CRANFIELD UNIVERSITY

JOSÉ PEREIRA

ASSESSMENT OF USAGE OF PLANNING & SCHEDULING PROCEDURES & ICT BY UK MANUFACTURING SME'S

SCHOOL OF AEROSPACE, TRANSPORT AND MANUFACTURING
Engineering and Management of Manufacturing Systems

MSc
Academic Year: 2016 - 2017

Supervisor: Professor Harris Makatsoris
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This thesis is submitted in partial fulfilment of the requirements for the degree of Engineering and Management of Manufacturing Systems

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ABSTRACT

This dissertation investigates the practices of scheduling and data management in small and medium manufacturing enterprises (SMEs). This work intends to identify and assess the stage of usage of tools and/or software used in companies across the UK, and their techniques. To make this assessment and compare the results within these practices, a combination of a web-questionnaire and interviews were carried out, where participants are asked for their insight and evaluation on issues that were found in literature.

To better analyse the impact of the tools and techniques, results were compared within these practices, the companies that show better results or lack of success are analysed by a series of performance indicators that may identify the result of such tools and techniques.

To perform this survey, a literature review was carried out to discover previous research that has been conducted on the topic and identify the gaps between theory and practices. Research presents positive and negative aspects of the more common and traditional scheduling tools, a classification for manufacturing scheduling tools, and the usage of ERP systems in SMEs.

Data was collected from the companies and is than analysed and discussed to identify trends and produce conclusions on the practices of UK manufacturing companies.

Keywords:

Software, Data Management, Survey, Key Performance Indicator

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ICT	Information and Communications Technology
SMEs	Small and Medium Enterprises
MRP	Materials Requirement Planning
MRP II	Manufacturing Resource Planning
APS	Advanced Planning and Scheduling
ERP	Enterprise Resource Planning
KPI	Key Performance Indicator
BOM	Bill of Materials
MTS	Make To Stock
MTP	Make To Plan
MTO	Make To Order
ATO	Assemble To Order
ETO	Engineer To Order

1 INTRODUCTION

This project seeks to assess United Kingdom's Manufacturing small and medium enterprises(SMEs). It sets to identify what type of tools and software are used to execute production planning and data management. It is intended to survey the stage of the technology used, what obstacles and benefits companies find when using these tools, what changes could be made to overcome such challenges and how the company performs in different key performance levels (KPIs).

There are many different types of scheduling and decision support software that companies use to plan or assist their production process, as well as data management software systems to store and manage information of the company's business. The scope of the project is to analyse the ways that small enterprises implement and use their production scheduling systems, as well as data management systems.

The definition of SMEs is that they employ less than 250 people. According to the European Commission, SMEs represent 99% of the companies in Europe (Commission, 2017a), and are the *"backbone"* of the European Economy (Commission, 2017b). In every industrial sector are distributed SMEs, and they perform various different activities (Thakkar, Kanda and Deshmukh, 2009), and contrary to large organisations, SMEs usually focus and specialise in a particular business sector(Vakasi, 2015).

Firstly, the research began by a literature review on the topics of scheduling tools, data management systems and customer and supplier relationship. Knowledge and information was gathered from recent journals, theses and books on the issues. Scheduling software and tools are identified and their advantages and disadvantages are analysed. The same is done in data management systems, as well as practices in SMEs. Then, the benefits and reasons of a more open and connected relationship of companies with their customers and suppliers is presented.

The next step was to collect information in the actual practices in UK enterprises that manufacture tangible goods. To achieve this, a web questionnaire was created and distributed to more than ten thousand SMEs to gather quantitative data. The web questionnaire set to identify the type of tools and systems used by the companies, other information was gathered to understand how the processes were influencing the company, or how the company influences the tools and systems used. The results were collected and it was intended to extract insight from it to elaborate questions of the interviews that would follow.

The interviews were conducted with ten professionals in manufacturing areas. Nine of them working in SMEs, and one working in a large enterprise. The interviews were to gather qualitive data, giving more insight on the topics of the research, such as, identifying benefits, barriers, and trends between different type of business strategy.

The results were analysed and comparisons were made with the information from the different companies. Tools and software were identified, as well as trends according mostly to the company's KPIs and views and opinions of the participants were considered.

An additional part of this project, is to survey the views of manufacturing professionals in the current political situation of "Brexit". Following the result of the UK referendum on 23 June 2016, where the United Kingdom voted to leave the European Union. The intent is to understand positive and negative impacts that they believe that "Brexit" will have on their company.

2 LITERATURE REVIEW

This literature review presents research on scheduling methods and software to plan production orders and data management systems for information management. Information about SMEs practices in these topics was also presented. This research introduces some of the most common scheduling tools used in manufacturing and a classification for the many existing tools and software. It also presents research on the practices of data management practices. Furthermore, a research on collaboration in business is shown, presenting the role of relationship in decision making and information sharing.

2.1 Scheduling and scheduling tools

Metaxiotis, Psarras and Askounis (2002) defined scheduling as "*the process of allocating limited resources to tasks over time in order to produce the desired outputs at the desired times".* Manufacturing scheduling is one of the key functions for companies to do efficient planning in order to keep being competitive in the marketplace (Metaxiotis, Psarras and Askounis, 2002), and although it has been done manually for years, there is the need to overcome the limitations of human memory when it is not capable of coping with large amount of information (McKay and Wiers, 2003). This problem increases when many constraints also have to be considered (Speranza and Woerlee, 1991). This necessity has led to the development of computer support software to help manufactures in decision making (Dios and Framinan, 2016). This group of systems are called manufacturing scheduling tools and present several different types of software, which purpose range from interactive systems that permit an automatic check of the feasibility of schedules, to sophisticated systems where optimal schedules are presented. In these types of systems there a variety of tools with specific functionalities, created for special type of business information systems (Framinan, Leisten and Ruiz García, 2014). The more common ones the Material Requirement Planning (MRP) that is driven by forecast, the Manufacturing Resource Planning (MRPII) which evolve from MRP, a result of the many problems that it caused, and Advanced Planning

Scheduling (APS), which were created to fill the gap of scheduling in Enterprise Resource Planning (ERP) systems.

However, since there is a great number of other scheduling tools, a framework was developed to classify the different contributions of these tools, considering they are created for special type of business information systems (Framinan, Leisten and Ruiz García, 2014). These types of systems can be described according to the type of business function that the system is meant to support. These will be described from now on as *"functionalities"* and will be the criteria to categorize the different type of tools. The type of functionalities will be the ones presented by Dios and Framinan (2016), they are presented in Figure 2-1. In this paper, the classification was based in the work of Framinan and Ruiz (2010), a work that sets to put forth a classification of generic functionalities of manufacturing scheduling tools.

Although, the main functions are devised into sub-functions by Dios and Framinan (2016), it will only be considered the main functions for this study.

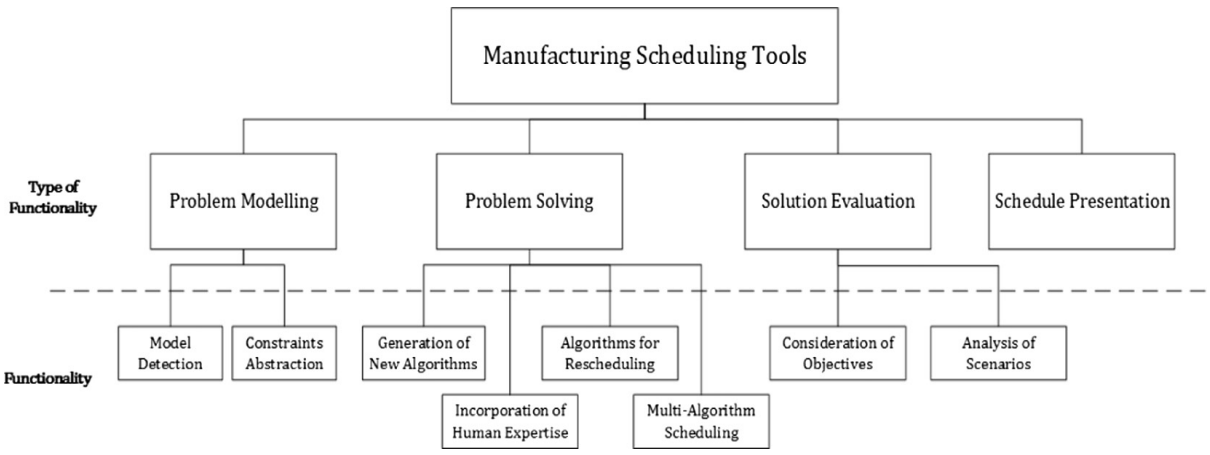

Figure 2-1 The functionalities of manufacturing scheduling tools (Source: Dios and Framinan, 2016, p. 231)

The description of the functionalities by Dios and Framinan (2016) are:

- Problem Modelling:

“This type of functionality refers to the ability of the tool to capture in an autonomous or semi-autonomous manner different parameters of the corresponding shop floor.”

- Problem Solving:

“The functionalities grouped under this type refer to how the system generates schedules (i.e. solutions to the problem). Based on the classification by Framinan and Ruiz (2010), a number of functionalities are identified.”

- Solution Evaluation:

“This type of functionality refers to how the tool evaluates the schedules obtained. Two aspects were identified within this type of functionalities.”

- Schedule Presentation:

“This type of functionalities refers to how the system presents the information to the Decision Maker and how it interacts with him/her. This type of functionality is adopted in the reviewed tools using different means.”

However, when it comes to scheduling practices, it is usually pointed out the gap of information between literature and scheduling in enterprises (Maccarthy and Liu, 1993; Dios and Framinan, 2016). One of the reasons are the constraints inherent to the type of business of that enterprise, and thus its manufacturing operations (Maccarthy and Liu, 1993), and, also the need to adapt to the demand of quick market change (Maccarthy and Liu, 1993).

Some scheduling tools were researched and categories were attributed to them according to information provided. This information was gathered from the GetApp (2017) website.

- Acctivate – problem evaluation
- Zoho inventory – problem modelling
- Fishbowl – problem solving
- Orderbot – problem solving
- CentralBOS – solution evaluation
- Rollbar – problem modelling
- OfficeBooks – scheduling presentation
- VersAccounts – problem evaluation
- Boxstorm – problem modelling
- SpiraTeam – problem modelling
- Asset Panda – scheduling presentation

- Fixed Asset Management – solution evaluation
- Conga Novatus – problem modelling
- Promapp – scheduling presentation
- Naranga – problem solving
- Q4 – solution evaluation
- PDXpert PLM – problem solving
- Accelo – scheduling presentation
- Rivo EHS Software – problem solving
- Adaptive Suite – problem solving

2.1.1 MRP – Material Requirement Planning

The Material Requirement Planning (MRP) system schedules production orders that derive from sales forecast or orders (Lambrecht, 1988, cited in Al-Hakim and Jenney, 1991). This makes MRP a "Push" system, where "*schedules cause work to enter the production process to meet the due date"* (Al-Hakim and Jenney, 1991). It schedules the delivery of different raw materials and quantities needed for production, in other words, "*what, when, and how much component and material are required"* (Šurka *et al.*, 2016).

However, MRP has not proven to be an effective scheduling system, according to (Al-Hakim and Jenney, 1991), many companies did not successfully implement this system. MRP is limited in considering other factors of the production process, which leads to implementation problems. The main problems in the failure of implantation are mentioned in the paper by Al-Hakim and Jenney (Lambrecht, 1988 cited in Al-Hakim and Jenney, 1991) (cited verbatim for the reader's understanding):

- *"MRP ignores capacity constraints to a large extent, which inevitably results in unrealistic plans. The widespread use of roughout capacity planning is actually a good capacity check at the planning state, but in many cases, this is not enough."*

- *"MRP cannot cope with the dynamic of shop floor activities and this results in uncoordinated actions. Furthermore, since planners have difficulties tolerating idle time they allow high inventories to avoid it even though such an action does not increase the throughout."*

- *“Predetermined parameters such as batch sizes, safety stock or fixed lead time result in rigid implementation. The complex interplay between them is not always well understood and the existing MRP software does not motivate planners to do much about it.”*

2.1.2 MRP II - Manufacturing Resource Planning

Because of the problems and limitations of the MRP implementation, a new scheduling system was created to prevent these issues. This system derived from the MRP to the Manufacturing Resource Planning (MRP II). The MRP II complements the previews MRP system with additional data, such as finance, engineering, purchasing, distribution and people (Šurka *et al.*, 2016). This way, the MRP II seeks to deliver better results for the production process and better decision making, by decreasing stock levels and holding costs, calculate the most economical lot sizes, track material requirements, allocating production time for different products and determine safety stocks (Šurka *et al.*, 2016). All this information can help companies reduce stocks and calculate accurate production loads and time lines.

