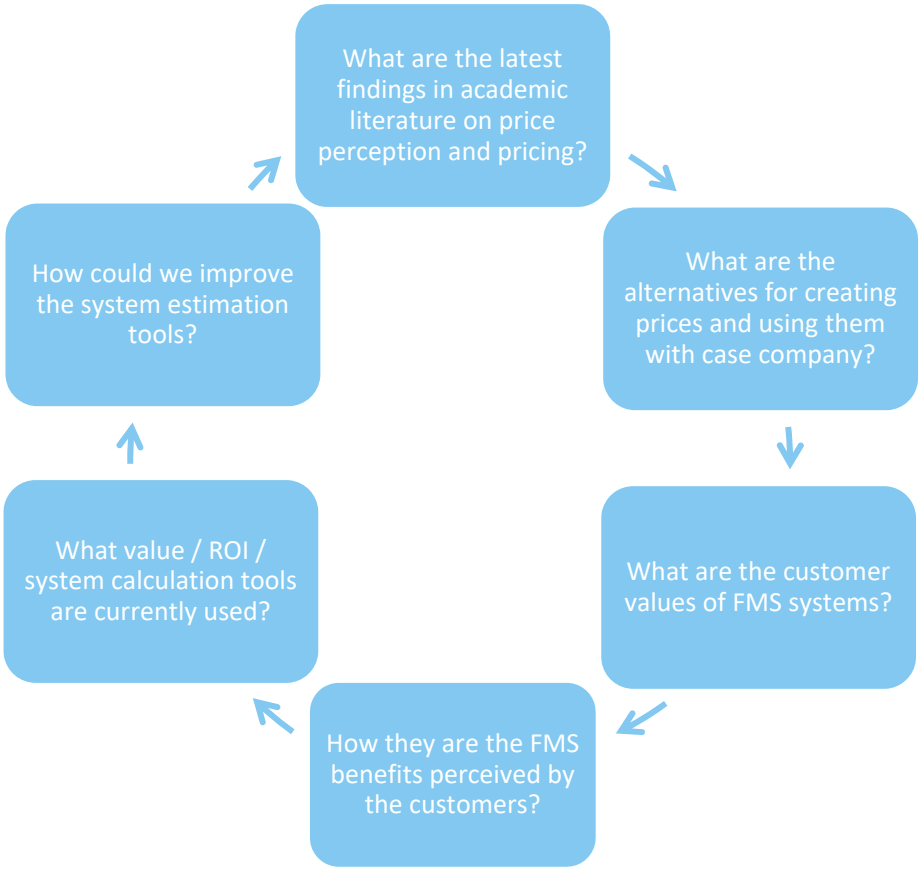


Figure 2. Thesis research questions

The research questions presented in figure 2 are connected to each other. The questions are not ranked on priority as all of them must be processed, but depending on the organizational preparedness on each question the deeper the study can reach during this thesis.

The case company is studying alternative pricing methods such as value-based pricing. To proceed in this kind of strategy, it requires the academic literature on the pricing basis and practical information on values customers are provided with the case company solutions.

To communicate the benefits of the case company solutions to customers or to use that information in pricing, one must quantify the benefits to some extend with return on investment or other value estimation calculations. If such value estimation calculations exist, they should be updated as useful.

1.4 Research methodology and theoretical framework

Relevant items around this thesis topic are managed daily in business actions of commissioning company. Industry technology, pricing and customer values have been processed within the case company along this study, which might reflect on some of the views presented without references. The nature of created data and its purpose the thesis can be described as applied research (Saunders, Lewis, & Thornhill, 2008, 9). The methodology was not constricted beforehand, so that the data could lead the research to the most practical and relevant sources. The study consisted of combination of methods.

The theoretical framework was compiled from literature using existing studies made for the company on relating customer value and industry investments, and latest scientific findings to support or update it. The approach can be described as deductive approach as the data from literature will be tested with the marketing tool that will be presented to customers (Saunders et al., 2008) s. 61. Industry and product details have been collected from academic literature, online marketing material and from internal product data of case company.

As topic of this thesis partially same two previous studies by Hallila (2007) and Kumpulainen (2013) it will only define basic details and needed updates on customer value, because it was processed in length in the previous studies, and focuses more on the practical implementation of this data for customer meetings and pricing.

The empirical part of this study was done with participating observation and interviews. Participating observation is a valuable tool especially when combining methods (Saunders et al., 2008, 281). In addition to participating observation, the company specialists been interviewed with unstructured interviews to understand the baseline and the areas of improvement.

After the first improvement results were presented to case company sales, a survey was done to establish the need for the results and to commit users to further development.

1.5 Thesis structure

First chapters of this paper establish basic understanding of the industry and the case company of which the benefits and customer values are derived. Chapter two presents the industrial framework of the flexible manufacturing systems. Chapter three examines the commissioning company that undoubtably influences the perspective on customer value and competing factors and solutions.

The academic literature and the impact of findings is examined in chapters 4 and 5. Thesis establishes the academic context for price, customer value and the elements affecting the perception of price and value. From the many pricing methods used in marketing, this thesis limits the study to two main methods in chapter 5. The pricing methods have been selected because, they have been either used in the commissioning company or have been identified as possible candidates for future pricing for products or services.

In chapter 5, this thesis also analyses strategies containing aspects that might be beneficial in the future business processes, and limits further analysis of those strategies to those that use customer value as an element for pricing.

Chapters 6 and 7 describe the development process of the new calculation model and the value selling narrative that was identified and refined for sales and marketing. Figure 3 presents the research process for the new calculation model. Chapter 7 analyses concepts and future development plans that rose during the development process. The results of and the goals set for this study are examined and concluded in chapter 8.

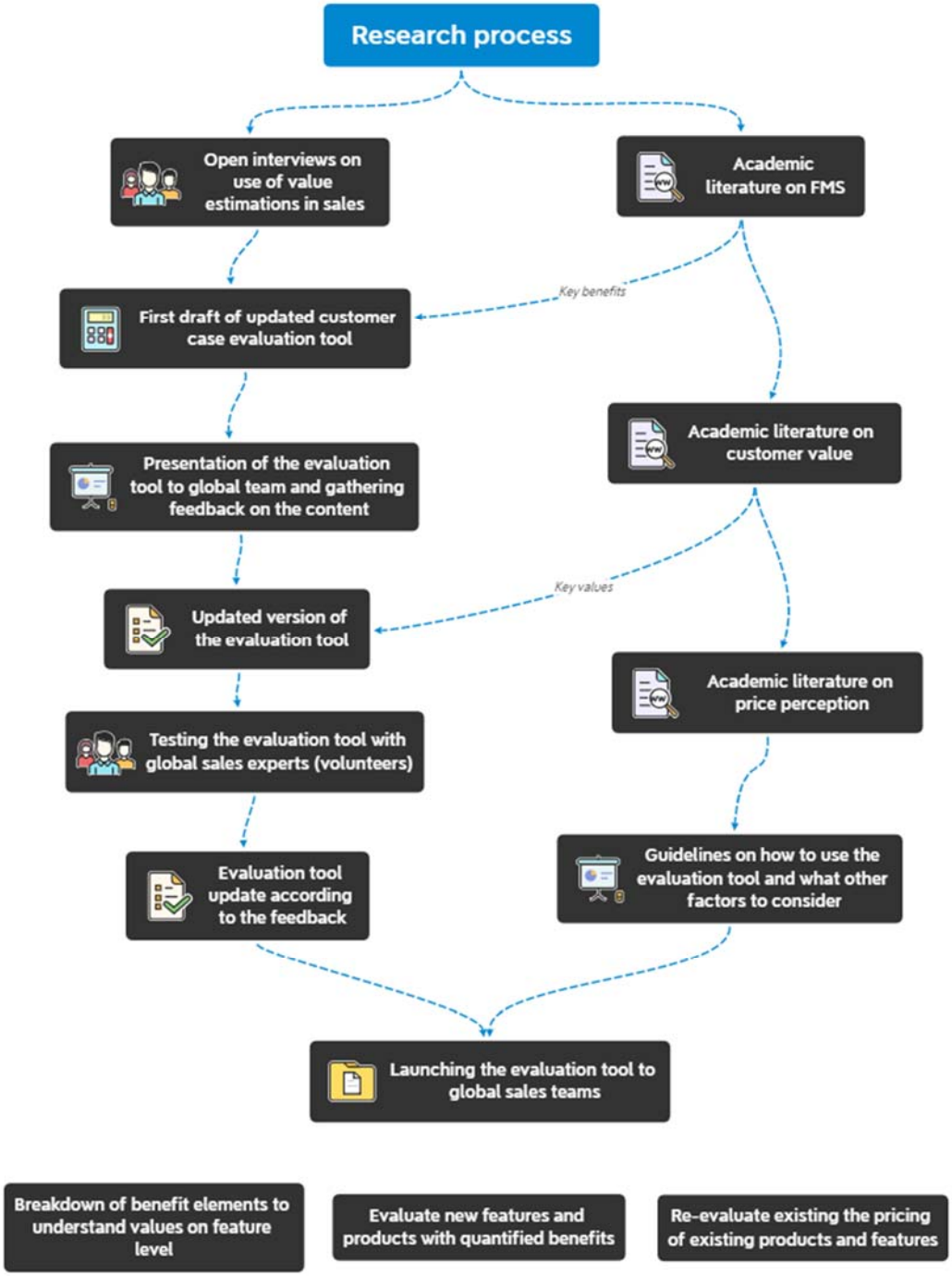


Figure 3. Research process and limitations

2 FLEXIBLE MANUFACTURING SYSTEMS

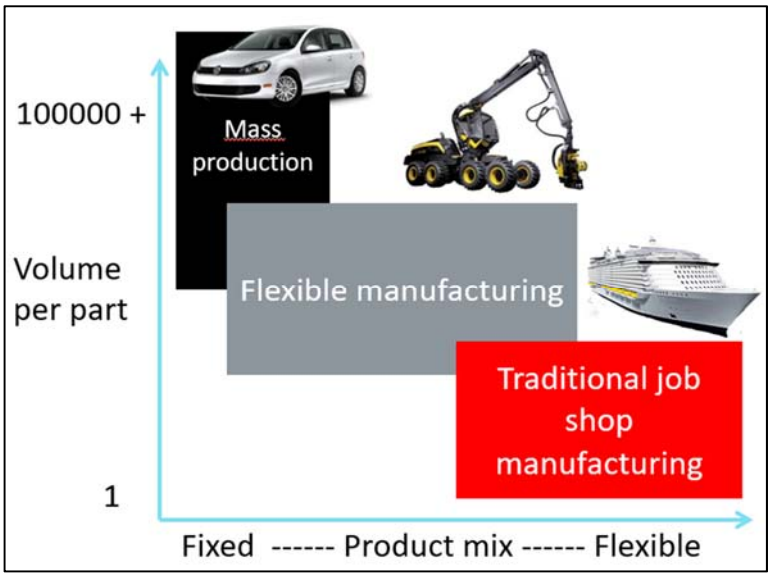
2.1 FMS concept and lean methodology

Flexible manufacturing system (or FMS) is an arrangement of manufacturing machines connect with a transport system and with a storage that are controlled with a system software. FMS is manufacturing technology and it is a philosophy with the “system” as the key word. The system processes automated material handling and production schedule (Shivanand, Benal, & Koti, 2006, 23).

FMS philosophy is still to some extent the same as it was thirty years ago (Mieskonen, 1987, 4-17; Shivanand et al., 2006, 25-29). Elements within FMS have developed enormously, especially the software, processes and robotic. In 2020 manufacturing tools are becoming more intelligent, but without planned use of the data, it doesn’t serve more than curiosity. As smart and highly accurate machining centres are available to any financially capable supplier, then the cost efficiency and scalability have become necessary business capabilities to succeed over the competition.

The goal of FMS systems is to provide accuracy and flexibility for industry suppliers. The systems are designed to manage the manufacturing process of different parts, quantities and schedules automatically. In ideal situation a requested number of parts will be manufactured and documented in multiple workstations automatically in a scheduled time.

Flexible manufacturing can be divided into more detailed parts such as flexible manufacturing unit (FMU) or flexible manufacturing cell (FMC), which may or may not be connected to other elements in the manufacturing process to create the wider concept of FMS (Mieskonen, 1987, 12-15). This thesis does not separate FMU or FMC from under the FMS concept, but rather identifies them using the same manufacturing philosophy and as parts of FMS or competitors of FMS concept when delivered with a machine centre with a limited scope.



PICTURE 1. FMS target segment, Fastems training material

FMS as a concept fits perfectly for manufacturing companies that produce large quantities of variable products. Shivanand et al. (2006, 23) presents the same principle of the FMS target segment as in picture 1 above.

The FMS systems are not designed to be fast enough and probably too expensive for single repetitive tasks as in takt time production often used in automotive industry. In traditional job shops, for example for aerospace industry, the manufactured parts might be too variable in sizes and weights and the production volumes are too low for the production to be cost-efficiently updated with FMS philosophy.

However, the subcontractors of both of these industries fit into the target segment. Component subcontractors for example for aviation or automotive supply variable sized disks, supports, valves etc. and in variable quantities, and their ability to handle orders with high accuracy, demanding schedule and cost-efficiency is their business lifeline.

Lean manufacturing strategies focus on finding out process waste and bottlenecks and eliminating them. In a way this is also a way to identify ideal FMS targets. FMS systems eliminate or mitigate process waste from machine tool setups, part loading and scheduling. Without automated solution these are done manually and often cause machine tools to wait. In a mass production machines produce the same parts in high volumes, so the ability to change setups, machine

tool programs or part manufacturing schedule does not eliminate any process waste. Traditional job shop often manufactures one-offs and components against highly varying order in which case the part loading or the setups do not present any significant part in the long lead times of this type of manufacturing nor there is any need for fine scheduling.

Modern FMS processes also try to implement best practices from Lean manufacturing strategies. Flexible manufacturing systems are designed to drive the in the most efficient way to fulfil orders in the system. Lean is a strategy to reduce waste in value creation. The set of selected tools varies a lot between different manufacturers. Non-value adding labour and waiting times are very typical process wastes in steel manufacturing. Practically this could mean the process would need an operator to monitor the manufacturing so it wouldn't stop or that machine tools are waiting for materials or instructions on what to do next.

Some Lean-terminology and tools such as JIT/JOT and KANBAN are visible in FMS manufacturing site, and some are coded inside the systems. JIT or JOT, Just-In-Time or Just-On-Time is at the core of efficient inventory management. In simplified terms JIT system aims to have all the right amount required resources just at the needed moment to complete the value adding task. Properly planned JIT reduces the need for large stocks and manufacturing waiting times. In FMS systems JIT often means that:

- the automatic material storage delivers the required resources to machine tools exactly when needed,
- the systems notify the operator(s) when more of specific materials are now needed to be loaded in the system,
- tooling in machine tools need changing within a given time and/or the systems makes and material order to the enterprise resource planning (ERP).

(Modig, Niklas ; Åhlström, 2013; Shivanand et al., 2006, 23-28).

KANBAN is a visual guidance system that creates a pull for resources and value adding work. As other Lean tools the Kanban system originates from Toyota manufacturing strategies. In the FMS world the Kanban system is managed visual identifiers for components, visual requests to operators and Kanban cards on materials and manufactured components. (Shivanand et al., 2006, 49-50).

Lean manufacturing strategies require control on the production and production development and it need system monitoring. Modern technology can provide great tools to accomplish this, but the best results can only be reached by developing processes in cooperation with all the manufacturing stakeholders. FMS in itself is not enough to transform the factory culture, and it needs the commitment from management and from the employees (Kuisma, 2007, 187-191).

FMS is adaptable in its core concept and it ensures the execution of lean process designed for the factory. Visual instructions for operators and automatic production scheduling are designed to eliminate human errors in inventory management and production execution.

In metal part manufacturing, very often the biggest value, in Lean-terminology, is added in machining, and very rarely any other process adds value as long as machining. Part loading can take more time than machining, but typically it doesn't add any value to the part. Whenever this is the case, any other bottlenecks or waste should be removed or reduced to streamline and increase the efficiency of the value adding process, which in this case is defined as spindle utilization rate.

2.2 Industry 4.0 and FMS

The term for future evolving manufacturing "Industry 4.0" named reminiscing software development. It is expected to be the fourth industrial revolution. In short, the need for further developing manufacturing has been summarized to following market pulls:

- Short development periods
- Individualization on demand
- Flexibility
- Decentralization
- Resource efficiency.

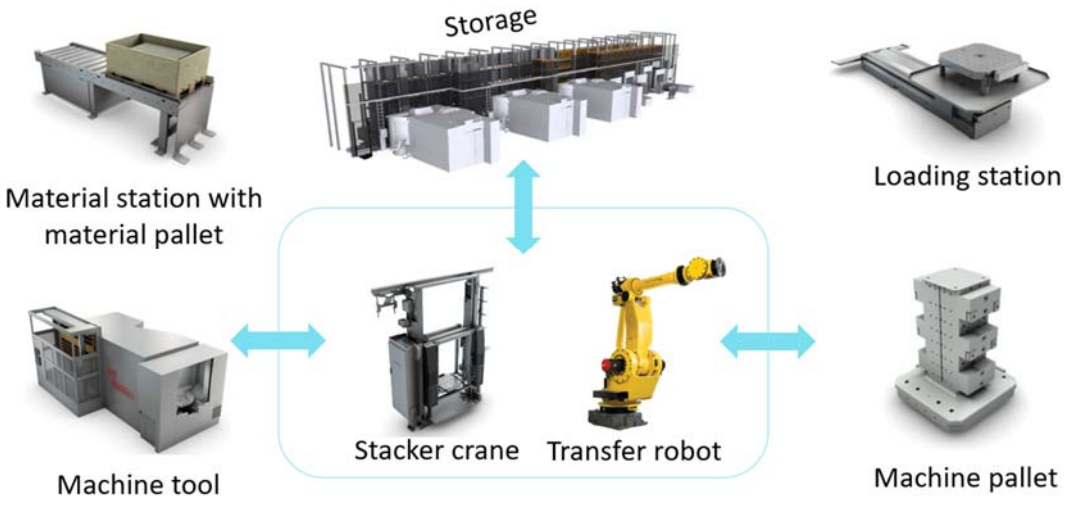
Which leads to technology-push for further increasing mechanization and automation, digitalization and networking, miniaturization. Usually refers to wide

range of current concepts such as smart factories with autonomous systems, self-organizations and cyber-physical systems (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014, 1-2).

Flexible manufacturing system philosophy is not identical to the “Industry 4.0” definition, but as it shares many its goals, and it is an effective tool for a “Industry 4.0”-production development. Flexible manufacturing is a way to build smart factory that is autonomous, controlled by dynamic control software and they are highly adaptable to the demand.

2.3 FMS components and roles

The main elements of flexible manufacturing systems are workstations, storage / material handling and the main control system.



PICTURE 2. Main components of FMS (Fastems training material)

Various workstations are typically:

- Computer control machine tools (CNC) turning and/or milling raw material into parts or components. In this thesis lathes, grinders or 5-axis machining centres are commonly named as machine tools or machine centres
- Loading and unloading stations
- Assembly work stations or work cells
- Washing stations
- Inspection stations such as coordinated measuring machines (CMM)

- Finishing cells, deburring etc.
- Forging stations.

The number and types of workstation varies from factory to another (Shivanand et al., 2006, 23-24).

Storage or automatic material handling will deliver parts and materials for each manufacturing process when they are needed. Storage system creates the flexible buffer for the manufacturing process. This buffer also enables flexibility to production planning and unmanned production. Automatic material system can consist of a single storage element or multiple storages that are connected with the main control system.

The main control system is the master monitoring the manufacturing according to given instructions. Within an FMS, the control system will have access to each work station, work instructions, logistics or storage and monitoring (Shivanand et al., 2006, 24). FMS systems can be expanded to have interfaces with enterprise resource planning (ERP) and quality and production reports.

Below are listed the most relevant roles and components in machine tool manufacturing that affect the FMS benefits processed in this thesis:

NC-programs

Machine centres such as turning and milling are commonly called. CNC machines, that process parts according to the CAD or 3D-designed numerical control programs abbreviated NC

Material pallets,

Material pallets store process related materials. Materials on pallets are typically unfinished parts waiting for machining or finished parts waiting to be unloaded from the system and shipped. Multilevel storage often saves floorspace. Control system can request operators to load parts from material pallets to machine pallets or autoloading cell can load finished parts to material pallets in lights-out production.

Machine pallets / zero-point plates,

Processed material must be fitted accurately in place while machine tools are turning or milling. The tolerances for accurate machining are measured in microns. Machine tool pallets and zero-point plates

are work holding systems designed for machine tool table tops. A pallet or zero-point plates can fit several with similar table top structures or they can be designated for each MC type. Parts will be mounted on the pallets or to a fixture that have been attached to the pallets. Machine pallet can be identified in the picture below (Picture 4).

Automatic pallet changer (APC)

Most of the machine tools are available with automatic pallet changers. It is a mechanism with two or more pallets attached to the machine. APC's allow loading or changing the pallet on one position while the another is machined.

Fixtures

Single pallet can hold one or more parts that will be machined when the pallet is delivered to the machine centre. Parts are hold in place in a fixture installed on top of the pallet. Picture below (Picture 3) has a DMG tombstone fixture with vises holding parts on each side. Parts on the fixture can be the same or different.

Operators

Operators are shop floor personnel that manage the manual processes and monitor the manufacturing. Tasks that operators perform have very variable skill level requirements. For example, machining centre specialists are required to manage machine tool diagnostics, setup changes and fault finding, and on the other hand part loading to fixtures or material pallets is simple and often instructed from the system.

Setup

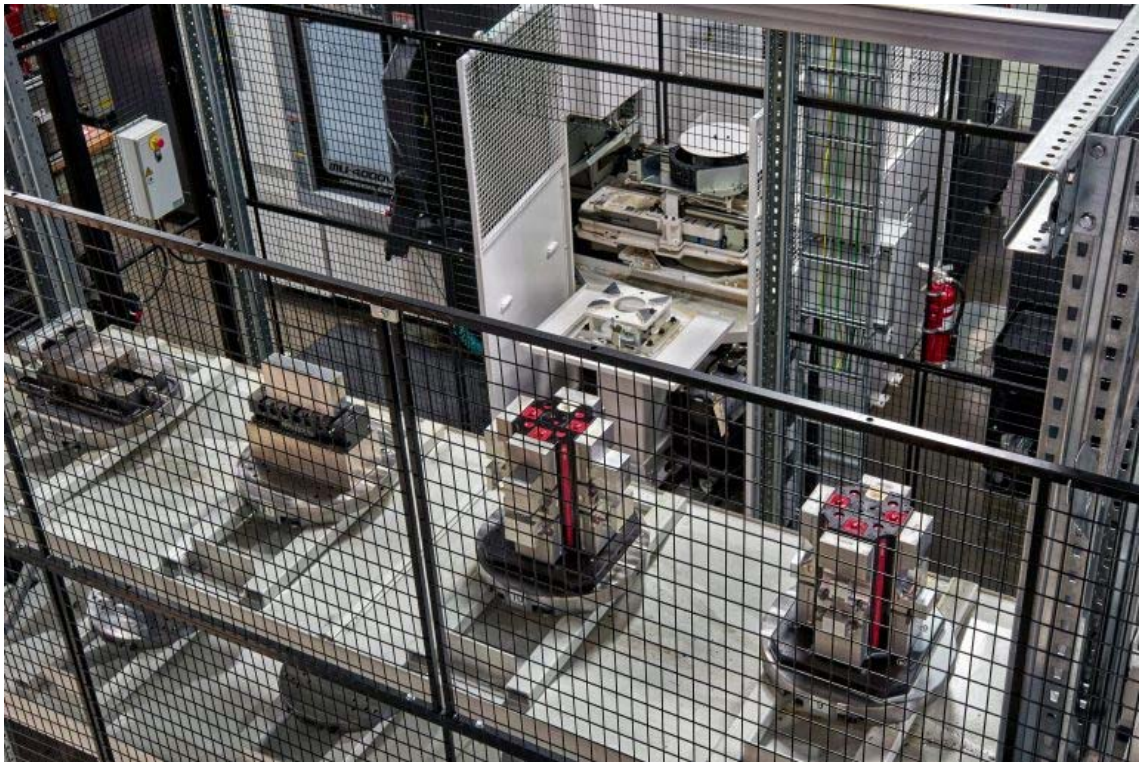
Setup is a combination of elements required for a batch of manufactured parts. A part batch may require changes to fixture or machine centre tools or machine centre setting, and the fixture changes can be done without stopping the machine if it is fitted with APC.

Tool magazines

Machine centres machine various metal materials with tools that have lifetime that is highly dependent of machined material and tool material. Tool lifetime can be dozens of minutes or only few minutes.

Tools are stored in machine centre magazines and have to be replaced once they are at the end of the lifetime.

PICTURE 3. DMG tower vise on a machine pallet (“DMG Tower vise,” n.d.)



PICTURE 4. Pallet storage at Hirch Precision a machine pallet (“DMG Tower vise,” n.d.)