The MRP II still presents some drawbacks for a proper implementation. It is a difficult to implement, costly and is time consuming (Šurka *et al.*, 2016). Another major drawback is the integrity of the input data. The system requires accurate inventory records or updated Bill of Materials (BOM) in order to provide the correct outputs (Šurka *et al.*, 2016).

Still, the MRP II provides more benefits to manufactures in relation to the MRP system when it comes to realistic production plans, batch sizes and lead times.

2.1.3 APS – Advanced Planning and Scheduling

The reason for developing Advanced Planning and Scheduling (APS) is the problems that arise from different aspects of the production process. Some of these are put forth by (Lee, Jeong and Moon, 2002). One of the problems is customer-specific orders that will be processed in a multi-project environment. This increases the makespan and makes the meeting of the due dates harder. "*Capacity is generally scarce because, to be competitive, fixed costs have been reduced by outsourcing in recent Years"* (Kolisch, 2000, cited in Lee, Jeong and Moon, 2002). Another need for APS is that ERP systems are not for planning purposes, which makes APS able to complete this gap. APS is found on the principles of hierarchical planning (Hax and Meal, 1973) and make great use of solution approaches that are mathematical programming and meta-heuristics (Stadtler, 2005). In summary, APS seeks to provide managers with information and decisions to manage the company's Supply Chain, by supporting the material flow and other business areas as procurement, production, transport, distribution and sales (Stadtler, 2005). McKay and Wiers (2003) put forth the scope of APS solutions (cited verbatim for the reader's understanding):

- *"Planning, taking forecasts from the sales department or customers and determining how resources will be used to satisfy the demand; and"*
- *"Scheduling, creating a sequence of jobs allocated to resources in a job shop, or assembly areas and build rates for dedicated flow-lines;"*
- *"Dispatching, from the work available to choose from, pick the next item to work on."*

An example of an APS application project in SMEs, was conducted, which addresses the issue of managing cooperation in dynamic SMEs networks using cooperative planning and control (Ryba et al, 2001, cited in Azevedo *et al.*, 2004).

2.2 Data Management

One of the objectives of the Project is to understand, first, if data is managed, and how they store and share it within the Company's functional areas of operation, and also if it is shared with customers and suppliers. This area is known as Information and Communication Technologies which is "*the infrastructure and components that enable modern computing"* (TechTarget, 2017), in other words, how people and organizations use networking components and systems to change information in the digital world (TechTarget, 2017).

Data management can present problems with the increase of information, which presents a challenge for the practices of data management. This is something common in today's companies (Breur, 2009). Another Challenge is the sharing of data, when it is fragmented across the different areas, and the same data is accessed from multiple sources. This data is then managed and stored in information silos (Vayghan *et al.*, 2007) and creates inconsistent information. "*Information silos also make it very difficult to optimize supply chains when operations and manufacturing responsibilities are distributed among many locations and partners"* (Vayghan *et al.*, 2007).

2.2.1 ERP – Enterprise Resource Planning

Enterprise Resource Planning is a system program that enables information to be transmitted across the Company's functional areas of operation, these are: Marketing and Sales (M/S), Production and Materials Management (P/MM), Accounting and Finance (A/F) and Human Resources (HR). "*The term ERP can be defined as an accounting-oriented information system for identifying and planning the enterprise wide resources needed to take, make, ship, and account for customer orders"* (Cox and Blackstone, 2005, cited in Lenny Koh and Simpson, 2005). Since ERP is a system of information, there is a gap when

it comes to planning and scheduling the company's production, which means that ERP will not be analysed, as much as the other systems. When it comes to scheduling, Stadtler (2005) stated that "*Enterprise Resource Planning Systems is not in the area of planning".*

Research has shown that, although until recently the ERP systems were mostly implemented in LEs, the SMEs sector has gained more emphasis among ERP vendors (Jain *et al.*, 2008). However, in the paper by Koh & Simpson (2005), a study was made that indicates how ERP can help SMEs plan scheduling. When wrong scheduling is planned due to changes in the customer orders, ERP can help managing these changes, before scheduling is done. Furthermore, it is indicated that most of SMEs use the ERP system for dimension changing in product design, only few use it to extend the customer order due date, and none seem to the ERP system to shorten supply lead times.

2.3 Customer/Supplier Relationship

The analysis of the scheduling process and data management system will also examine the influence and the part that Customers and Suppliers have in production orders and decision making in the Company. Arduin et al (2013) states that companies that share knowledge efficiently are improving their competitive advantage and collaboration with stakeholders. "*Collaboration is defined as the total of the various courses of actions two individual entities undertake in order to achieve a common goal. These actions cannot be accomplished independently and requires the combination of their different skills"* (Kumar and Naberjee, 2014, cited in Vakasi, 2015). To achieve an efficient collaboration, the main issue is the design of a process that coordinates the independent members of the Supply Chain to be capable of accomplishing common goals and increase profitability (Singh, 2011).

"Nowadays, companies have to cope with constant discontinuities in the marketplace and respond to fast changing market conditions" (Makatsoris and Chang, 2004). Many researchers agree that collaboration in production planning

and manufacturing is very important, this has been considerably recognized by academics and industry for decades (Makatsoris and Chang, 2004).

Since SMEs are usually component manufactures for large companies, there is a need to quickly respond to changes in requirements (Little and Lee, 1999, cited in Singh, 2011). "*Competitiveness of SMEs also depends upon competitiveness of their supplier and customers"* (Singh, 2011). This means that SMEs cannot compete if they do not have effective coordination in their supply chain.

3 METHODOLOGY

In this chapter, the select approach of the research is put forward. The structure and the process of the survey is presented and explained. The selected tools and participants are explained and analysed. Also, the selected methods of ensuring the ethic, reliability and validity of the process and the results, are presented.

3.1 Research Aims and Approach

This project sets to assess the current practices of UK manufacturing SMEs, regarding planning and scheduling procedures, as well as data management systems. The project aims to identify the stage of usage of tools and/or software in manufacturing companies and identify trends within the companies' performances. To achieve this, a survey consisting of a web questionnaire and phone call interviews with professionals working in the industry were conducted. The total interviews mount to ten, with two of them being with professionals working in micro enterprises, seven with professionals in small and medium enterprises, and one with a professional in a large enterprise.

An additional part of the survey is to assess the views of manufacturing professionals in the current political situation of "Brexit", following the result of the UK referendum on 23 June 2016. The survey intends to know the opinions of manufacturing professionals on the challenges and benefits that they believe that their companies will face from the outcome of "Brexit".

3.2 Quantitative and qualitative research

In order to gather data from the web questionnaire, quantitative data is used to transform information into numbers for statistical analysis. This method enables the generalization of the data (Balnaves and Caputi, 2001, cited in Vakasi, 2015). Following the questionnaire, special terms that are used in the industry

were to be identified that could be used later to communicate more efficiently in the following interviews.

On the other hand, to gather descriptive data, qualitative research is conducted, when carrying on the interviews. The interviews allow the participants more freedom to give information and description on a subject, this way, providing an understanding of their views and interpretation of the topics found in literature. The result of this method is that it discovers themes and ways that represent how production scheduling and data management practices are done in practice (Mammersley, 2013, cited in Vakasi, 2015).

3.3 Questionnaire – Strategy and research

The survey process begun by a web-based questionnaire entitled “Scheduling Software and Data Management Analysis”, contained a combination of 19 open and close ended questions and the completion time was between 10 to 15 minutes. The full questionnaire is attached in Appendix A.

3.3.1 Data collection tools and procedure

To create the survey, the university online service “Qualtrics” was used. This service was selected since it provided data gathering tools and data analysis that are used in the report. Another reason to resort to this type of survey is that web questionnaires permit the gathering of large amounts of data with the need to few resources. Also, the results can be exported from the software and analysed in statistical form, that was mandatory for this project. Since this service is provided by Cranfield University, the access and use is for free. The questionnaire was then sent in an email with a link to the survey, which the participants were then able to access with minimal effort. All the responses were kept anonymous and private.

The link to the questionnaire was sent to the selected companies in an email that described the purpose of the survey and an overview of the needed

information. Also, that privacy and anonymity were ensured. The link would then re-direct the participant to the Qualtrics website where the questionnaire could be accessed and completed. The results were gathered and analysed by the program.

3.3.2 Content of the Questionnaire

The topics on which the questionnaire enquired was structured as follows: Data Management Systems, Scheduling Systems, Customer/Supplier Relationship and Brexit/Political Affairs. The last topic was an optional one, since it is related to political affairs and a complementary study of the project. The questionnaire consisted of three types of questions: multiple choice, matrix table, and open text entry. Results are attached in Appendix B.

3.3.3 Sampling criteria

To identify and select the participants, the FAME database was used. The database contains information on companies from the United Kingdom and Ireland. The criteria were selected and of the companies shown, the ones who made their email address available were exported. The companies selected were Micro, Small and Medium Enterprises, meaning that they should employ up to 249 employees. Also, the criteria were that the companies should manufacture tangible goods and be located in England, Scotland, Wales and Northern Ireland.

Dozens of thousands of emails were sent to companies, and the amount of responses was 22. Participants were asked to categorize their companies according to the number of employees. The European Union categorizes companies with less than 10 employees as Micro Enterprises, with employees between 10 and 49 as Small Enterprises, with employees between 50 and 249 as Medium Enterprises. Of the companies that answer the questionnaire, 0.5%

(n=1) were Micro Enterprises, 25% (n=5) were Small Enterprises, and 70% (n=14) were Medium Enterprises (Figure 3-1).

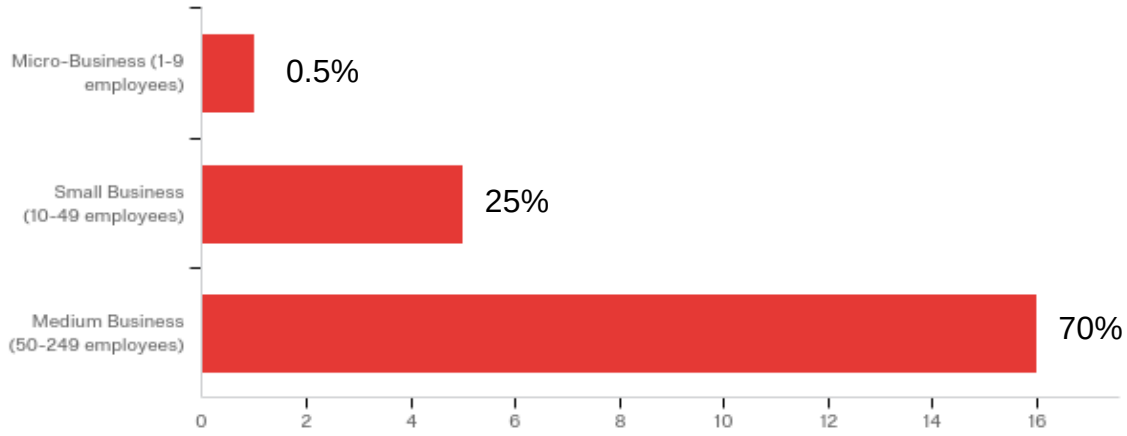

Figure 3-1 Number of companies according to categories

3.3.4 Reliability and Validity

To ensure that honest responses would be given, privacy and anonymity was ensured to the participants. The number of questions was kept to a minimum to retain the participant's interest and avert uncompleted questionnaires. Of the participants who entered the questionnaire, 80% completed it fully. For content validation, the topics of the questionnaire were chosen in a way that covered all the main points of the survey. A series of questions were included to make sure that proper data would be gathered. To devise the questions put forth, they were based on literature about current practices in SMEs. This was validated by the fact that open-ended choices were rarely selected, and the researcher's email address was provided for further assistance.

3.3.5 Ethical Considerations

To ensure that the research was ethical, anonymity, confidentiality and consent were ensured. By agreeing to complete the survey, permission was obtained from participants before starting the questionnaire. The participants had the

freedom to withdraw from participating at any time. The purpose of the research and the requested information were described in the email. Since confidentiality was ensured, any information the participants provided will not be used in a way to publicly recognise them.

3.3.6 Data Analysis

The data was gathered and analysed by the software. Mean values and frequency tables were created automatically. Also, open-ended questions were analysed. Some data was isolated to analyse manually and compared for conclusion making.

3.3.7 Limitations of web-questionnaires

There are limitations when conducting an online questionnaire. The participants can lose interest or respond influenced by the choices of the questionnaire. Additionally, research has shown that web-questionnaires have different response rates than traditional questionnaires (Couper, 2000, cited in Vakasi, 2015). Furthermore, the responses reflect the views of the participants and may vary from the company's actual practices.

3.4 Interviews

3.4.1 Process overview

The process begun by collecting the companies' phone number to conduct phone call interviews. To collect phone numbers, an internet search was conducted to select manufacturing companies. A university polyphone was then accessed to contact professionals in manufacturing areas. More than 200 phone calls were made. When contacted, it was requested to speak with a person in charge of the manufacturing department that would be willing to provide a phone call interview. Requests weren't always accepted as the

person would have time, could only be reached through email or simply wasn't available.

3.4.2 Participants Selection

The participants were selected based on the criteria that were chosen for the research purpose. The selection criteria when conducting the internet search were, areas of manufacturing such as electronic and plastic components, and UK manufactures by district. There are 5.4 million SMEs in the United Kingdom, constituting 99% of all business (Commission, 2017a), this meant that when contacting the companies, there would be a high probability that they employed a number of people within the SME category range. The participants needed to professionals in charge of the company's manufacturing, such as managing directors or operation managers, among others. Although this research focus on SMEs, a large enterprise participant was interviewed and kept for analysis, since it can still provide insight for the survey.

As many interviews were done to achieve significant data results. At the end of the process, 10 interviews had been conducted. Although each person can always add more information and unique points of view to the research, the main focus is on gathering the sufficient needed data that can be analysed, rather than a large amount of data with little importance to the research (Silverman, 2013, cited in Vakasi, 2015). Literature suggests that a desired number of participants can go from 5 to 30 participants (Vakasi, 2015), it is however, for the researcher to establish the optimal sample for the survey.

3.4.3 Interview Recording

For better collection of information, all the interviews were recorded after asking for the participant's approval. This way, there was less dependency on field notes, where important information can be easily missed. Nonetheless, when analysing the data, both recording and written data were used.

3.4.4 Validity and Reliability of interviews

The validation of the interviews sets to prove that the interviewing process was solid and reasonable.

Validation of the interview was ensured by the adequate length of the interviews that gave more detailed insight of each topic, with the help of recording and field notes to give further evaluation of possible missed data. This data was also compared with the data from the web questionnaire.

An issue that might make the collected information specific to a region is that, seven of the interviewed companies are located in Bedford and Buckinghamshire, although their business industry are distinct from one another.

3.4.5 Data analysis

Upon conducting all the interviews, a summary for each one was written and main points were identified. The time that each interview took varied from seven to eleven minutes, according to the information that each participant was able to provide.

Anonymity was ensured to the participants before conducting the interview, this made answers to be given more truthfully and reliable. To guarantee anonymity, the companies will be referred to as Company X, as they are represented in Table 4-1.

Upon contact with the participants, information about the survey was given, as well as the duration of the interview, the information being collected was explained and anonymity was ensured. When permission was given, the interview would begin. The interview began by asking the participants position and some company's detail, after the topics asked would be the same as the web questionnaire: Data Management Systems, Scheduling Systems,

Customer/Supplier Relationship and Brexit/Political Affairs. The reason for the interviews was to allow the freedom to the participants to describe their thoughts and provide insight on the topics asked. In the topics of data management and scheduling, participants were asked how the software or tools work for their type of business, and were asked to give positive and negative remarks that they felt that it was reflected on the company's performance. The questions that were asked are presented in Appendix C, and the information collected is presented in Appendix E. The audio files of the interviews were also submitted with the thesis.

4 DATA ANALYSIS

In this chapter, the results of the questionnaire and interviews are discussed and analysed. The companies are presented with a short description, and in Appendix D, their areas of business are further described. Since the participants requested to remain anonymous, the companies will be referred to by code name with which they are described in the chapter. The research results are then presented for each topic.

4.1 Companies

4.1.1 Questionnaire Companies results

The results of the companies that answered the questionnaire regarding to size and business strategy are presented.

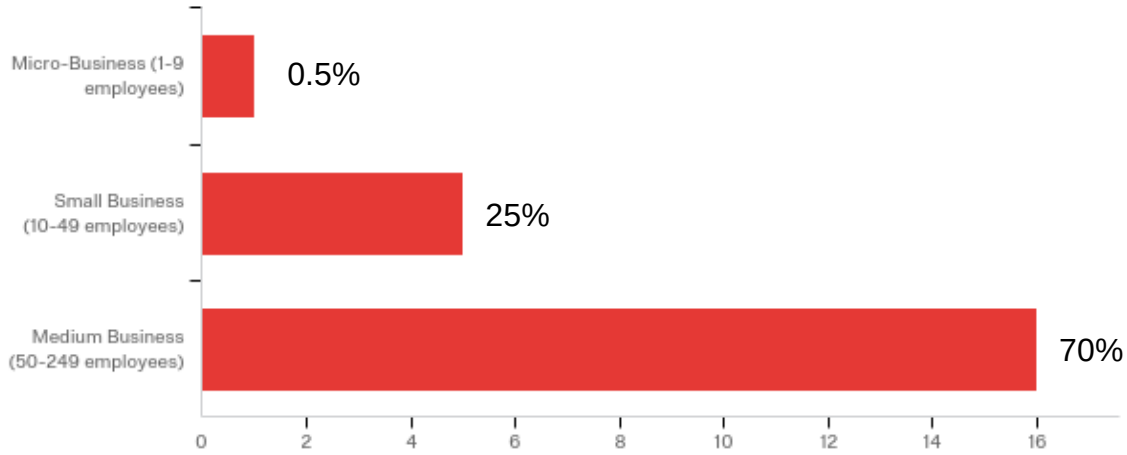

Figure 4-1 Companies size

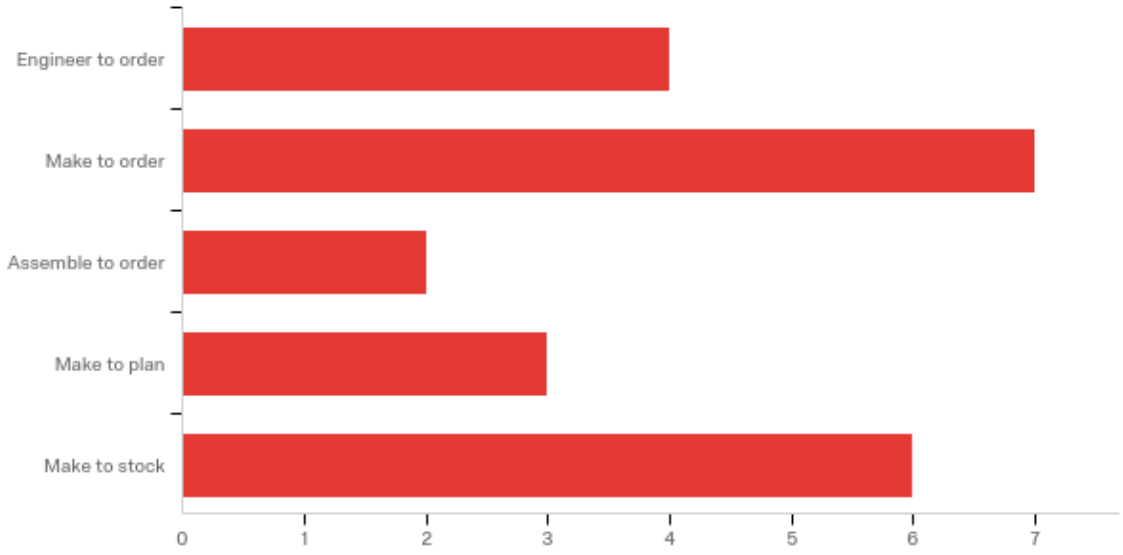

Figure 4-2 Companies business strategy

4.1.2 Interviewed Companies

For each company, key elements are presented, such as company size, main sector and type of exchanged goods. The information was provided in the interviews and from information published online.

Table 4-1 The company industry title and the interviewee position

Code Name	Company Industry Title	Position of the interviewee in the Company
Company A	High-tech Bonding Technology	Operations Manager
Company B	Optical Applications	Managing Director
Company C	Water Softening	Production Supervisor
Company D	Slitting and Rewinding Equipment	Operations Manager
Company E	Plastic Fabrication and Machining	Managing Director

Company F	High Quality Precision Engineering	Engineering Manager
Company G	Signs Design	Managing Director
Company H	Polyurethane Moulding and Toolmaking	Technical Sales Manager
Company I	Sound Amplifier and Musical Instruments	Production Manager
Company J	Structural Steelwork	Project Manager

4.2 Data Management

The data management procedures and software used by the companies are presented and analysed according to the companies' size, the participants opinion and information sharing.

4.2.1 Questionnaire results

4.2.1.1 Software and tools

In the questionnaire results, 90.91% of the companies had a data management system (Figure 4-3), this include a micro enterprise.

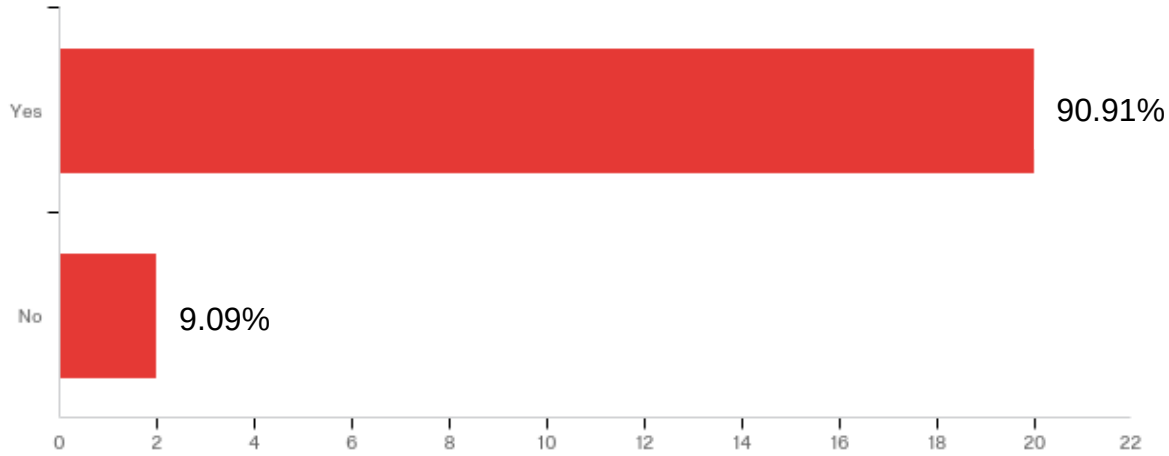

Figure 4-3 Number of companies that use a data management system

The only one micro enterprise that answered the questionnaire, had an ERP System. Out of the five small enterprises reported, one did not have a data management system, one used Excel for data management and two used an ERP system. The fifth company answered that it used a data management system, but did not identify which one. Out of the sixteen medium enterprises reported, one did not have a data management system, one used Excel for data management, and thirteen used ERP or a software to manage data.

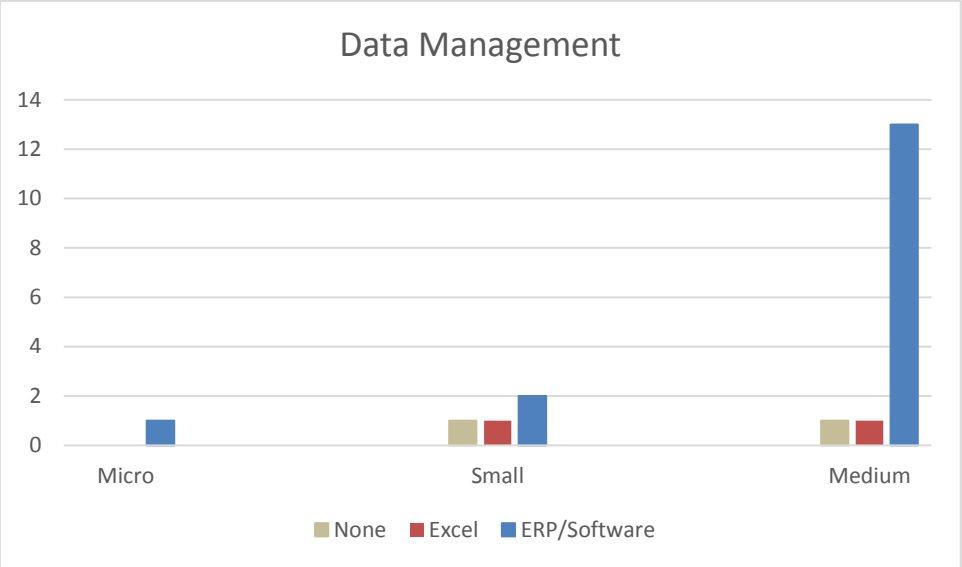

Figure 4-4 Data management system type according to the companies size

It is seen in Figure 4-4 the use of ERP or software, as sizable as the companies become.