2.4 FMS benefits

Machine tool manufacturers often use the machine tool spindle utilization rate as one of their key performance indicators, and it is very understandable. The spindle utilization rate is the percentage of the time a machine centre is processing

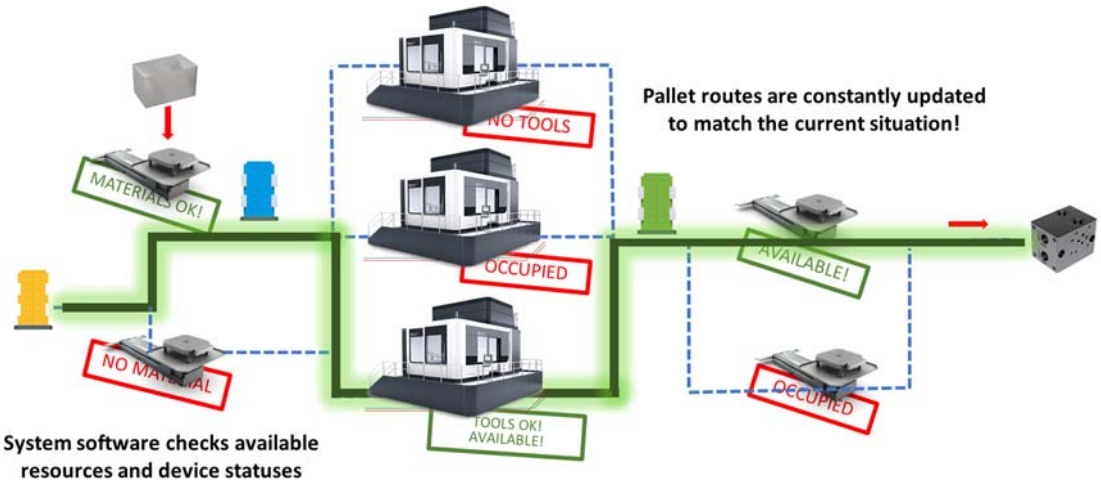
parts per year or per planned manufacturing hours. Manufacturers invest to high cost machine tools and they create value to their customers and revenue when their machines are running. Utilization rate is easy identifier of process bottlenecks. Machine centres stop running there are no parts loaded, setups need changing, tools are needed or orders haven't been processed.

As fixed costs from manufacturing will run daily any way regardless of the manufacturing efficiency, the most logical step is to look into methods to manufacture more during the work shifts, ways to use machines unmanned shifts and use personnel more effectively.

TABLE 1. Typical benefits in FMS applications (Kuisma, 2007, 23-24; Kumpulainen, 2013, 45; Fastems marketing material)

Capacity	Machining centre number can be easily altered to accommodate capacity. Machine centres can be driven unmanned to increase machining hours.
Production volume	Change in production output does not necessarily cause changes personnel. JIT production reduces storage WIP
Production mix	Parts and their variants can be easily added or removed. Setup changes do not stop the machining.
Personnel	Tasks can be assigned to meet order due dates. Loading and unloading instructed. Specialists can monitor several machining centres.
Logistics	FMS organizes what is needed, where and when. Storage can be integrated to FMS to save factory floorspace

Small batch production is often one of the drivers to invest in flexible manufacturing. Picture 5 below is from a customer case, where customer two different machine for different manufacturing steps, by changing them to machine centres capable of handling both steps allows it for the FMS software to adjust the fine scheduling and to react to possible difficulties in the system. This change allowed the customer to reduce the number of machine tools and to increase system reliability and serviceability.



Picture 5. Process benefits from fine scheduled parallel machine tools

2.5 FMS as an investment

According to studies by Kuisma (2007, 118), most of the companies investing to flexible manufacturing use return on investment (ROI) calculations as their evaluation. Even though the flexible manufacturing philosophy might represent a big change in the manufacturing culture the target return of interest periods are as low as two to four years or even shorter (Naskali & Kuisma, 2013, 13).

Factory automation with flexible manufacturing system does enable higher production, smaller batch production and other benefits described in earlier chapters. Depending on the complexity of the system in can cost less or more than a single machining centre. In some scenarios investing into FMS, could end up saving a cost of a machining centre or more in a production plan.

As the benefits of FMS vary, so do the customer motives for investment. Improvements in quality and performance, and reduction in lead times are significant factors for factory automation investment (Singh, Garg, Deshmukh, & Kumar, 2007, 244). The motives for investment will also alter regionally. Some countries have high labour costs, and some areas might be struggling with availability of labour force for tedious and repetitive tasks such as deburring or sanding machined parts.

Singh (2007, 244-247) and Kuisma (2007, 189-191) both highlight the fact that the manufacturing philosophy change is so great that the implementation of new manufacturing system will require commitment from management to shop floor to succeed. Table 2 lists the key factors from Kuisma (2007,191) on vision, technology strategy and order managements. Referred study also found many operative and technical characteristics in successful applications of FMS. In practice, this means that a factory might have a modern manufacturing system, but they are not using it in the full capacity, because they haven't fully adopted the manufacturing philosophy.

TABLE 2. Factors in successful FMS implementations (Kuisma, 2007, 191)

Setting the goal	Design phase	Start-up and Implement phase	Use and development phase
Vision of the goal	Strengthening the corporation culture	Understanding the new culture and values	Maintenance and daily use
Technology strategy	Mapping out alternatives	small teams to plan the production ramp up	Updated yearly, Readiness for change
Order management	Setting up pull process and milestones	order process training	interfaces must be monitored

The successful implementation of the new manufacturing philosophy – and the investment to it – can be succeeded as Kuisma (2007, 191) lists out with proper preparation and trainings before the system is up and running, but also with supporting technology. Some modern manufacturing software's, as case company's MMS – have features that by default guide the production in more effective process. For example, a system operating panels are often set to list next process tasks for the operators, rather than having the operators' plan their day according to his or her preferences.

3 FASTEMS OY AB

3.1 Company and organization

Fastems is the leading supplier for factory automation. Its open system solutions are used as in integrators for all machine tool brands. Fastems key market areas are flexible manufacturing systems, automation hardware and lifecycle solutions.

Major part of 2019 sales were export deliveries with US and Europe as the biggest market areas. Europe is divided in to two categories in the sales follow-up, the DACH (Germany, Austria and Switzerland). DACH area has a significant automotive and aviation technology industry that is often considered as one of the key markets for FMS solutions. The US has been for long time significant market for high-end industry technology, and the Asian countries are growing in business potential as in many industries.

3.2 History

The origins of Fastems dates back to Valtion Metallitehtaat founded by Finnish ministry of defence in 1942 to Linnavuori. Part of the factory, the Valmet Tehdasautomaatio developed turning and milling metal works since the early days and eventually turned into its own business unit.

Valmet Tehdasautomaatio operations expanded in the turn of 1960’s and 1970’s from tooling department to manufacturing special manufacturing machinery. More focused business and product development began in the early 1970’s. During that era the priority in the manufacturing market was to increase productivity in the metal processing works. Flexibility was at best the secondary focus. Most of the machining processes were designed to manage large manufacturing patches. Loading and machining setup often took more time than the actual machining. (Naskali & Kuisma, 2013, 18-21)

By the end of 1970’s Valmet had created and delivered their own numerical control for 8-axis CNC machinery. This was the cutting edge of technology in the

world at the time. 1978 the first “portal loader” was made for crankshaft manufacturing cell. The first “portal FMS” was built for Valmet Diesel flywheel cell and launched to markets in 1985 in EMO Hannover. From 1970’s to 1990’s, the machining centre technology developed tremendously in metal cutting field. The machine efficiency and utilization rate remained the most common priority, but the flexibility started gaining increase in demand. (Naskali & Kuisma, 2013, 18-21)

The factory automation division was sold to Mercantile Oy in 1997, moved to Tampere Lahdesjärvi and was named Fastems, as the other Valmet operations in Linnavuori stayed with Sisu Group. Mercantile Oy is part of the Helvar Merca Group. Fastems also was also the area distributor for machining centres in Finland. Today Fastems manufactures FMS systems and relating services from the same factory site in Tampere and has delivered over 4000 solutions and over 1500 FMS systems. The facilities have been expanded over the years and are currently under renovation to update the manufacturing facilities and office areas to modern level.

3.3 FMS Solutions for manufacturing customers

Fastems has divided the product portfolio into two overlapping domains: part handling and pallet handling. Both are supported by digital services and life cycle services. FMS deliveries can be categorized to productized, modular and tailored projects according to customer needs.

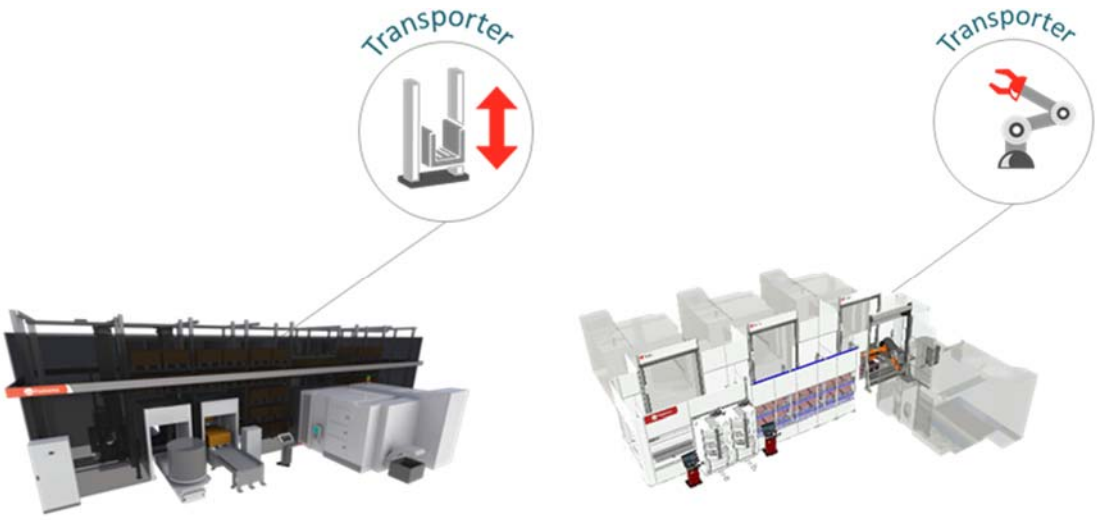
Fastems product strategy defines the available features, functions and modules available for products and modular systems. Products are predesigned sets and benefit most from quick delivery times and lower prices from prefixed costs that are supported by delivery volumes, but are often limited with strict limitations to any other solutions part from product portfolio. Modular solutions are slightly more flexible in delivery content using a number of predesigned modules, and even single modules can have some variations between deliveries. Predesigned modules lower the costs and keep the delivery times in reason. Tailored solutions are targeted to fulfil customer needs with any feasible way. Tailored systems benefit

from using modular systems, but the delivery organization is more prepared for new solutions or structural one-offs.

Flexible pallet container (FPC) is a product range available for machine tool builders and end customers around the world. FPC is a perfect example of a compact FMS system. Inspired by the easiness to move and setup sea containers to an industrial site. The FPC includes all of the FMS elements in a compact and preset solution. Extendable systems include pallet storage, stacker crane for storage and machine tool access and loading stations for operators. The load range of the PFC products is from 750 kg to 3000 kg, and it can be extended up to three machine tools.

Picture 6. Flexible pallet container (FPC), Fastems marketing material

Fastems has large number of modular structures and functions for flexible manufacturing systems. RoboFMS One and FMS One is modular product series that are extendable to multiple different machine tools with a wide range of software tools. Both have modular loading stations for different weight levels, extendable storage and selection of pallet handlers depending on pallet dimensions and loads. RoboFMS is equipped with robot pallet handler that is moving on a track and the FMS One has a stacker crane. RoboFMS One has weight class from 1 to 275 kg and the weight range for FMS One is 700 – 3000 kg.



Picture 6. FMS One and RoboFMS One in Fastems marketing material

For demanding customers and manufacturing solutions Fastems offers Multilevel system (MLS) or a RoboFMS solutions. As mentioned above with the RoboFMS and FMS One, the first has a robot on track handling pallets and the latter has a stacker crane. Both the MLS and the RoboFMS are fully customizable within feasible solutions.

Typical system for RoboFMS has few different turning and/or milling machine centres with pallet loads above RoboFMS product range and with customer specific systems such as CMM or washing machines. RoboFMS has a weight range from 1 to 400 kg. MLS solutions have the full range of features and options from tilting loading stations, autoloading cells, deburring cells, material storage and special customer requests.