The ERP and software systems identified were:

- Epicor
- Salesforce
- SAP
- Diomac
- IFS
- Sage
- Saleslogix SLX
- Syspro
- Juno
- Shuttleworth
- Progress Plus
- Dimensions
- Lake View
- IQMS

All of these programs had good reviews from the participants, except for Shuttleworth and Dimensions, especially regarding information exchange.

4.2.1.2 Data sharing

From these data management systems, only in four companies is the information shared automatically with the scheduling tools. This is shown to be in advantage for the company, has it is reflected in the KPIs (Figure 4-5).

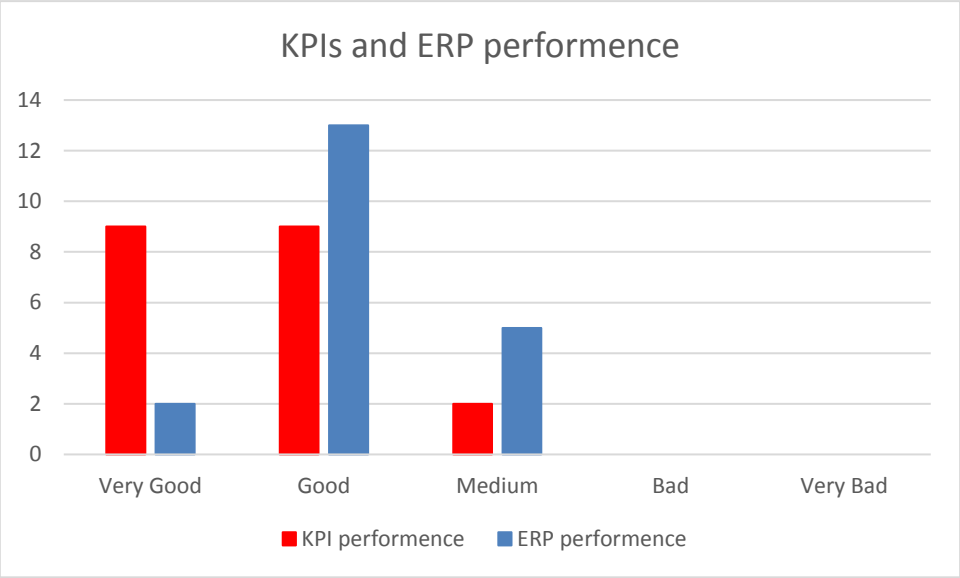

Figure 4-5 KPI performance and ERP performance

This proves the information found in literature by (Arduin, Grundstein and Rosenthal-sabroux, 2013), were it is stated that companies that share knowledge efficiently are improving their competitive advantage. It is further proved that information is well managed and shared since participants attributed good performance to the ERP and software used to do so.

4.2.1.3 Customer/Supplier relationship

To assess how the companies improve their competitive advantage and have an effective supply chain coordination, it was asked if their data management system had a platform to communicate with customers and/or suppliers. Some of the companies achieved this through an ERP system. In the responses

where communication is done, it is analysed and compared the participants opinion on the performance of the ERP itself, the ERP performance in handling communication with customer and/or supplier, and the companies' KPI's.

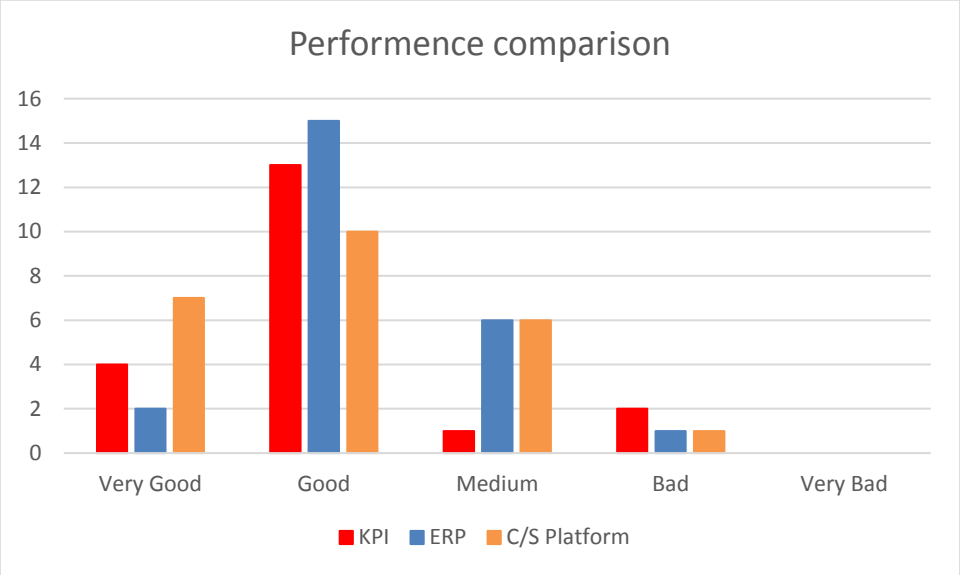

Figure 4-6 KPI performance, ERP performance KPI and ERP performance on customer/supplier relationship

It is seen that most companies that have good remarks for their ERP system also have good remarks for the ERP platform with customers and suppliers. Most of these companies are the ones that also share information with their scheduling tools. Again, this is reflected on the companies KPI's, which, on average are good.

4.2.2 Interview results

4.2.2.1 Software and tools

From the companies interviewed, both micro enterprises, Company E and F, stated that they didn't have a data management system, the reason being that the companies were so small that there was no need for such a system. The

companies that use ERP were A, B, C, D and I. Companies G, H and J resourced to Excel.

Company A used a Sage system. It was acknowledged that this system is outdated, since the company grew from when it was initially acquired. For this reason, the system has some drawbacks and causes some problems, being realized by the interviewee that it needs to be updated. Company B had an ISO system that has been specifically design for the company's requirements, and it was stated to run perfectly. Except for the micro enterprises, all companies had some data management system, whether it was an ERP system or Excel. All four companies that used ERP gave good performance remark to the system used. These were:

- Sage
- ISO
- Filemaker
- IFS

The remaining three stated that benefits of using Excel is that is easy to use, allowing it to be accessed by different people, although admitting that it is outdated.

4.2.2.2 Data sharing

The companies that used Excel as their data management system, had to exchange information manually with the scheduling system, which was acknowledged to be time consuming and prone to mistakes. Company D stated that they intend to connect the ERP system to the scheduling system for data exchange. In companies A and B, the ERP system shares data with the scheduling system. Although company A had the problems that is explained above, it still had good KPI's performance, as for company B, the interviewee stated that the company has great performance levels, proving the benefits that were found in literature of data sharing.

4.2.2.3 Customer/Supplier relationship

Except for Company D, all the interviewed companies did not have a platform to communicate with customers or suppliers. Only Company D used its ERP system to communicate with suppliers, and only with about 25%. All companies resourced to phone, email or fax.

4.3 Scheduling System

The scheduling system procedures and software used by the companies are presented and analysed according to the companies' size, the participants opinion and business strategy.

4.3.1 Questionnaire results

4.3.1.1 Software and tools

In the questionnaire results, 50% of the companies said to use a scheduling system for production planning (Figure 4-7).

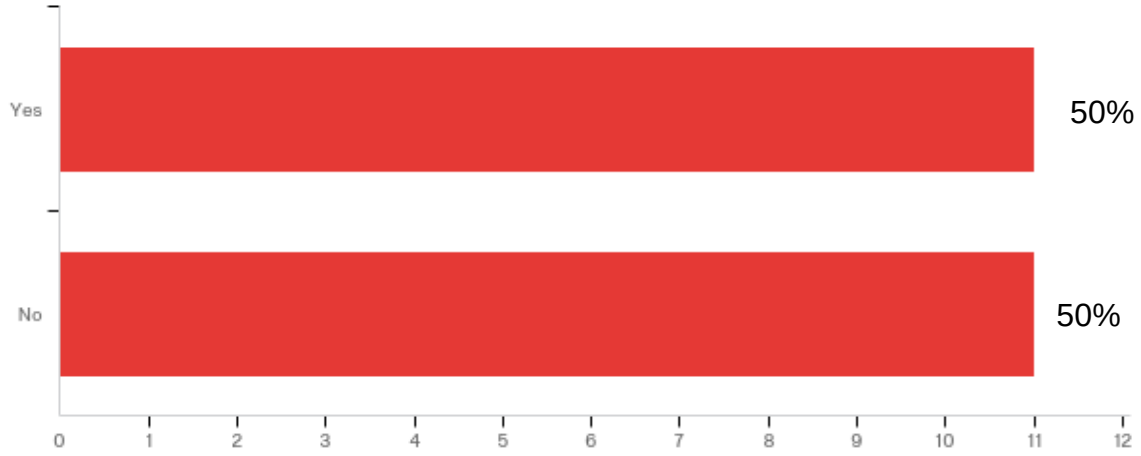

Figure 4-7 Number of companies that use a scheduling system

To perform scheduling, the companies, often used a combination of tools. Since the software mostly used were MRP and Excel, all other software will be presented in Figure 4-8 generically.

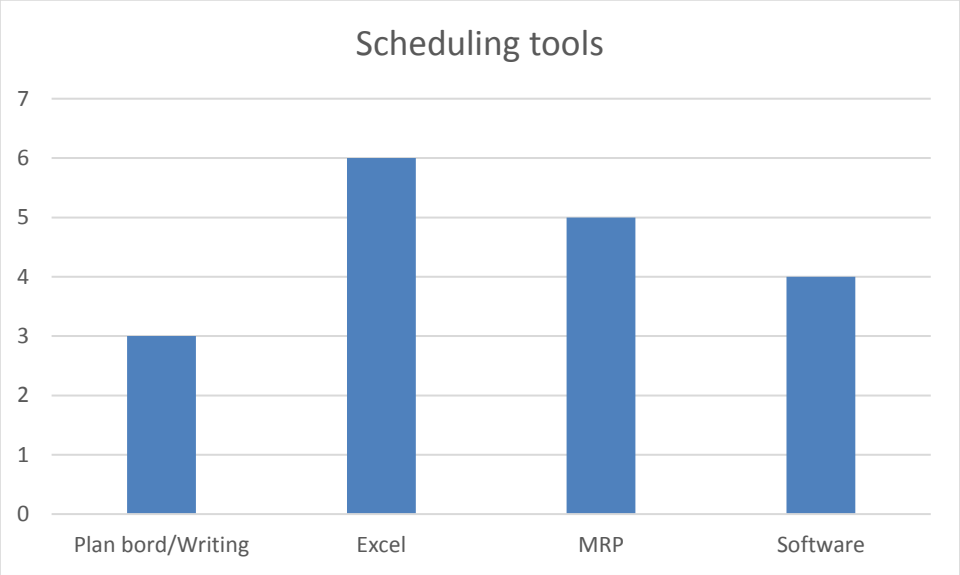

Figure 4-8 Scheduling tools used by the companies

The software systems used for scheduling identified were:

- Syspro
- Epicor
- MS Project
- Primavera 6
- SAP
- IQMS

Trends to the type of tools used according to companies' size were not found, for example, a medium enterprise reported that one of the ways to perform scheduling was writing.

The number of each business strategy reported is presented in Figure 4-9.

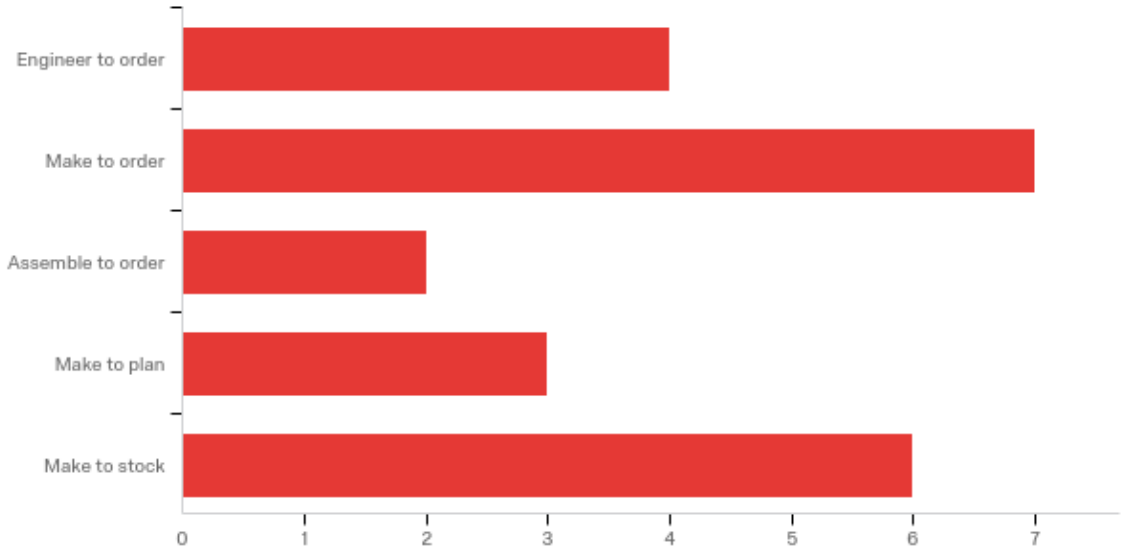

Figure 4-9 Number of the company's business strategy

Comparison was made between the companies' business strategy and the scheduling tools used (Figure 4-10). To narrow the results, they were allocated to similar business strategy.