PICTURE 7. Multi-level system rendered 3D-design, Fastems training material

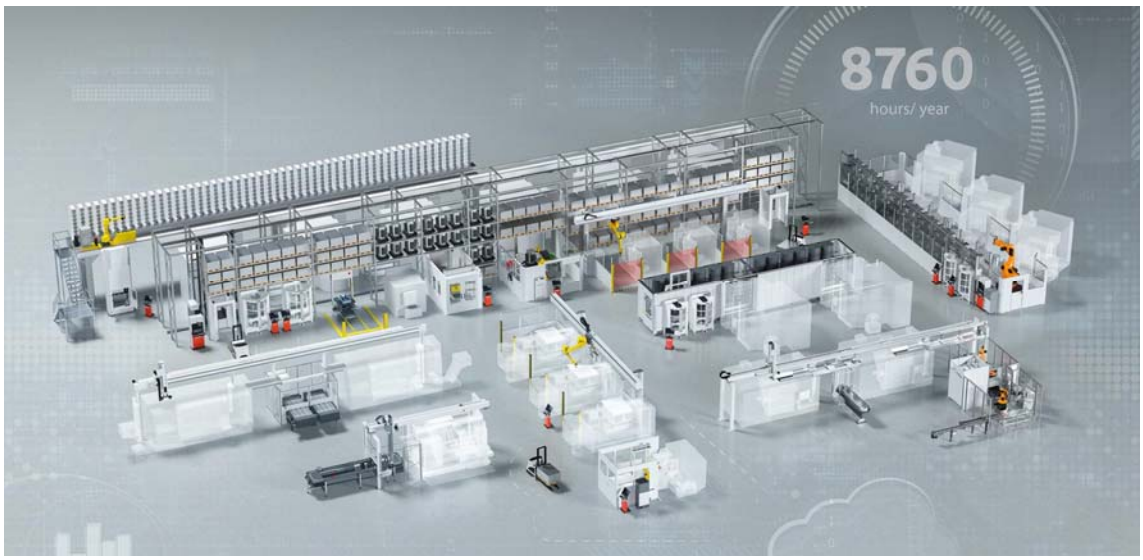
For the customizable systems Fastems also offers tool automation systems GTS (Gantry Tool System) and CTS (Central Tool System). Gantry tool system has a single gantry alongside tool storage with a robot delivering tools to machine centres. Central tool system can have multiple gantries and robots with a central tool storage supplying the gantries to machine centres. Tool automation can save in the investment costs as optionally large magazines are not needed, and in tool costs, because the factory doesn’t need to buy every tool for every machine as they are shared. Tool storages can hold hundreds or thousands of tools as shown in picture 8.

PICTURE 8. Central tool storage, Fastems marketing material

3.4 Fastems value proposition

Every successful company must identify their main customers and design their products, organization and marketing to maximize performance in key areas. A company must decide how they'll differentiate and position itself in the marketplace. Value propositions answer the customers question "why should I buy from them rather than from a competitor" (Kotler, Armstrong, & Parment, 2016, 15).

Fastems factory automation solutions will add value to their customers manufacturing processes. Adding factory automation to existing or new manufacturing machinery will increase their production capability and flexibility to compete in their key markets.



PICTURE 8. Fastems portfolio, Fastems marketing material

Manufacturing processes always have bottleneck that define the process speed. Experts supporting FMS developing project for customers FMS aim to have the valuable process step to set the pace by eliminating other slowing elements. To ensure this Fastems has provides solution support in sales and delivery phase and trains customer personnel before the delivery as often as possible. The experience with modern manufacturing can also be utilized with after sales consultation to further develop the FMS use in a new site.

3.5 Customers and competitors

Fastems focuses on FMS solutions on hardware, software and services. As the characteristics and benefits of flexible manufacturing systems, described in the previous chapter, the market focus has to be limited. Fastems is not and should not focus on customers that are looking mass production solutions or job shops often building customized one-off parts. Aerospace, automotive, military and production technology to are good examples of markets that have mass production and single part production, but also a large number of companies with highly varying small batch production. These companies that produce variety of multiple high accuracy parts to demanding customers have the most to gain from FMS benefits and therefore the key market targets for Fastems.

The markets for turning and milling machine tools is multibillion market yearly. As with most industry it is highly susceptible to major market trends and forecasts.

This creates a market potential hundreds of millions for manufacturing automation for new machines each year and on top that the potential for existing machines sold in previous years.

This large and growing market for industry automation is attracting increasing amount of competition. Markets have growing automation companies such as Erowa, Liebherr automation, Promot automation and BMO automation to name a few (“Automation of CNC machines | BMO Automation,” n.d.; “Automation systems - Liebherr,” n.d.; “Erowa System Solutions,” 2019; “Werkzeugmaschinen Automation - PROMOT Automation GmbH,” n.d.). Most of the competitors have very limited weight range, products range or global coverage. Fastems has the technology advantage with more extensive compatibility with branded machine tools, wider part weight range, material storage and wider range of pallet or part handling, which has made Fastems the market leader in flexible manufacturing systems.

Fastems has the capability to integrate their system with all of the major brands in the markets. Integrating customer’s machine centres with shop floor management and storage system, the machine centre dealers and distributors are a natural business partners for finding and contacting end customers. But as a global integrator Fastems has to balance delicately with their partners, because machine tool dealer might have conflict of interest in introducing Fastems solutions to the end customer.

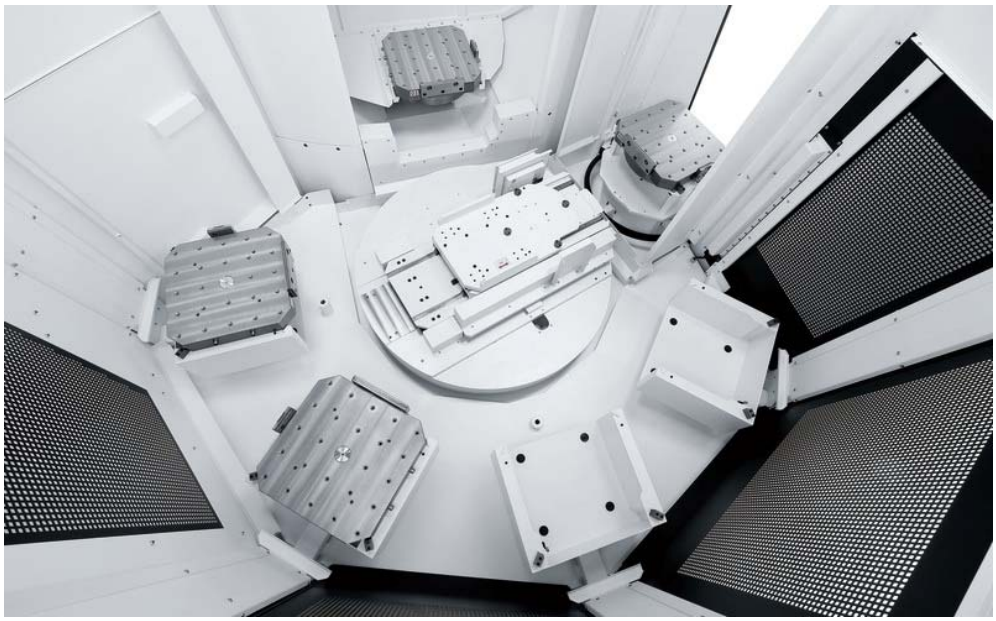
The conflict of interest could origin from two obvious reasons:

- The use of FMS technology and production planning raises the spindle utilization resulting reduced need for machine tool numbers
- Fastems customers/dealers sometimes also sell their own alternative solutions.

DMG Mori and Mazak are perfect examples of the partial controversy of partnership and competition Fastems faces. Both are world class machine tool manufacturers with global markets and both with their own solution for increased flexibility and production. DMG Mori with RRP pallet pool and Mazak with Palletech Hi-Rise system. Still aforementioned companies and their high-quality machine

tools are often perfect match with Fastems FMS, and Fastems sales and marketing must balance delicately in the intertwined dealer network.

DMG RRP is just one of the pallet pools in the market. Pallet pools do not fulfil all of the main characteristics of FMS, but the ability to increase spindle utilization and unmanned manufacturing times with a production buffer and often with smaller price tag compared to flexible manufacturing systems creates a significant competing argument.



PICTURE 8. DMG Round Pallet Pool (“DMG MORI Round Pallet Pool system,” n.d.)

4 SALES PRICE AND CUSTOMER VALUE

4.1 What is price

As this thesis develops methods for sales to communicate benefits and value with the customers. The counterweight on that discussion is always the price. This chapter analyses that counterweight to add structure and support the customer communication and to accumulate knowledge for the case company on how prices are perceived.

Price is the sum of the values a customer has to give up in order to gain benefits of having access to service or owning a product or rights to use a product. It is the only flexible element in marketing mix and the only one that creates revenue. Unlike product features and marketing channel commitments, prices can and often will be changed frequently (Kotler et al., 2016, 280).

As consumers, we often see the price as the amount of money charged for a product or a service. Price is often included with wider concept including all the values the customer must to give up acquiring the product or service. With this definition any commitments (such as subscriptions) or any convenience can be

Somervuori (2018, 10) emphasizes, that pricing is the most effective way to influence profitability, more effective than cost saving. Studies suggest, that even as little as 1 % increase in price results to 10-20 % increase in profitability on average even with the resulting slight decrease in demand. Of course, some products and services are more price sensitive than others depending on market competition. Dibb et al. (2013, p. 626) shows similar examples for the profitability increase and examples for changes in demand: "*By raising price, they (marketers) can emphasise the quality of a product and try to increase the status associated with its ownership. The declining fortunes for Chevas Royal Scotch whisky were reversed following a substantial price rise. Lowering a price can also have a dramatic impact on demand, attracting bargain-hunting customers who are prepared to spend extra time and effort to save a small amount*"

4.2 Context of price

A price has two-way effect to a buyer's value perception. According to Somervuori (2018, 15) the price is an indicator of the costs related to the service or the product. A high-priced product signals quality components and vice versa (Somervuori 2018, 15). These signals can be used to highlight product quality or to increase the status associated with its ownership.

The effect of price value perception should be carefully considered especially when launching new products or reaching new customers, because significance of the value perception is highlighted when the customers doesn't know the services or the products beforehand. (Somervuori 2018, 84).

4.3 Reference price

When the customer is presented a price, not only do they compare the price with their perception of the value, but they are also comparing it a reference price. A reference price is a comparable price created on the last time they were buying the product/service or similar product/service, competitor price, an advertisement or a combination of all these. Person's or groups reference price concept is always affected when they come across to prices of relating content. It is very important that sales persons pay close attention to customer's reference price conception. One of the best ways to influence customers perception of price is to affect their reference price conception. (Somervuori 2018, 96).

Kotler et al. (2016, 299) described the reference prices as the prices that buyers carry in their minds and recommended using product positioning with others on display or on the market to imply that they belong in the same category or class. Luxury cars or high-end are easily identifiable categories where a marketer might want to present their products. Product classes are targeted to customer groups which by itself influence customers self-reflection. Dibb et al. (2013, 179) describes these reference groups as a *group with which an individual identifies so much that he or she takes on many of the values, attitudes or behaviour of the group*. Ironically many of these customer groups have been created by marketers with clever branding, and sales and marketing very often use this information.

Pricing of a branded products must be within a reasonable range from the reference group. Product development and sales should evaluate what is the price range in their reference group. If bigger discounts could be made in a sales case or if a cheaper product could be developed for the company, one must consider will it change the reference group perception of the company. Sliding into a wrong category will be more costly than losing a single sales case.

Once a price has been created and a delivery has been agreed, the customer will start the post-purchase evaluation which is a significant factor for a reference price. Many of the product or service criteria processed during the sales period will be re-evaluated during this period. Post-purchase evaluation can be managed or lost with customer communication and service. If a customer experiences poor communication or service during a delivery project it will affect their value expectations and price reference, but on the other hand a good after sales service can build business relationships even further (Dibb et al. 2013, 167).

Reference price is highly important when building a marketing. For evaluating customer relationships sales persons should take caution before jumping to any conclusions. Some studies have shown that buying the cheapest brand in one product category has no predictive value for a price sensitivity in another product category (Desmet, 2019, 6).

4.4 Customer value

Customer value is this one of the key concepts in marketing literature. It is connected to the price or some other cost that is considered as a trade-off. It is always abstract perceived value and in the best cases it is a quantified benefit from a solution or a service. And it could be related to a single case or part of a value chain.

Santtu Kumpulainen (2013, 8-16) defines the customer value extensively in general and in metal machining industry. The underlying concept of customer value in the previous study for the case company is still valid.

Essentially purpose of sustainable business is about creating value to customer and create profit from that process. For the company to create profit from and to their customers they must have an overall assessment of how they will help their customers and what do their customers bring to them. Perceived values should be quantified if possible. (Kumar & Reinartz, 2016, 36-62).

Identifying key customer values is important. The company must also consider how much weight customers give to them. Salience is the term used for this in the marketing literature. Dibb et all describes salience as “Salience is the level of importance a buyer assigns to each criterion for comparing products. Some features carry more weight than others. The salience of criteria varies from buyer to buyer” (Dibb, Simkin, Pride, & Ferrell, 2013, 167). For example, some FMS customers may place highest importance on the production speed from increase spindle hours, quality (reducing human errors), or production savings (more unmanned hours).

In more modern point of view from Kotler (2017, 2) encourages business-to-business marketer or salesperson to develop and deliver a narrative to their customers that explains the preferences and benefits. The customer representative that the salesperson manages the business relationship must be able to deliver the same arguments and choice to his or her business associates. This was a key finding to further develop the way the case company highlights the benefits of their offering to their customers.