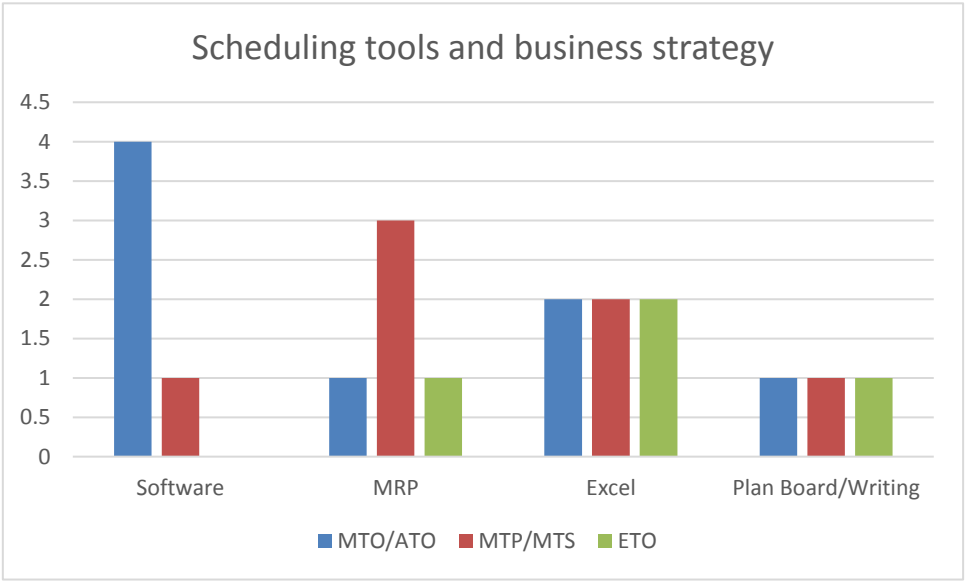

Figure 4-10 Scheduling tools according to the company's business strategy

Regarding Excel, plan board and writing, they are used in fairly the same amount across the different business strategies, given that the number of strategies recorded are different. It is seen that MRP is used more frequently in make to stock (MTS) and make to plan (MTP) business, and the use of a type of software is more common in make to order (MTO) and assemble to order (ATO) business. This might be because of the amount of products manufactures that are usually related to the different business strategy.

MTO and ATO businesses usually do not manufacture great amount of products, these are companies that offer more customizable products (Investopedia, 2017a). This might be the reason to resource to software scheduling tools that can easily cope with changes in materials, operations time, and other factors, to respond to customers demand. Although ETO is a business where companies offer more customizable products than MTOs and ATOs, the number of products is usually low (Arena, 2017) this might be the reason that the companies do not often use a specific software tool.

MTS and MTP businesses tend to manufacture great amount of products and in low variety (Investopedia, 2017b). This means that there are not many changes in manufacturing and so, this might be the reason for the companies resourcing more to MRP. Since MRP provides the materials required for manufacturing the products, other specification might be done resourcing to other tools.

4.3.1.2 Software and tools functionality

One of the findings in literature that is presented, is the categorization of scheduling tools by their functionality. Participants were asked to classify the tools used according to their opinion. Unfortunately, there were few tools that were categorized, and the ones that were, were only reported once. Still, the classification of Excel and MRP are showed in Figure 4-11 and Figure 4-12.

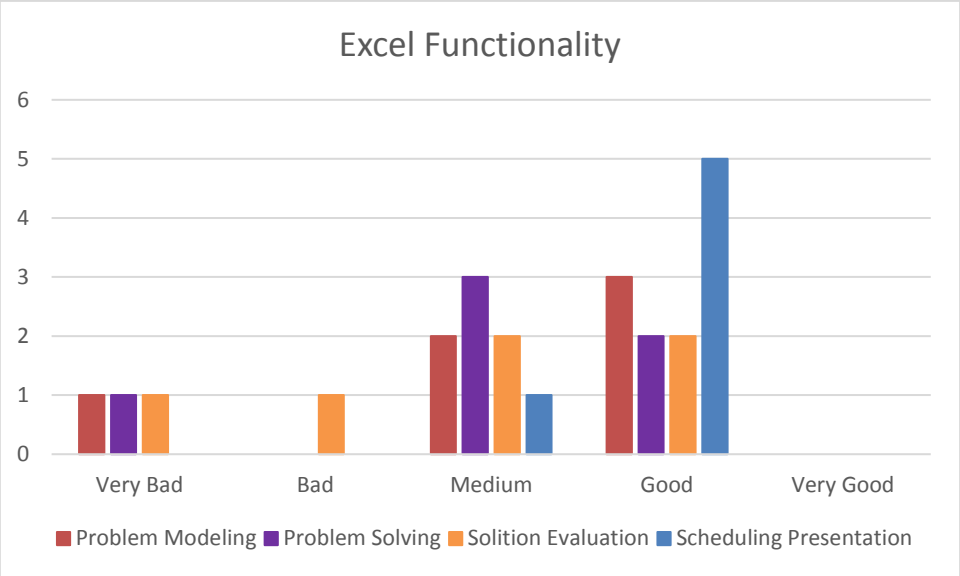

Figure 4-11 Excel functionality as a manufacturing tool

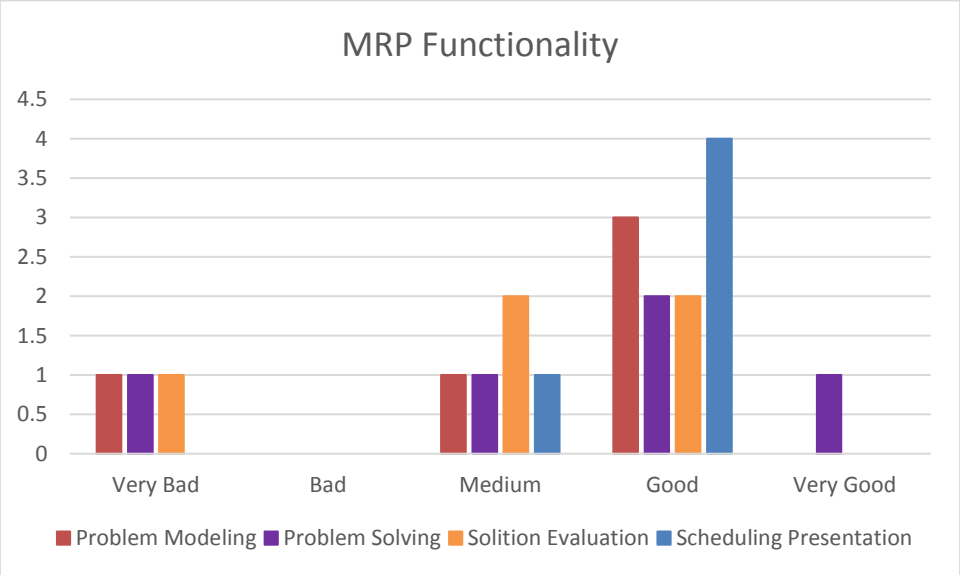

Figure 4-12 MRP functionality as a manufacturing tool

According to participants, Excel is mostly good for Scheduling Presentation. The same classification is attributed to MRP, and of Problem Solving.

4.3.2 Interview results

4.3.2.1 Software and tools

Company A stated that they used the software Preactor for a few months, however they discard it because it wasn't fast enough to cope with changes. They now resourced to MRP to generate production orders, which are then sent to the shop floor, that are then sequenced by the operators. Company I also use MRP and stated that one of the benefits is that it allows manufacturing control from the raw materials to the final product.

Both Companies B and C use a Kanban system for production, the difference is that in Company B, the Kanban system accesses information from the ERP system to generate production orders, and then create the Kanban tickets. As for Company C, the Kanban tickets are set out manually, although was said to be good for inventory management and gives transparency in the company, it has the downside of being a slow process.

Companies D and H both resource to Excel for scheduling. As is explained above, Company D stated they intend to connect the ERP system to the scheduling system for data exchange. This can be seen as the company's belief that data sharing is a benefit for the production process. As for Company H, it was stated that MRP would be too complicated for their type of business.

The micro enterprises companies, E and F do not use any software tools. Company E stated that there was no need for such, since it is a small business and they rely on their experience. As for Company F, it uses a plan board, since it is easy for everyone to access.

The only companies that use a different type of software from the ones above were Companies G and J. Company G operates with SignLab, a specific software for signs manufacturing, and also a Plan board. Company J uses Microsoft Project to generate Gantt charts. The tool is familiar and easy to use, as the interviewee stated. It was further said that the company is trying to implement a new software called Easyprojects.

4.3.3 Results conclusion

The results from the web questionnaire and interviews are presented. These are the ones regarding the data management used according to the companies' size and the type of scheduling tools used.

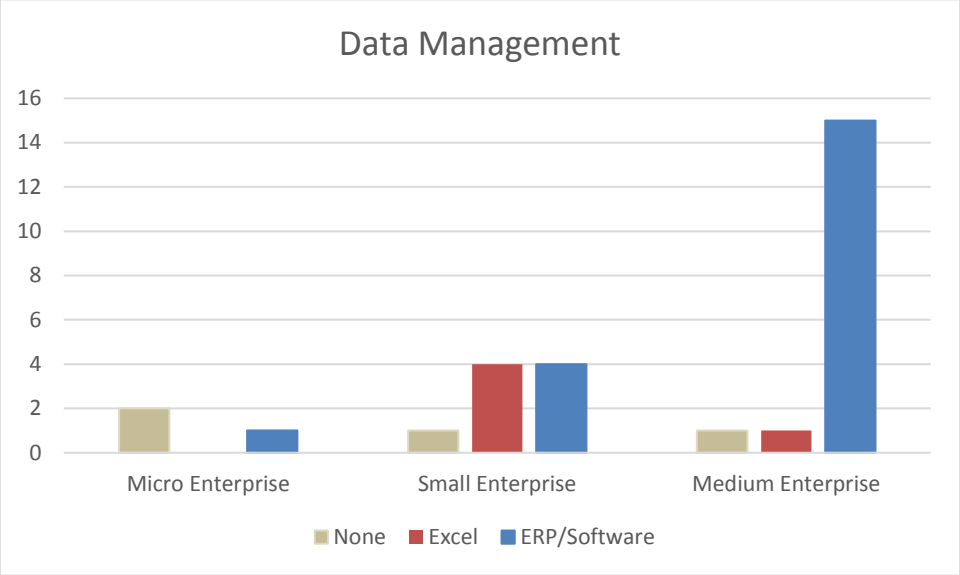

Figure 4-13 Data management systems used according to company's size

The use of an ERP system or software is seen as larger the companies are.