4.5 Factors of Choice

Numerous things have happened and are happening when a purchase or an investment decision is been made. Decision makers reflect their perceptions and expectations on the products and services they are evaluating.

Somervuori (2018, 20) and Kahneman (2003) describe the two main psychological types that have been used to categorize in decision making. These two categories are type 1 Intuitive and type 2 as deliberate judgment. Type 1 is characterized as fast, automatic, slow to learn, emotional and does not need conscious though. For example, daily grocery shopping, which is often done while talking

on a phone and supervising children. Type 2 decision process is described as slow, deliberate, takes effort, based on rules, flexible, neutral emotions and takes conscious focus to make the decision. Categories are not based on different brain regions and the effects and risks of the decision affect which type of choice process will be used (Kahneman, 2003, 1450-1452). Engineering and investment decisions are commonly expected to be managed with more deliberated judgment process. Emotions are always involved in decision making, and according to studies the automatic or intuitive decision process is more susceptible to emotions (Somervuori 2018, 23).

Dijksterhuis, Bos, Nurdgrena & Baaren and Baaren (2006, 1005-1007) point out some of the weaknesses that the deliberate conscious decision making has:

- Conscious deliberation can make multiple evaluations of the same object less consistent over time
- Conscious thought does not always lead to sound choices
    - consciousness has a low capacity, causing choosers to take into account only subset of the relevant information.
    - Second, conscious thought can lead to suboptimal weighting of importance of attributes: we tend to inflate the importance of some attributes at the expense of others, leading to worse choices.

Contradictory to the common division how the decision methods are divided, the post purchase satisfaction is higher for conscious buyers buying simple products and unconscious buying complex products and visa-versa with the negative emotions (Dijksterhuis, Bos, Nordgren, & Baaren, 2006, 1005-1007).

Modern neuroscience findings highlight the importance of intuitive decision making even further. Fabritius & Hageman (2017) writes:
"*According to Wolf Singer, former directory of Max Planck institute for Brain Research in Frankfurt, Germany, our unconscious accounts for a major part of our decision-making activity. In fact, whenever we take action, our conscious brain is often the last to know. There's a good reason for this. Our conscious is designed to work faster in order to ensure our survival*" (Fabritius & Hagemann, 2017, 187).

When one is called upon to make a decision, the unconscious brain begins processing it right away, even if one is not consciously aware of it. Once a conscious

decision if finally made, one's brain compares it with the unconscious decision. If the decisions correspond, the brain registers subtle reward response. If decisions don't match, it registers as a threat. Both responses create physical reaction. Everyone surely is aware of the feeling when a decision does not feel right even after careful deliberation. These findings suggest that the intuitive processes – the more susceptible ones for emotional responses – take place well before the moment of deliberate conscious choice (Fabritius & Hagemann, 2017, 194).

Iyenger & Lepper (2000, 1003-1004) investigated the effects that the number of choices have for decision making. They challenged the more traditional notion that the increased opportunity for choice – even if it is purely illusory, would be powerful and beneficial for example for sales. Their three studies and supporting literature demonstrated that increase in options creates more interest (prospects) and tendency to sample products, and made prospects enjoy the decision process more, but limiting options to six or less made the selection process easier resulting to more sales. The proposed goal is not to make the customer unhappy, but to rather to avoid exposing a customer with abundant options, that could make them unsure of the decision. Burdened with the unsure decision the customer is likely to withdraw from the situation without selecting anything. (Iyengar & Lepper, 2000, 1003-1004).

Where do these findings leave us with pricing? In light of the latest scientific findings it is safe to argue that purchase decisions and the perception of price is very susceptible to emotional factors and subtle cues long before, during and after the purchase decision. Every part of the messages to a customer has to be in line with the price profile or the price will trigger physical threat responses to persons making the decision.

The choices the case company makes with the price has to be in line with everything around it. If the offered solution causes a lot of costs or needs a lot of resources, those elements should be highlighted. If the offered product is premium by price it should reflect it with few key benefits and with supporting factors such as extended warranty or something similar.

5 PRICING STRATEGIES

5.1 Pricing basis and strategies

Once a sales organization adopts customer values and benefits as one of their core concepts in customer communication it opens up different possibilities to manage prices with that customer value, depending on the markets of course. This chapter studies the few main pricing methods and strategies that can be used to manage price with accumulating knowledge of customer value.

Marketing literature uses a mixture of terms for pricing methods, basis and strategies. Textbooks and definitions are not controversial on the main methods nor with the most common strategies. Different authors highlight different details or slightly different approaches to strategies. Described methods will be analogous to other marketing literature taught to students.

Kotler et al. (2016, 281-288) refers pricing basis as pricing methods, and simplifies the framework by setting it to only two: Cost-based pricing and value-based pricing. Dibb et al. (2013, 657) adds different pricing basis types with variations of cost-based pricing such as mark-up pricing and adding market situation to the mix with demand-based or competition based. Universal to these basic marketing concepts is that the cost levels should be known and not overlooked, and that the main difference is how is the targeted margin level set in given markets.

5.2 Cost-based pricing

Cost-based pricing driven by production costs. The major input for the price comes from calculus and controlling. Product management, sales and/or marketing designs what is a good product or delivery content for a project, adds up the costs of making the product or delivery scope and sets a price that covers the variable costs and a target profit with a margin or a mark-up. The added element is commonly the definer in the more detailed names such as cost-plus pricing or mark-up pricing. Target profit is set up to cover company’s fixed costs with expected sales volumes (Kotler et al., 2016, 281). Cost-plus method is often used

when production costs are difficult to predict or production takes a long time (Dibb et al., 2013, 657).

In the case company, the cost-plus method is applied in as much detail as possible with highly variable project deliveries. The delivery scope of a complex project is very rarely the same is in another project, and deliverable system elements don't yet have standardized product structure or exact price reference.

Figure 4. Cost-based pricing process (Kotler et al. 2016, 282)

As customer need arguments for price increase or decrease to accept the situation and not to expect the situation to be unfair, the cost-plus methodology is also the most often used argument for it. Value-based arguments typically have different effect. One can imagine for themselves would they rather accept the explanation that "a cost of manufacturing steel has been increased and therefore we must raise our price", or "as we now, that we realize that the value of this solution has increased to you and therefore we must increase our price".

Not taking note of company's fixed costs or products manufacturing and development costs is always self-deceit, but fixating only on costs will lead into suboptimal profitability. Setting the price above the costs with a mark-up or margin will cover the costs, but it might not lead to the highest level the customers are willing to pay (Liozu & Hinterhuber, 2013, 596).

5.3 Value-based pricing

For a good pricing a company needs a complete understanding of the value that their product or service creates for their prospecting customer. Value-based pricing uses the buyers' perception of the value as the factor to pricing. It cannot overlook the costs, but costs do not define the price. The value-based pricing reverses the pricing process from the previous model. A company sets their target

price or price levels according to their understanding of their customers' needs and value perceptions. The set price level will give directions to product design and other cost decisions. A characteristic feature for this pricing model is that the pricing input signal comes from markets and not from financial controllers (Kotler et al., 2016, 281).

For this Kotler et al. (2016, 74-77) sets the customer value in centre with customer value-drive marketing strategy. This strategy involves segmenting potential customers, selecting target markets and target audience and price positions are built for each product and service for the segment. This does require extensive market analysis. The analysis can be made in lengthy time period, and companies are very likely doing this unknowingly as they are reacting to customer demands.

Figure 5. Value-based pricing process (Kotler et al. 2016, 282)

Companies do not have the resources to every potential customer. Identifying customer segments and markets focuses the efforts to the most fitting targets (Kotler & Armstrong, 2016, 74-77). The same segments and market localization can also be used in product management and pricing. Some features can be designed to solve a specific problem in a target market and priced based on the cost savings from that problem.

Somervuori (2018, 55-56) adds price position to the marketing strategy. Price position is typically depicted by mapping solutions in the market to a price-quality chart. Market position map can help analysing the value of products or services, target price level, competitors and identifying potential markets (Somervuori, 2018, 55-56). Market positioning can be very difficult as is it needs not only information what the kind of quality is in the markets, but also price information of competing products.

Smith (2016, 56-57) digs even deeper with price-to-benefit map, to analyse the pricing capabilities and potential. Price-to-benefit map sets the offered solution with perceived price and perceived value. In short, it adds other factors in the market to the evaluation. In some circumstances, prices must be set to a low level compared to perceived value in order to penetrate to the market. If the competitors in a market offer significantly less perceived value, the price level can be set to skim-level.

Value-based pricing does need detailed understanding of offered customer value. Company's marketing or product management must analyse and set monetary estimates to their solutions and products. In other words, they must quantify the benefits they are offering. This analysis requires a lot of effort. Is it worth it?

Studies performed by Liozu & Hinterhuber (2013, 594) surveyed more than 1800 business owners or marketing professionals and found a positive relationship between value-based pricing and company performance. Should also be noted that the same study did not find the same relationship with competition-based pricing. Value-based pricing does not mean changing higher price for the same products and services. As a concept it implies and requires better understanding on customers willingness to pay, alignment of pricing and value-focused communication to customers (Liozu & Hinterhuber, 2013, 594-607).

5.4 Value-adding selling

The literature so far recommends the use of value-based pricing for the case company where ever possible. This sets analysis and development needs to product management and marketing, but is that enough? If the customer value will be moved in the centre of customer communication, it will also create pressure for sales organization to adopt value-based sales techniques.

Value-added selling is a business philosophy that would enable the approach from sales perspective. Value-added selling is a proactive mentality focusing on customer's needs – not against competition - maximizing the value in the relationship for both parties. The sales process begins with developing an in-depth understanding of buyer's expectations, concerns, needs and wants. Value-added

salesperson focus in customer satisfaction and long term benefits. (T. P. Reilly, 2018).

The full process of value-added selling has many strategies. Most of them focus on understanding the customer (T. P. Reilly, 2018). Basically, joining the customer in the journey to find the solution. This type of sales philosophy fits case company markets very well, as many of the customers will need the benefits FMS can provide, but the methodology and best practices are not so widely known.

Understanding the needs and wants of the customer, a salesperson can evaluate the problem they would be solving or the benefit they would creating. This information could be used to adjust the pricing decisions during the partnership. The accumulated knowledge could and should be later used to guide product development and marketing strategies. A framework to support this type of communication could reinforce the use of value-added sales strategies.

6 CALCULATION MODEL FOR FMS INVESTMENT VALUE

This chapter describes the development process of the updated investment value calculation model. The process involves the analysis of the existing tools and what elements of them needed updates, improvements or changes in the ways they were used. The financial numbers used in presented calculations are purely exemplary and do not represent accurately any prices of machine tools, system elements or FMS.

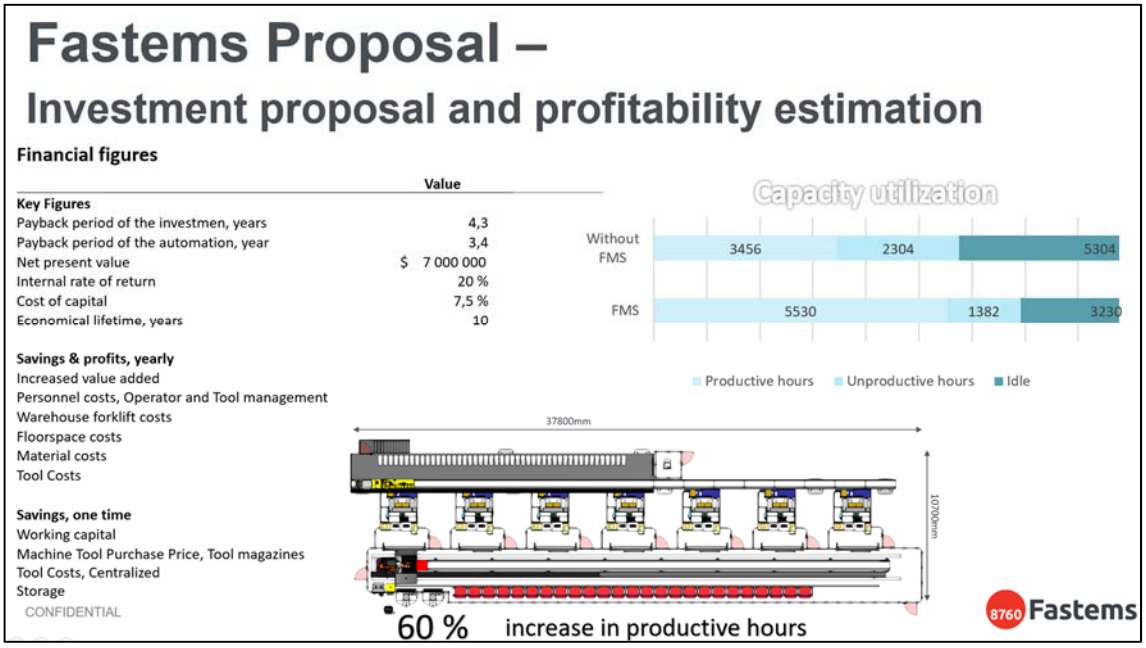
6.1 Existing investment calculation models

Heikki Hallila (2007) and Santtu Kumpulainen (2013) made extensive and detailed evaluation tools for manufacturing automation investment evaluation. The use of these tools in daily business life was analysed with the product manager of pallet automation solutions and the vice president of pallet automation at Fastems. With these calculators or a calculation similar to these one could analyse the financial impact of a solution in detail, and that detail could be used as a study basis for value-based pricing elements (Saarimaa, Peltonen, 2019).

On that meeting it was also established, that the existing return on investment calculation models are not widely used. The calculations might need updating so that sales would use it to communicate with the customers. This could support the case company in value-added selling and would create a starting point for the value estimations for different features.

Soon after the interview with Saarimaa and Peltonen sales managers from US sales requested support for financial justification for major sales project, and the tools were presented an authentic test of use. The return on investment estimation was presented using calculation model created by Santtu Kumpulainen (2013). Visual presentation and estimated values were produced after initial learning period and with few manual modifications. Value fields in the calculator were understandable but so numerous, that without training one could easily be lost in all the data.

Picture 9 illustrates the proposal that was made for the sales case. The calculator creates productivity charts and lists of key financial figures such as estimated payback time. Key charts and lists were the taken to a PowerPoint presentation. Figures on the picture 9 have been altered from the actual presentation for business confidentiality reasons, and therefore only represents the visual possibilities from the data.



Picture 9. Investment summary with existing investment evaluation tool

Once the financial estimation results were printed out, it still lacked credibility as the customer had not participated in the estimation, and the source of the data was difficult to present. The calculation formulas itself are sound, but they have been hidden inside a multi-layered calculation and new customers might have issues with the credibility of the calculations that they can see and verify.

The calculator created by Kumpulainen (2013) estimates the payback period for the system investment and presents the increased profits and savings according to input values. The possibility to create accurate results from many inputs also creates another significant weakness for its use. Persons evaluating the system on the investment stage often do not know or are not willing to share all related production cost details such as margin levels of manufactured parts. This can make the salesperson and the customer precarious to use the evaluation tool in their first few meetings.

During this first step of the empirical phase it became apparent that FMS systems are financially justifiable with the existing tools with abovementioned limitations. Next goal was set to interview the most experienced sales persons available of their use of the tool and find out ways to improve it and to make it more accessible. User participation in calculation model development is also vital to ensure that it serves the purpose and to increase commitment in its use.

6.2 Development basis for the investment calculation model

In the aftermath of the aforementioned customer case in US, the case results and the presentation style were sent to the US sales team and the use of similar calculation models were questioned via email. Two of five sales members interviewed recognized the tool created by Kumpulainen (2013), and one reported using older and more simplified version of the payback calculator as he couldn't localize the results or fully knew how to use the calculator.

From Fastems head office two experienced salespersons were interviewed for the initial development. The sales persons were selected as both had more than 10-year experience in the industry working with customers, and both were familiar with the previous investment calculation models.

During an interview with the business area manager (Niemi, 2019), he presented his viewpoints and experiences with the previous calculation models with customers who are buying new machine tools or relocating current units to meet a production demand. He had evaluated many cases with his customers and the discussions often had led to a different discussion rather than the payback period calculation. The business area manager used the evaluation tool created by Kumpulainen (2013) with the customer on to understand their goals. The conversation with customers usually listed out the basic details of the planned manufacturing investment:

- Number of machine tools
- Estimated price level of the machine tools
- Estimated price level of the FMS system from case company

- Estimated production hours per year (weeks, manned shifts and unmanned periods)
- Average work piece NC-time
- Personnel during manned work shifts
- Machine tool spindle utilization rate with and without FMS.

The machine tool spindle utilization rate is the most important and the most difficult one of these details. (Niemi, 2019).

According to the business area manager, customers often do not measure the spindle use accurately before implementing any manufacturing automatization and easily overestimate their utilization rate. Production managers feel like they are working as much as they can, and they might perceive that always when operator is managing the machinery it is being used, when in fact all the times the machine is waiting for new NC-program, setup change or new parts to be loaded/unloaded it is in downtime reducing the utilization rate. Based on his experience the business area manager estimated that the utilization rate is often well below 30 %, but customers might assume it be above 50 %. With FMS systems the utilization rates above 60 % or even above 90 % are achievable. (Niemi, 2019).

By setting the input values mentioned above and the utilization rate with the customer, the next step is to evaluate the profitability. According to interviewed area sales manager usually is the point the customer realizes the significance of the investment plan (Niemi, 2019). Table 3 is created with calculation model by Kumpulainen with three machine tools, and the difference between with and without FMS is the length of unmanned production hours per day – with FMS two hours unmanned production per day – and the utilization rate which is set to 30 % without FMS and with FMS it is set to 70 %.

TABLE 3. Production volumes with profitability calculator (Kumpulainen, 2013)

Production Figures

Recommended system:	RoboFMS		
Production	**Without FMS**	**FMS**	**Change**
Machine hours available	26,280	26,280	
Machine hours used	15,552	17,280	
Productive machine hours (NC-time)	4,666	12,096	
NC-time per piece, minutes	40	40	
Production volume, pcs per year	6998	18144	159%

The results in table 3 show that the systems are not comparable. For a fair comparison, the production volumes should be set to same level. The level customer is planning their investment. If customer is planning a manufacturing site for approximately 6000 parts then with FMS, they would only need single machine tool. In addition to saving the extra machine tools, the FMS investment cost would also drop significantly. If the customer needs a production for 18000 parts, they would need four machine tools more for standalone use to reach those volumes. In both cases the actual investment cost is significantly lower for the customer with FMS system. This is not necessary always the case, but it raises the most relevant aspects of FMS to the discussion.

This approach was also presented to key account management director in an open interview. It was concluded that a simplified version of the calculation model, that could help salespersons to process these same numbers with the customer easily would be useful. It was also noted that it is really easy to get mixed up with the input terminology even with professionals (Karppi, 2019).

The initial feedback of good ways of usage and difficulties with previous tools set out the parameters for next improvements. The calculation model had to be approachable for sales and transparent in results to increase credibility in the eyes of customers.

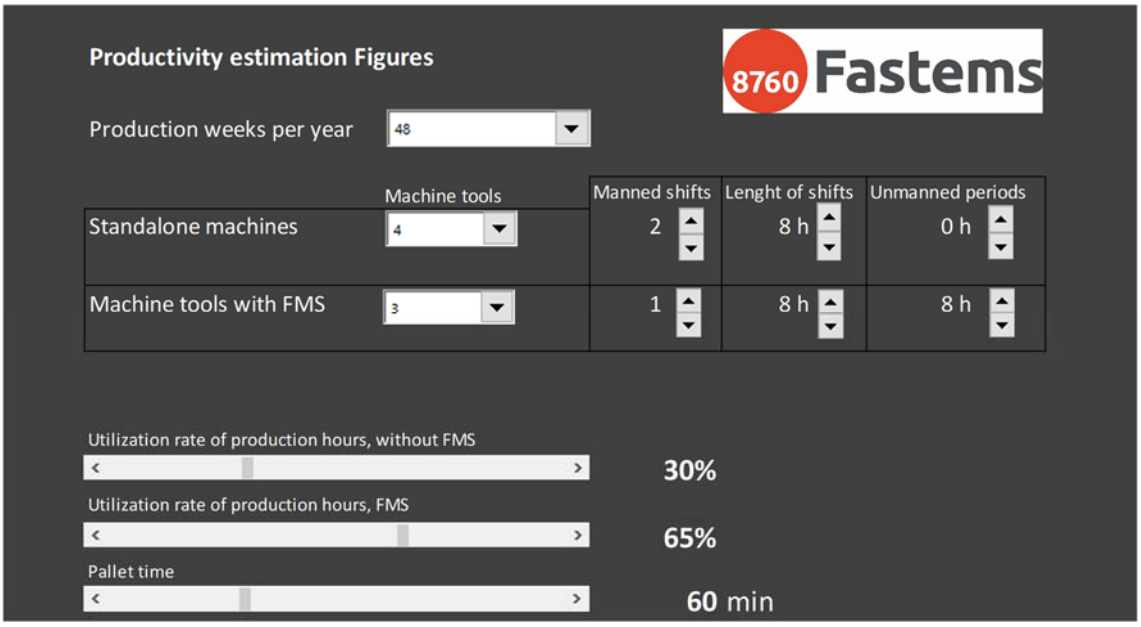
6.3 Updated production volume calculation model

The production volume estimation highlighting the machine tool spindle utilization rate is fairly simple. The equation (1) for the pallet production estimate is presented below. For the easiest user interface only the most relevant factors could be included in the calculation model to avoid distraction.

$$\frac{prod.weeks \times prod.hours\ per\ week \times machine\ tools \times utilization\ rate}{Pallet\ time} = Pallets\ per\ year \quad (1)$$

From the previous calculation model, the part production was simplified to pallet numbers. Parts per pallet varies from 1 to dozens from system to system, but the number is usually not known in the early stages of the production planning.

To help the comparison between standalone machinery and machine tools the number of machine tools in each alternative must be easily selected as well as the length of manned and unmanned periods. Selection buttons and sliders were used to input allow the selection of values in a way that they could be used in multiple calculation sheets.



Picture 10. User input fields in the updated production volume calculation model

The selection of inputs was now set to most basic level. For the salesperson it creates easy platform to discuss with the customer, what their production goals

are and what is the financial impact of FMS investment. Setting the utilization rate together with the customer can also provoke the discussion of what enables the higher value and how it could be attained. Customers with long standing business relationship with the case company might take the word of an expert when evaluating the utilization rate for their solution, but for new customers the system references and testimonies from other customer must be presented as well.

The parameters are set with the selection buttons and sliders so that the values can be linked to next calculation steps. The return of investment calculations is the next intended discussion, but before that discussion the sales must first establish customers goals as current setup is probably not even comparable. Perhaps it is unnecessary step if required number of standalone machine tools end up costing more the machine tools with FMS.

TABLE 4. Production volume results

Production Figures	Without FMS	FMS
Production weeks per year	48	48
Machine tools	4	3
Manned hours per week	80	40
Unmanned hours per week	0	40
Production hours per week	80	80
Available machine capacity per year	15,360	11,520
Utilization, of production hours	30%	65%
Productive MC hours	4,608	7,488
Pallet time, minutes	60	60
Production volume, pallets per year	**4,608**	**7,488**

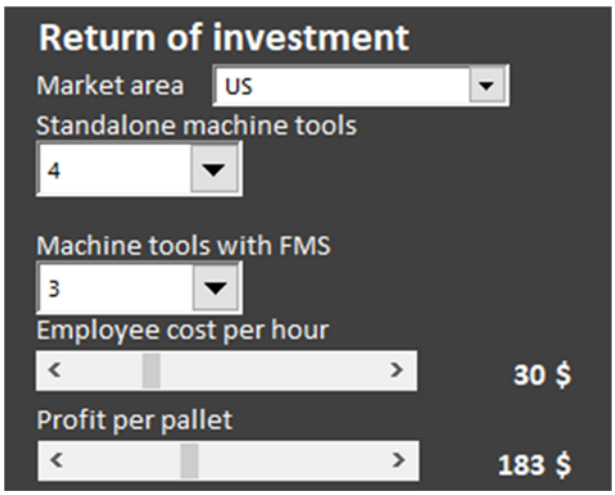
At this point, it is important to process the results with the customer. The table 4 show the production volumes in simplified terms next to the calculator sliders. Calculation formulas are fairly simple and from here the customer can check the basis of the results. In this example (Picture 10), the estimated production volume with three machine tools with FMS can produce almost than 7500 pallets per, which depending on fixtures could be anything from 7500 to 75000 parts per year. Is the customer planning a production site for 4600 fixture sets or 7500? If they

need more than 7000 pallets/fixtures per year they would need to have at least seven machine tools compared to three with the FMS. In a comparison between standalone machine tools and with FMS the FMS solution would most probably be lower investment cost.