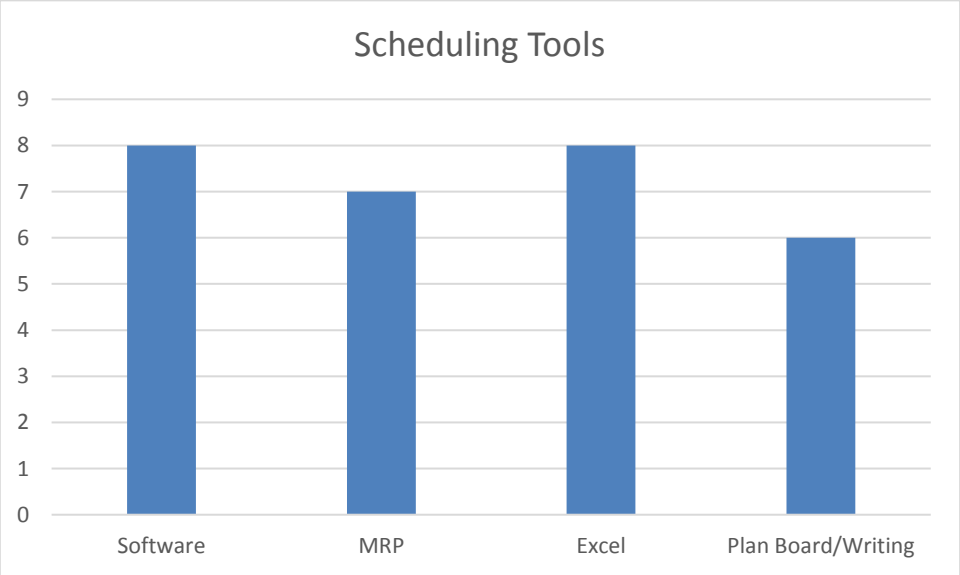

Figure 4-14 Number of scheduling tools used

It is seen that the most common scheduling tools are Excel and MRP. Also, that manually tools are still used, not usually on their own but in addition with other tools.

4.4 Opinions following the UK referendum of 23 June 2016

The analysis will be done on the opinions and views of manufacturing professionals following the leave of the UK from the European Union (EU), as a result of the UK referendum on 23 June 2016. Both results of the questionnaire and interview participants are summarized. Participants were asked at first to rate how they believe their company would react to the UK departure from the EU in these topics: readiness to risk, risk mitigation and responsiveness. Results are presented in Figure 4-15.

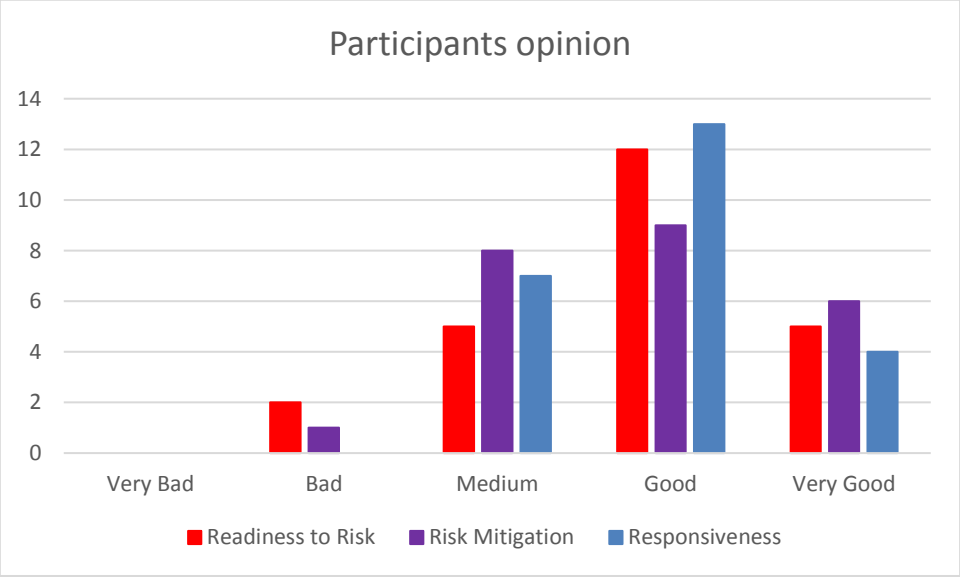

Figure 4-15 Participants opinion on the company reaction to the topics

The graph shows that participants are in general optimistic on how their companies will react in the challenges that they could face.

Opinions on positive and negative outcomes to the company were further asked. The answers ranged from good and bad perspectives. Some participants had no comment to add on the issue. On the interviews, it was explained by few, not just because it is a political issue, but because of the uncertainty involving the process, they simple could not be sure of the outcomes. To some, this uncertainty itself was a negative aspect, for example, that it can undermine confidence to investments.

Some participants see the leave of the European market as an opportunity for other markets. To companies that only have business in the UK, this was said to have no effect, although for others, it is seen as an opening for new markets, which can have a reduction in bureaucracy for those markets. This was pointed out to be a negative impact for Europe, has the UK still has many manufacturing industry and cannot stop selling to other European companies. Negative impacts were concerning export rates, if the EU decides to inflict a duty on British products, exchange costs will go up. Many participants were concern with the leave of foreign labour, especially European skilled labour. However, some saw this has an increase of jobs for British labour.

5 CONCLUSION AND DISCUSSION

5.1 Limitations

The research covered the objectives that were put forward, however, there are limitations that could not be avoided. While there was adequately data gathered, the companies selected were from among different business industries. This means that selecting specific sectors, more in-depth analysis can be done. For example, how the scheduling practices of such companies can influence their performance relating to the type of machines and the level of technology of the processes, operations time and layouts. Moreover, a larger number of participants could provide more concrete analysis to the results. Finally, the outcome of the results can differ depending on the participants. This happens especially in questionnaire, as the participants response can be affected from the choices that they are presented with.

5.2 Conclusion

Although the use of software tools is more common as larger the companies are, the use of writing is still used by some companies as a support, regardless of their size. This use of software tools is especially seen in data management systems. In small enterprises, the use of Excel, software or ERP system are the same, at least on this research results. However, in medium enterprises, it is seen a higher use of a software or ERP systems. This is likely driven from the larger amount of information that arises, and the acknowledgement of the companies in the need of a high-performance system to enable their competitive advantage. Also, the benefits were shown in companies where their data management system shares information with their scheduling tools. This was reflected in a good level of their KPIs, showing that companies improve their performance with a more automatic and fast way of sharing information between their scheduling process and data management system.

The main way that companies come into contact and handle production orders with customers and suppliers is through telephone, email or fax. Only few had a platform where their customers and suppliers could directly communicate with

the data management system. Most of these companies are also the ones that their data management system shares information with their scheduling tools, and again, it was reflected in the KPIs as a positive factor.

The research shows that Excel and MRP are the most common scheduling tools used by companies. This was explained in the interviews that they are familiar to users and easy to work with, making them the preferred scheduling tools. Nonetheless, the downsides are pointed out as being time consuming and prone to mistakes, since most of the information exchange is done manually. The type of tools used by the companies were analysed according to their business strategy. When it comes to Excel and forms of written tools, there are no significant trends. Regarding MRP, it is a type of tool used more by MTS and MTP businesses. As for other and more specific types of software, these were shown to be used more in MTO and ATO businesses.

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APPENDICES

Appendix A
Scheduling Software and Data Management Analyses

Company Profile

Position/Role in Company:

E-mail:

Location:

What type of products does your company manufacture?

Please choose the category of your company depending on the employee number.

- ○ Micro-Business (1-9 employees)
- ○ Small Business (10-49 employees)
- ○ Medium Business (50-249 employees)

Please indicate the type of production strategy of your company.

- ○ Engineer to order
- ○ Make to order
- ○ Assemble to order
- ○ Make to plan
- ○ Make to stock

Data Management

1. Does your company has a data management system?

- ○ Yes
- ○ No

If the answer is “No” please skip to question 5.

---

2. Please select which data management system your company uses.

- ☐ Excel
- ☐ ERP
- ☐ Software
- ☐ Other: _____

---

3. If the format is software or ERP, please state which one it is:

---

4. Please rate the level of efficiency of the company's data management system on these issues.

	Very Low	Low	Medium	High	Very High
Level of ease	○	○	○	○	○
Information exchange	○	○	○	○	○
Cost reduction	○	○	○	○	○
Inventory management	○	○	○	○	○

Scheduling

5. Does your company has a manufacturing scheduling system/software or scheduling tools?

○ Yes

○ No

If the answer is “No” please skip to question 13.

---

6. In which of these formats is the scheduling process done?

- [ ] Excel
- [ ] Plan Board
- [ ] Writing
- [ ] Software
- [ ] MRP
- [ ] MRP II
- [ ] Other: _____
- [ ] Combination of the ones selected/mentioned Please state which ones (8)

_____

---

7. If the format is software, please state which one it is:

---

8. If your company uses both a scheduling system and scheduling tools, please indicate if they "share" information.

- ○ Yes
- ○ No

---

9. Please rate the level of efficiency of the company's scheduling system or scheduling tools in these issues.

	Very bad	Bad	Medium	Good	Very Good
Problem Modelling	○	○	○	○	○
Problem Solving	○	○	○	○	○
Solution Evaluation	○	○	○	○	○
Schedule Presentation	○	○	○	○	○

---

10. Please rate the company's scheduling system efficiency on these performance indicators.

	Very Bad	Bad	Medium	Good	Very Good
Inventory Levels	○	○	○	○	○
Quality	○	○	○	○	○
Lead Time	○	○	○	○	○
Delivery Time	○	○	○	○	○

11. For better results in the previous indicators that were bellow "Good", what do you believe that would be the main drivers for selecting a scheduling tool? Please rate the level of importance of these categories.

	Unimportant	Low importance	Important	Very Important	Critical
Problem Modeling	○	○	○	○	○
Problem Solving	○	○	○	○	○
Solution Evaluation	○	○	○	○	○
Schedule Presentation	○	○	○	○	○

12. If your company uses both a scheduling system and a data management system, please indicate if they "share" information.

○ Yes

○ No

Customer/Supplier

13. Please select the level of importance of these drivers, when accepting manufacture orders.

	Unimportant	Low Importance	Important	Very Important	Critical
Price	○	○	○	○	○
Quantity	○	○	○	○	○
Quality	○	○	○	○	○
Lead Time	○	○	○	○	○
Other:	○	○	○	○	○

14. Regarding manufacturing orders, does the company’s data management system communicates directly with Customers and/or Suppliers?

- ○ Yes
- ○ No

15. If the previous answer was "Yes", please rate the level of efficiency of the company's data management system with the Customer and/or Supplier relationship.

	Very Low	Low	Medium	High	Very High
Information exchange	○	○	○	○	○
Correct information	○	○	○	○	○
Reaction to demand and lead times	○	○	○	○	○
Risk mitigation	○	○	○	○	○

16. Regarding manufacturing orders, does the company’s scheduling process communicates directly with Customers and/or Suppliers?

- ○ Yes
- ○ No

17. If the previous answer was "Yes", please rate the level of efficiency of the company's scheduling system with the Customer and/or Supplier relationship.

	Very Low	Low	Medium	High	Very High
Information exchange	○	○	○	○	○
Correct information	○	○	○	○	○
Reaction to demand and lead times	○	○	○	○	○
Risk mitigation	○	○	○	○	○

Brexit/Political affairs

This section of the survey is optional to answer. It connects external industry influence with political affairs regarding the supply chain management.

18. Regarding the impact that Brexit will have on the British economy, please rate how do you believe that your company is ready to react to these issues?

	Very Bad	Bad	Medium	Good	Very Good
Readiness to risk	○	○	○	○	○
Risk mitigation	○	○	○	○	○
Responsiveness	○	○	○	○	○

19. Please outline at the most, three positive and three negative impacts you believe that Brexit will have on your company.

Appendix B

Default Report

Scheduling Software and Data Management Analyses

Q1 - Position/Role in Company:

Position/Role in Company:
Sales Administrator
Managing Director
Market Engagement Specialist
Business Line Leader - Engineering
QA / Technical Manager
Sales Manager
Head of Quality, Environmental and Health & Safety
Head of Sales
Managing Director
Administration Officer
General Manager
Managing Director
Planner
Sales Director
managing director
Solutions Manager
Director
Group Head of IT
Customer Service Manager

Sales & Marketing

MD

Q3 - Location:

Location:

Tayport, Fife, Scotland

Oakham, UK

Cambridge

Hertfordshire, United Kingdom

Hampshire

Banbury, UK

Coventry

Mostyn

Stoke-on-Trent

Belfast, Northern Ireland

Cambridgeshire

Carmarthenshire

Royston, Herts

Hyde Group Ltd Manchester

Dewsbury, West Yorkshire

Bellshill

Bognor Regis

Somerset

Reading

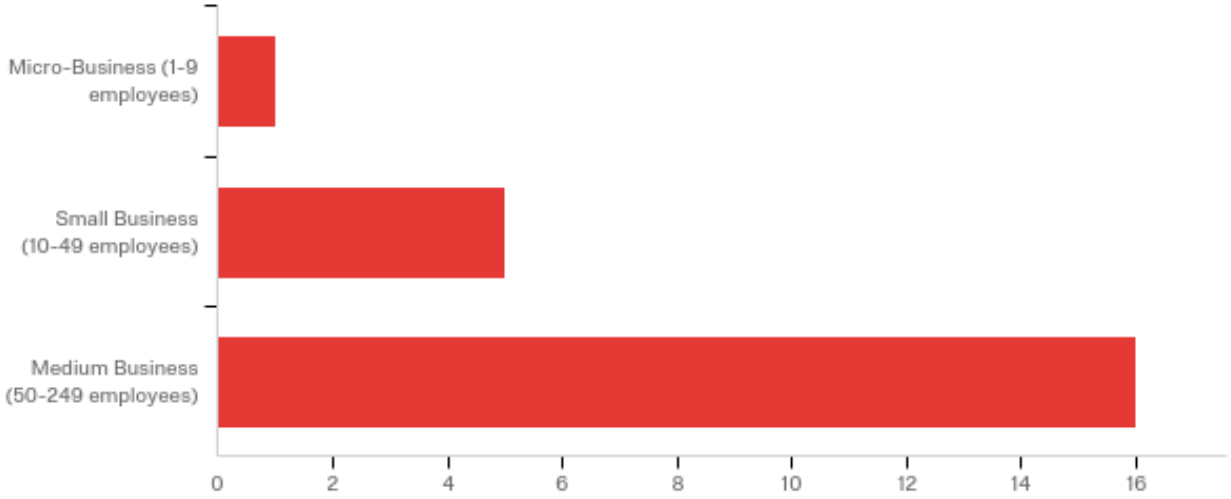
Wokingham

Ramsgate

Q4 - What type of products does your company manufacture?