6.4 Return on investment calculation model

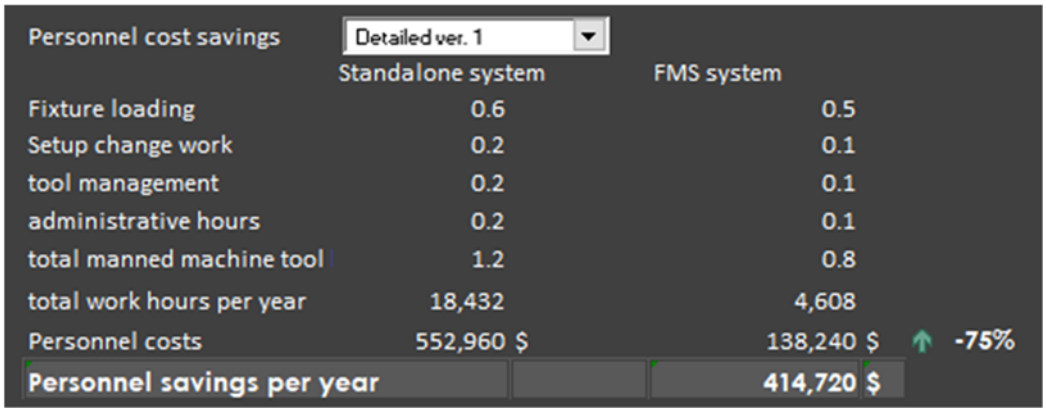
It is possible that the customer is able sell the increased production as in the example shown in table 4, and wishes to compare the investment alternatives financially. In this of situation, the increased profitability, cost savings and pay-back time period become highly relevant discussion topics. For accurate return of investment calculation employee costs, fixed costs and profits are needed. To process this information – which is rarely shared between buyer and a seller of any industrial system – two new ways were created, and localization platform was set up. Machine tool numbers and production volumes on this section are linked to the set parameters in the previous phase.

Customers in different industries have very different costs and profits from their production. For the return of investment calculations, two sliders were set so that customer and the salespersons can speculate and test out different scenarios and market area could be set with selection box to change currency. Factory managers and business owners roughly know the employee cost level and it can be set easily during a business meeting. As mentioned before, the part margins and detailed profit information is very rarely shared between parties. With a profit slider salesperson and the business owner can test different profit levels easily without actually sharing any business secrets.



Picture 11. Selection tools for cost/profit analysis

The machine tool numbers and employee costs per hour are used to calculate differences between standalone machine tools and with FMS. FMS software of the case company has the ability to show the schedule when setup changes, tool changes, new parts and finished parts are expected which all save labour time. Estimations were listed for both alternatives (Saarimaa, 2020). The summation of labour per each machine tool hour and the cost of employee hour defines the yearly personnel costs for both alternatives and the savings are of course the differences between the two. A selection box was also added so that the localized estimations or alternative calculation models for labour hours can be added easily. An example of one of these labour factors is presented in picture 12.



Picture 12. Personnel cost savings and factors in the calculation model

Profits that had been estimated in the example above will simultaneously update the profit calculations (Table 5). As in this example, the increased pallet volume per year creates a significant difference in the profits created in a year. These

parameters estimate more production for the customer with FMS, so with the profit slider they can check the profitability by increasing sales volumes by lowering margin/profit level.

TABLE 5. Production profit calculation model

Production Figures	Without FMS		FMS		
Production weeks per year	48	w	48	w	
Machine tools	4	pcs	3	pcs	
Manned hours per week	80	h	40	h	
Personnel costs	552,960	$	138,240	$	
Production volume, pallets per year	4,608		7,488		
Profit per pallet	183	$	183	$	
Profits per year	**843,264**	**$**	**1,370,304**	**$**	**63%**

The total investments for both alternatives were then summarized with partially manual table (appendix 2.). The number of machine tools is automatically updated, but the range of machine tool prices is wide, so it is much easier to input the values manually. The FMS interfaces (mechanical and controls) need extra options or small modifications for machine tools and pallets, both which increase the investment costs for its side.

The second new way to approach the profitability discussion was to calculate the break-even thresholds between the two solutions with set parameters. Break-even points were calculated from the cumulative cash flow from the increased costs weight in against cost savings and increased productions.

TABLE 6. Cumulative cash flow comparing investment difference

Year	***0***	***1***	***2***	***3***
Increased costs	-960,000			
Cost savings	0	414,720	414,720	414,720
Cumulative cash flow	**-960,000**	**-545,280**	**-130,560**	**284,160**
increased pallet production		2,880	5,760	8,640
profitability required per		189	23	-33

The calculation done in Table 6 and the output Table 7 allows visibility of the set investment plan and estimated benefits without any other internal business information outside the investment than the labour hour cost estimate.

TABLE 7. Production profit calculation model

break-even threshold with 30 $ employee cost and 65 % machine tool utilization rate	
years	Profitability per pallet
1	189
2	23
3	Cumulative profits

The new calculation model made the financial justifications transparent and easier to use. It is designed to avoid the weaknesses the previous calculation models suffered, such as the requirement for confidential business information. Another lesson from history the implementation. It was imperative to make sure that the calculation model was user-friendly and understandable. The use of the value selling and the calculation model must be encouraged and supported.

6.5 User feedback and trainings

The calculation model was now updated and modified according to user feedback. The next step was to present it to the global sales. The new calculation model was presented to sales team in annual sales training week with the narrative presented in this chapter. The use of the narrative and other approaches to customer benefits and investment motives were processed in an open discussion.

Some of the sales persons recognized the previous calculation and some used their other basic parameters to estimate customers spindle utilizations before investing to automation systems. Overall, the reaction to from the first introduction of the updated calculation model was positive judging from the general feedback comments and new volunteers that signed up to test the current version of the calculation model first hand. As the open format of the discussion made the feedback unquantifiable the feedback was decided to be replicated via online survey.

The user feedback during the first introduction had great update and development requests, such as production cost structure and personnel resource localizations,

different language options and separate versions designed to be sent to customers were among the most frequent requests.

The online survey was done to verify that the calculation model development is following user needs. If the users will not find the model useful in their daily business, it will be forgotten or unused and some of the benefits from this study will be lost. The survey had five questions. First two were set to verify that the assumptions about the previous tools were accurate. Third was about willingness to join first group of users and the fourth was a scale for the significance of this and similar tools to their daily business.

The online survey was sent to 30 sales persons that were invited to the training and the reply rate was 53 %. Approximately two thirds of the responders recognized the two earlier calculation models for return on investment estimations, and some had used them. This correlates to earlier assumptions from the open interviews, that these elements are processed with customers, but they are not as widely used as hoped.

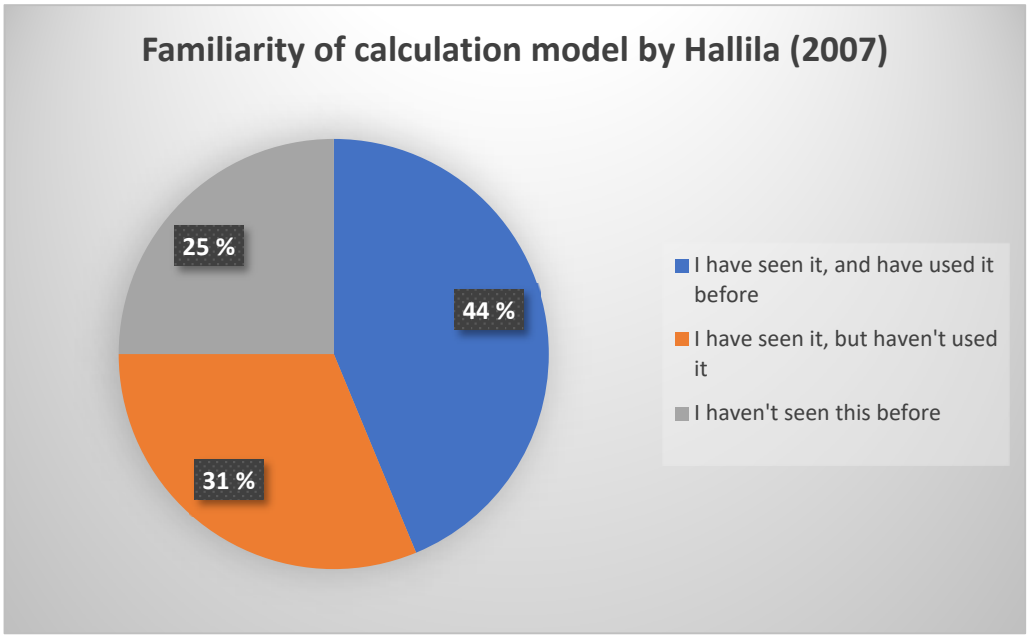


FIGURE 6. Survey results on existing calculation model by Hallila

As the survey was replied by approximately half of the active salespersons. It is very hard to evaluate the reasons for missing answers.

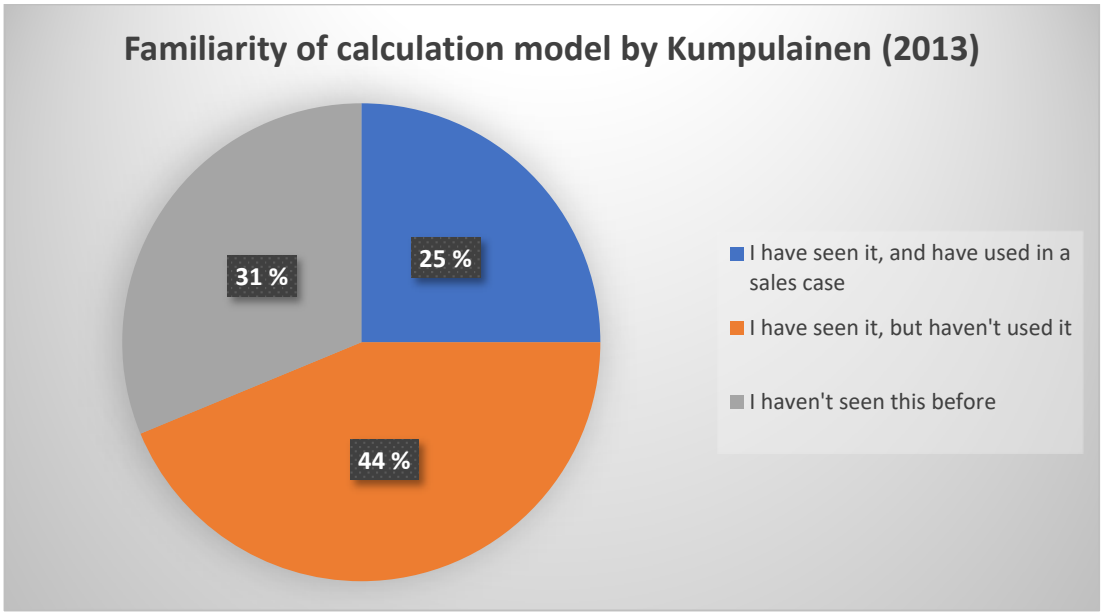


FIGURE 7. Survey results on existing calculation model by Hallila

The significance of similar calculation models was asked with question with point scale from 1 to 5. The question “Are this kind of tools needed in FMS sales?” with descriptions

- 1 is really not needed,
- 3 is maybe sometimes
- 5 is needed for most sales cases.

The need for this kind of tools received 3,88-point average from the participants.

Reaction to updated production volume and investment calculation model can be considered positive. Most of the survey responders (43 % out of total salespersons) indicated their willingness to start using the new calculation model and participate the development process. The calculation model was shared with all volunteer salespersons, and they were offered meetings and additional trainings for the use of the calculation model. The first online trainings were after two weeks from the initial introductions.

The communication with the sales teams surrounding the benefits processed in this calculation model has also added engagement to develop other easy system calculation tools to help communicating with the customers.

Active use of the updated calculation model in business has now been started. The participation of the users to further development and the continuous effort to support the use of the calculation model are believed to be the key strategies to encourage active use of the value-added selling process and to increase the business success from it in future.

7 DISCUSSION

The thesis topic evolved during the study process. The thesis was initially set to study alternative pricing models and especially the value-based elements for pricing. To map out or to quantify customer values and benefits one needs a calculation model. This led the study to re-examine the existing models and the need to update those. The updated calculation model and the combined academic literature on pricing, customer value and value selling are a set of baseline data on which more detailed development can continue.

7.1 Re-evaluating the price position with the investment calculation

The calculation models created during this study were designed to be as simple as possible to lower the threshold to use them and to increase the transparency in the discussions with the customer. The data the new calculation model uses can be made more detailed and can be customized for a focused use on product lines or market areas. If the use of the calculation model continues to be active it will also accumulate data on the customer motives on when and why a customer chose to invest in flexible manufacturing.

More detailed information could be, for example, the cost of personnel and the required resources: a skilled machine tool operator or an average factory worker has a different cost in USA than in China, or the manufacturing culture or union rules might require different number of workers for each manned or unmanned machine tool hour. This has a significant impact on the accuracy of the financial planning of the investment. Specifying and updating localized cost structure with area sales and customers in the region will not only improve the calculation model, but it will also increase knowledge on the benefits created by the offered solutions.

Cost savings can also be itemized regionally in greater detail. After a basic understanding of localized personnel costs have been reached, more detailed task can be studied. If a certain task or administrative work stands out in the cost structure, then that information can be used to quantify the benefit of a software feature. For example, manufacturing report with part serial numbers if one such

task that would require operator and administrative work, but could be done automatically in the management software. Cost saving from this repetitive task is a direct benefit with a value from a software module, and it can be in the calculation model as a cost saving element. Once the benefit has been quantified it can be used to re-evaluate its price position or to guide the product development.