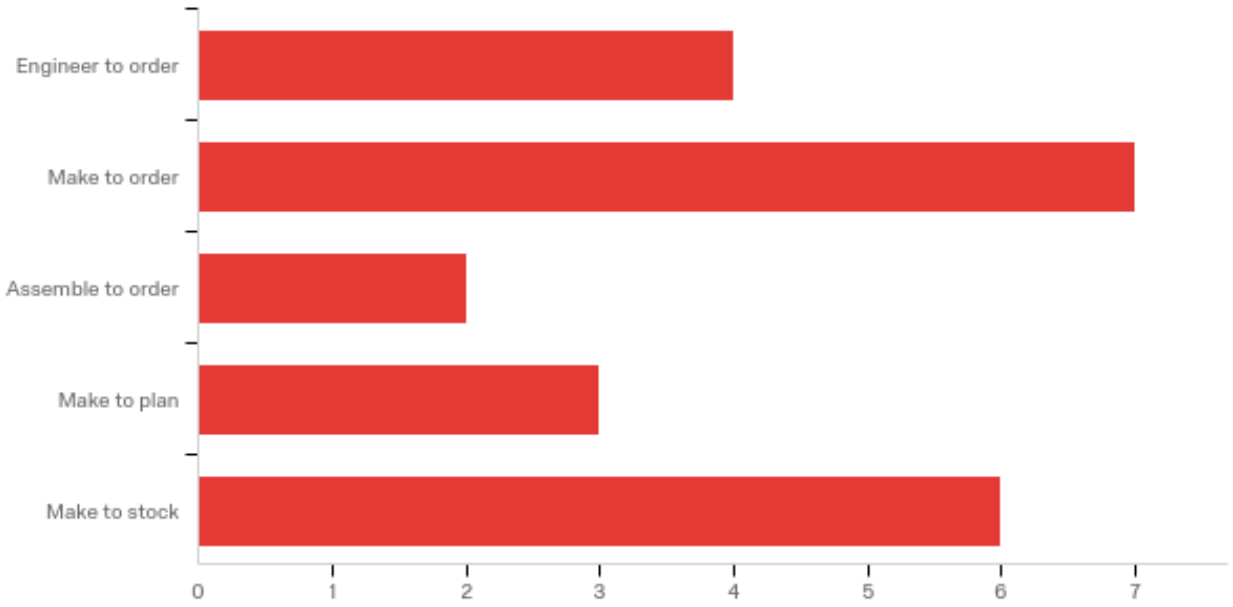
What type of products does your company manufacture?
Industrial Textiles
Varied - injection moulded
Liquid Handling, Sample Management and High Throughput Screening systems
Polymer machined components
Frozen Meats
Copper braid
Power generators
Chemicals
Ceramic clay bodies
marine vessels and structures, renewable energy devices and structures
Industrial absorbents
Pre built GRP composite Kiosks , enclosures , buildings
Aerposapce components
Tooling , SPTE, and Development Manufacture -Design and Manufacture
woven worsted fabrics
Print and Postage
Composites Parts and Assemblies
Cement additives
Thick Film Printing Inks
Rugged PC, DVR, Tracker software, Video management system
Plastics Products

Q5 - Please choose the category of your company depending on the employee number.



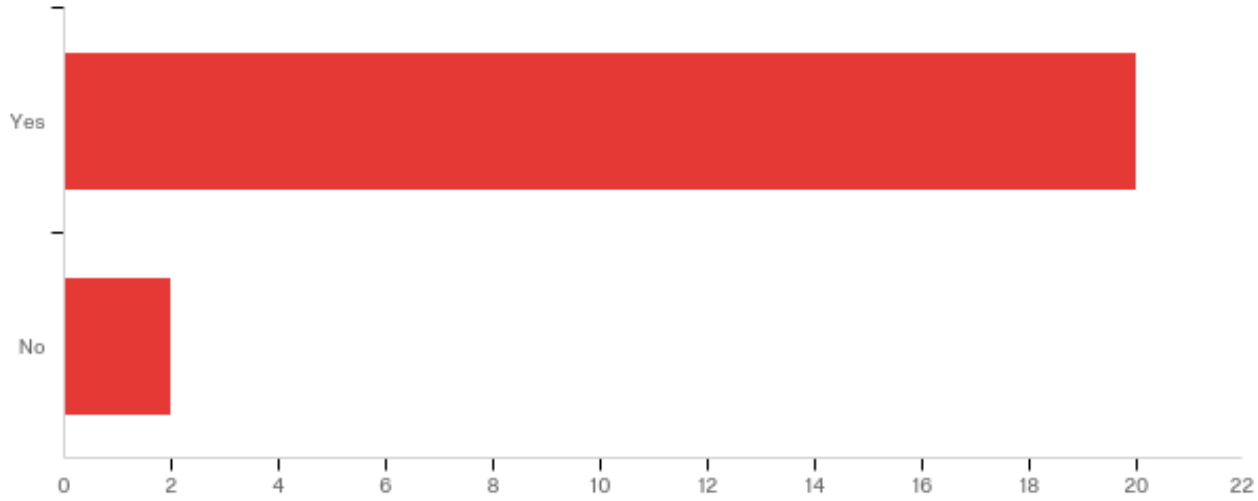
#	Answer	%	Count
1	Micro-Business (1-9 employees)	4.55%	1
2	Small Business (10-49 employees)	22.73%	5
3	Medium Business (50-249 employees)	72.73%	16
	Total	100%	22

Q6 - Please indicate the type of production strategy of your company.



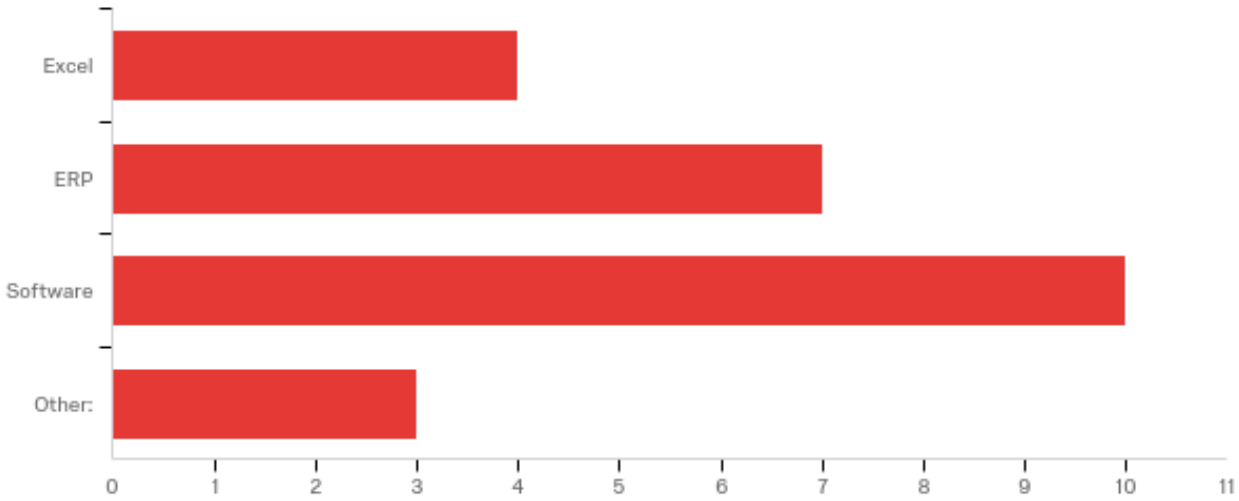
#	Answer	%	Count
1	Engineer to order	18.18%	4
2	Make to order	31.82%	7
3	Assemble to order	9.09%	2
4	Make to plan	13.64%	3
5	Make to stock	27.27%	6
	Total	100%	22

Q7 - 1. Does your company has a data management system?



#	Answer	%	Count
1	Yes	90.91%	20
2	No	9.09%	2
	Total	100%	22

Q8 - 2. Please select which data management system your company uses.



#	Answer	%	Count
1	Excel	16.67%	4
2	ERP	29.17%	7
3	Software	41.67%	10
4	Other:	12.50%	3
	Total	100%	24

Q8_4_TEXT - Other:

Other:
SAP

Q9 - 3. If the format is software or ERP, please state which one it is:

If the format is software, please state which one it is:

Epicor

Salesforce

SAP Business One

Diomac

Oracle

IFS

Sage

Saleslogix SLX

Syspro

SAP

Juno is the name (bespoke)

Shuttleworth

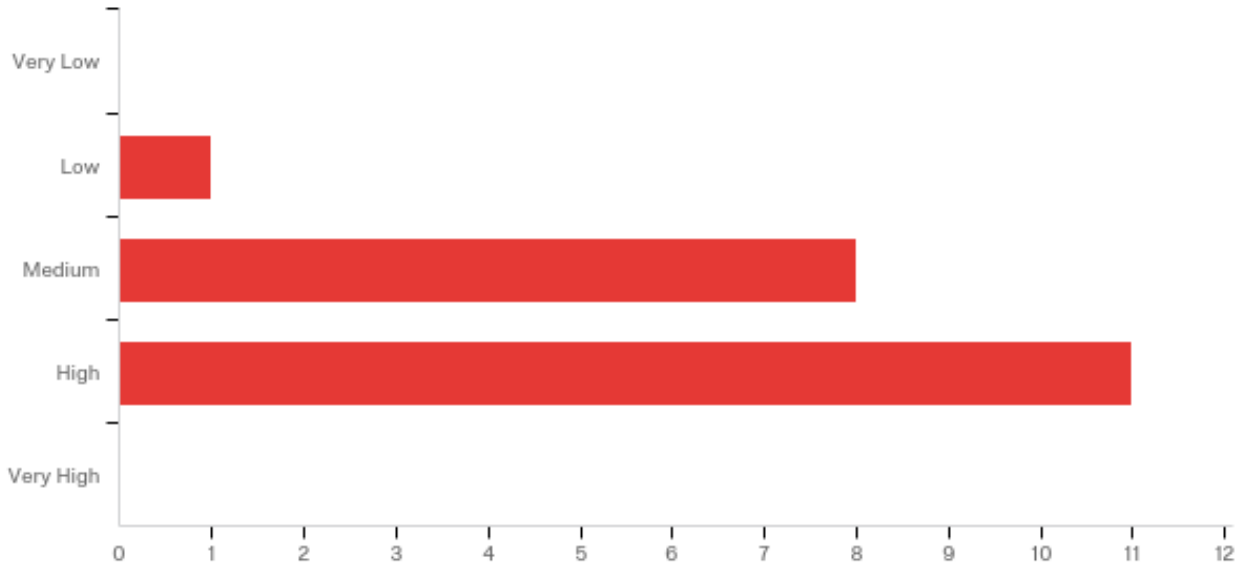
Progress Plus

Dimensions

Lake View

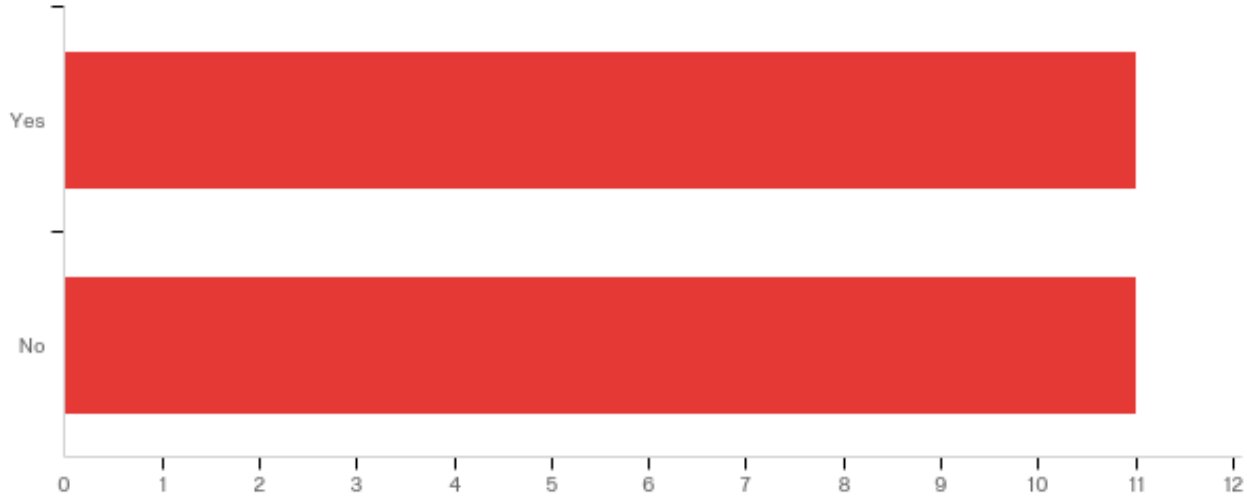
IQMS

Q10 - 4. Please rate the level of efficiency of the company's data management system on these issues.