As the investment justification is recommended to be processed with the customer and saved for the individual sales case it will also create an opportunity for the salesperson to report the customer motives to the sales and product development organization. Once a salesperson has processed the financial arguments of the FMS investment with the customer, they should have an understanding what kind of increased profits or savings they are expecting and what was the driver that made the investment plan successful. Again, these findings can be used to evaluate the price of the total systems or elements for future cases.

Business cases of product development projects often evaluate individually the financial impacts of features and updates to the customer or to delivery organization. If a customer cost savings from structures or features are itemized in with localized costs, it might be possible also to evaluate the impact with the full delivery scope.

7.2 Reference price impact to value-based pricing

The weight of the reference price is easily understated. It was described as a single significant factor in chapter 4 and it has been an adjacent factor to many other elements described there as well. People base their concepts on quality and value to the reference points in their memory. The reference points can be very similar or very different, but it doesn’t really matter if they don’t realize it. Often those reference points have some kind of price level.

Observing price discussions in offer projects showed, that reference price concept is present in almost every sales case. The salespersons have a memory of prices from the solutions they’ve sold one or ten years ago, customers have reference price from the previous system they’ve bought or previous offer even

though the product or the delivery scope might be very different. And of course, there are often also the competitors setting their own price level.

Arguably the concept of reference price is a factor in change resistance. At least for value-based pricing. If steel prices rise globally, the increased cost in storage is easily explained and accepted. Unless the item or service been sold is totally new, then the desired price level probably should be set as a target and reached gradually to avoid too much of change resistance from internal sources and from the customers.

The further study of customer cases with the calculation model with localized costs might highlight some features or structures that could have potential for significantly higher or pressure to lower price. In any case, the concept of reference price cannot be overlooked when modifying the prices on value based, perhaps from accumulated data from the calculation, to a more accurate level. or when communicating the new level to sales and to customers.

7.3 Value selling narrative

The narrative used for the financial justification calculation was – although successful – still from one salesperson. The value argument from the increased utilization rate and from the cost savings are still valid all over the world where ever FMS in general is fitting for the customer, but each salesperson must adopt and practice their own style of carrying it through. The tool provides the structure for them to process the most important financial benefits with the customer in their own style. This is also an opportunity for the salespersons to develop their value selling capabilities.

Selling value is important strategy to the business success regardless of the pricing basis. If the salesperson and the customer agree on the financial benefits and the payback period of the investment, then the value-based price has a solid argument. If they don’t agree on mentioned basis or the reference price from external sources indicates otherwise, then a cost-based evaluation of the delivery scope will be under scrutiny during the sales negotiations.

8 CONCLUSION

The thesis set out to analyse and implement alternative pricing solutions, but shifted to quantify and explain current customer values and benefits to case company sales organization and their customers. The study created new calculation models to support value selling. The calculation model and findings on its use will serve as a basis for building the value-based pricing elements.

The theoretical framework set out to analyse customer value of the case company FMS solutions. The academic framework has been done extensively for this industry in the two previous studies for the commissioned company. As a concept those manufacturing philosophies are still relevant and valid, and there was no need to change the industry descriptions. This thesis re-evaluated the FMS philosophy benefits on the concepts that have been changed over the year and examined the benefits closer to customer in a practical level. In a sense, by the study the customer interaction reinforced the statements in the main academic literature.

Identifying price perceptions was another objective for the supporting theory. The active research field on price and sales provided ample material to support price concept. The theory to support pricing process was compiled on several aspects, but as the empiric part of the thesis focused on building the foundation and arguments for value-based price evaluation and sales argument, a large part of the price theory was not implemented as intended in the original objective.

The secondary objective of identifying areas for updated pricing methods was partially achieved. The new calculation model processes customer benefits and cost savings in the most elemental level. By breaking down the factors underneath the benefits and costs it is possible to quantify the customer value on function or feature affecting it. The thesis scope identified elements that are applicable for value-based estimation and how they could be defined in detail. Further analysis to those elements will require on-site studying on costs and benefits and to test different pricing models.

The value estimation and the return on investment calculation models were successfully updated according to the original thesis plan. Thesis study found successful practices to process customer benefits and to discuss the investment plan. A successful value selling narrative highlighting the production volume change with FMS on increased machine tool spindle usage guided the development process.

The new calculation model needed to be simple and adjustable for localized needs. It was also established that the use of value selling calculation models needs user involvement and continuous efforts to keep them active. A new calculation tool was updated and handed to sales organization with user trainings.

Sales organization cooperation aided the development process greatly. Many of the salespersons volunteered to continue the development efforts beyond the scope of this thesis. The study provoked very detailed discussions on FMS benefits in active sales cases and as such served its purpose in increasing knowledge in the daily business of the case company.

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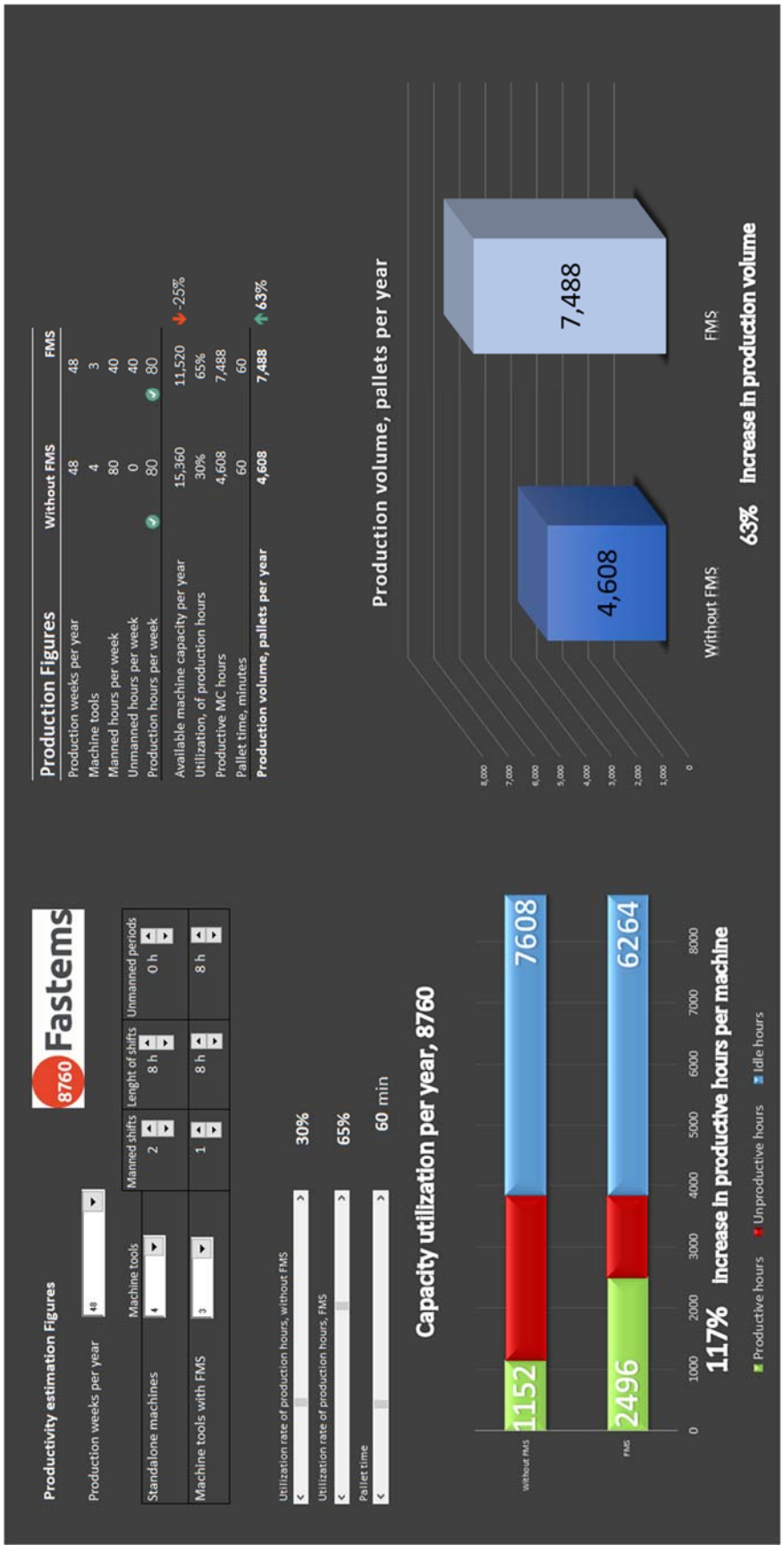
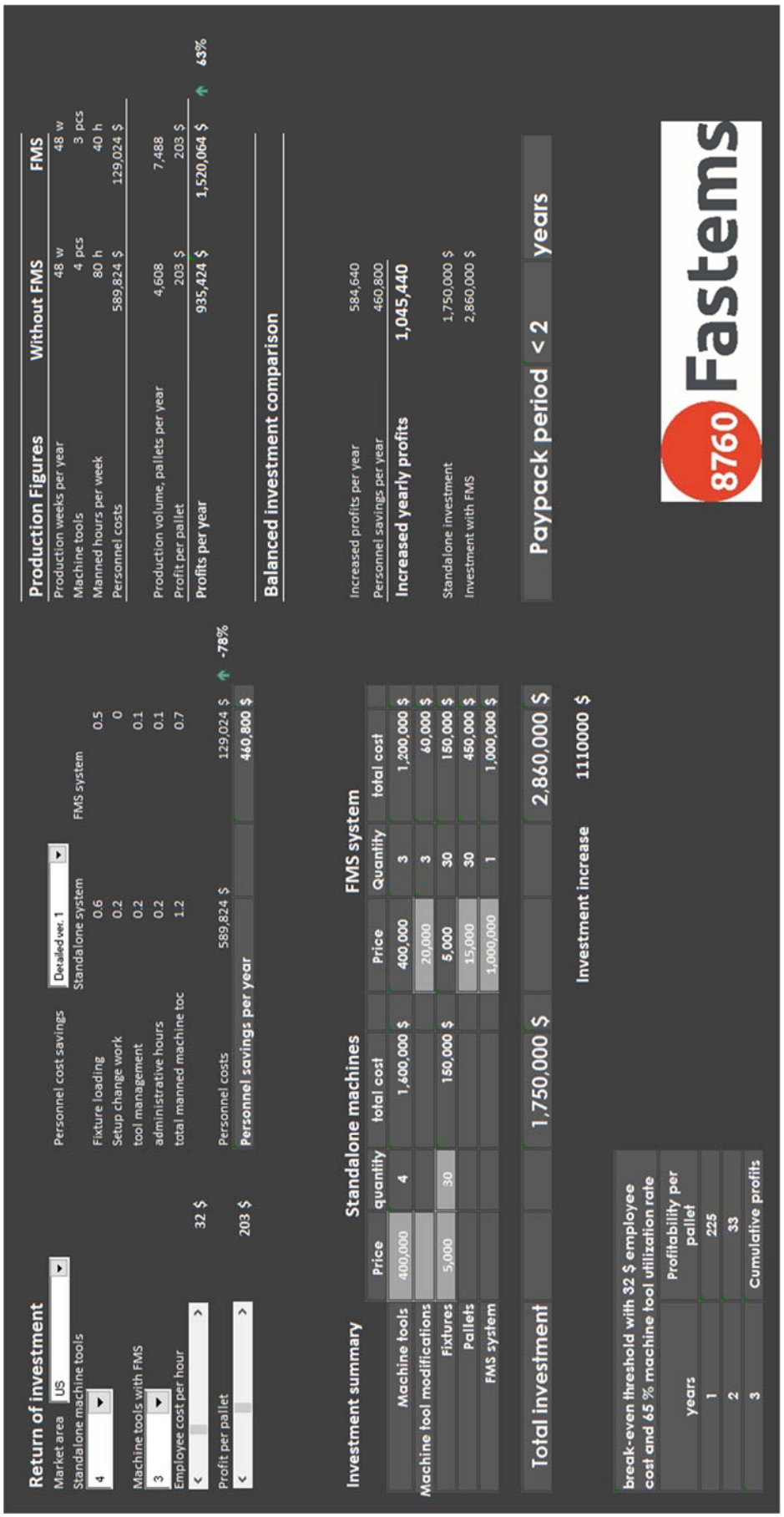
APPENDICES

Appendix 1. Production volume calculation model to sales



Appendix 2. Return of investment calculation model



Appendix 3. Printout example of the results

8760 Fastems

Estimated benefits

↑	63%	Increased Productivity
✓	75%	Personnel cost savings per year
	960,000 $	Investment capital needed
	941,760 $	Increased yearly profits
	< 2 years	paypack period

Additional unquantified benefits

Floorspace costs
Errors elimination
Continuous improvement
trace performance problems
batch release cycle minimize
reaction time to proactive
Better workplace for workers