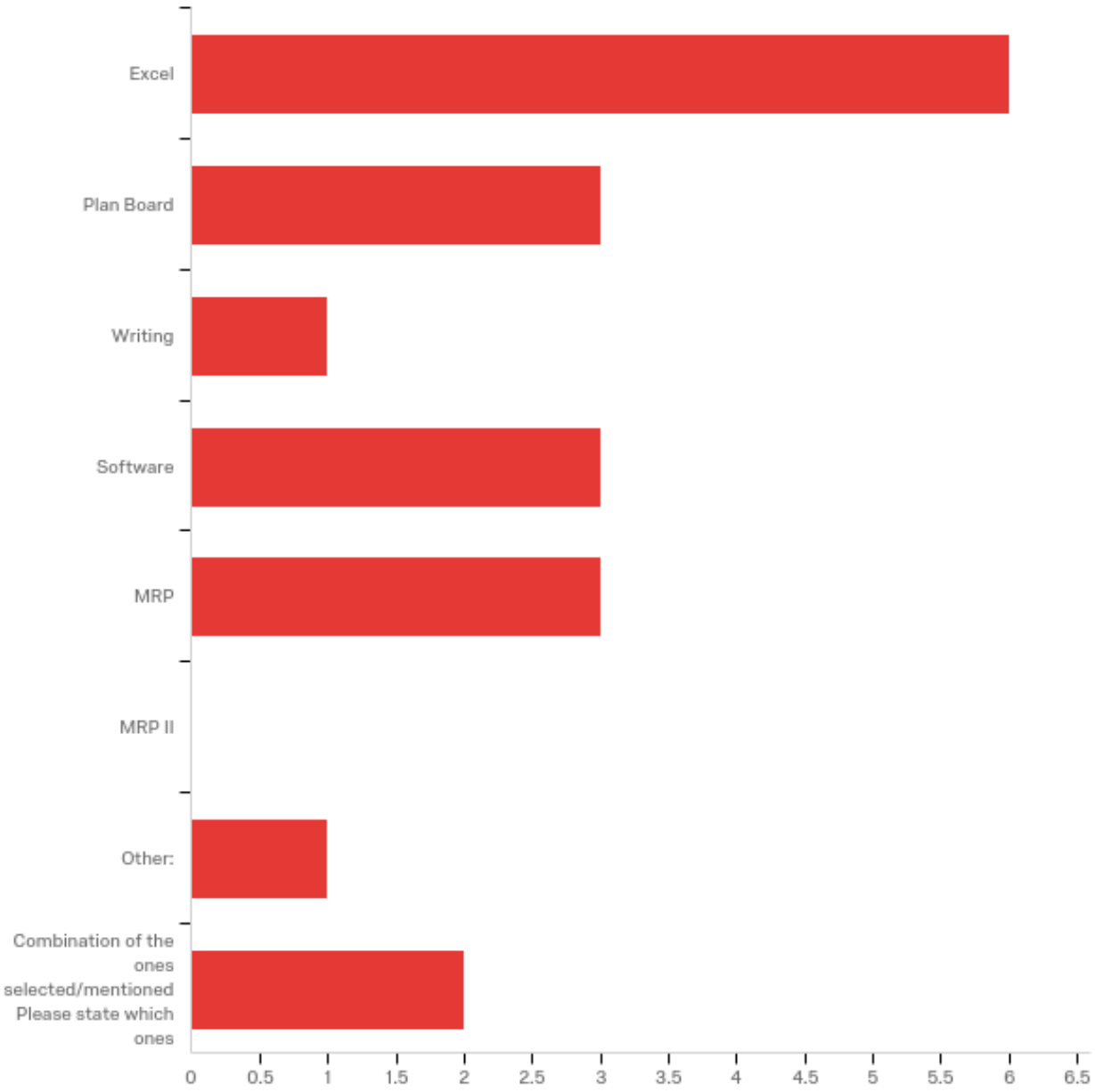
#	Answer	%	Count
1	Very Low	0.00%	0
2	Low	5.00%	1
3	Medium	40.00%	8
4	High	55.00%	11
5	Very High	0.00%	0
	Total	100%	20

Q11 - 5. Does your company has a manufacturing scheduling system/software or scheduling tools?



#	Answer	%	Count
1	Yes	50.00%	11
2	No	50.00%	11
	Total	100%	22

Q12 - 6. In which of these formats is the scheduling process done?



#	Answer	%	Count
1	Excel	31.58%	6
2	Plan Board	15.79%	3
3	Writing	5.26%	1

4	Software	15.79%	3
5	MRP	15.79%	3
6	MRP II	0.00%	0
7	Other:	5.26%	1
8	Combination of the ones selected/mentioned Please state which ones	10.53%	2
	Total	100%	19

Other:

Other:
Project

Q12_8_TEXT - Combination of the ones selected/mentioned Please state which ones

Combination of the ones selected/mentioned Please state which ones
MRP, Excel, Plan board
Excel, Syspro

Q13 - 7. If the format is software, please state which one it is:

If the format is software, please state which one it is:

Epicor

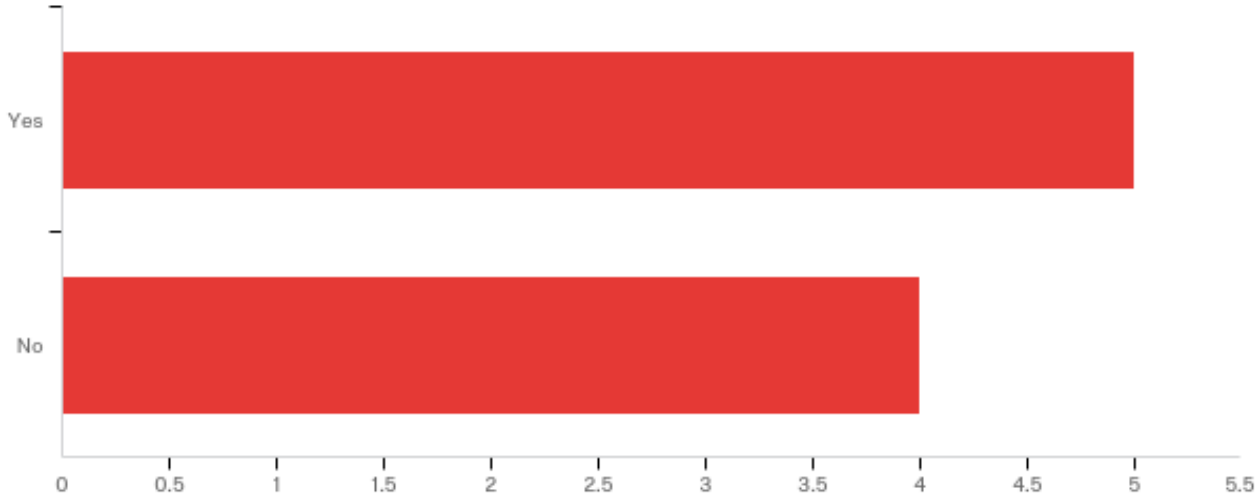
MS Project and Primavera 6

As above

SAP

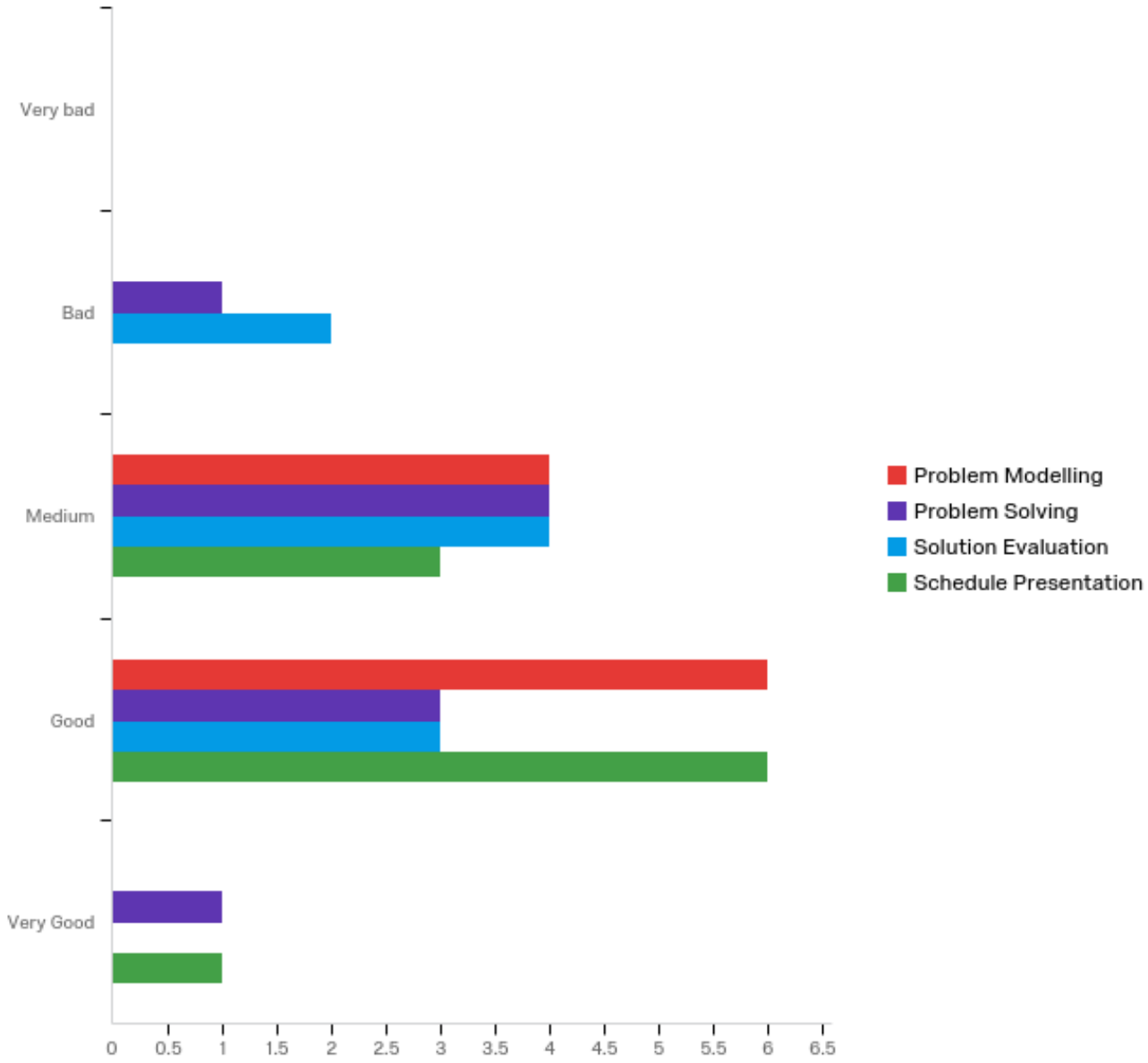
IQMS

Q14 - 8. If your company uses both a scheduling system and scheduling tools, please indicate if they "share" information.



#	Answer	%	Count
1	Yes	55.56%	5
2	No	44.44%	4
	Total	100%	9

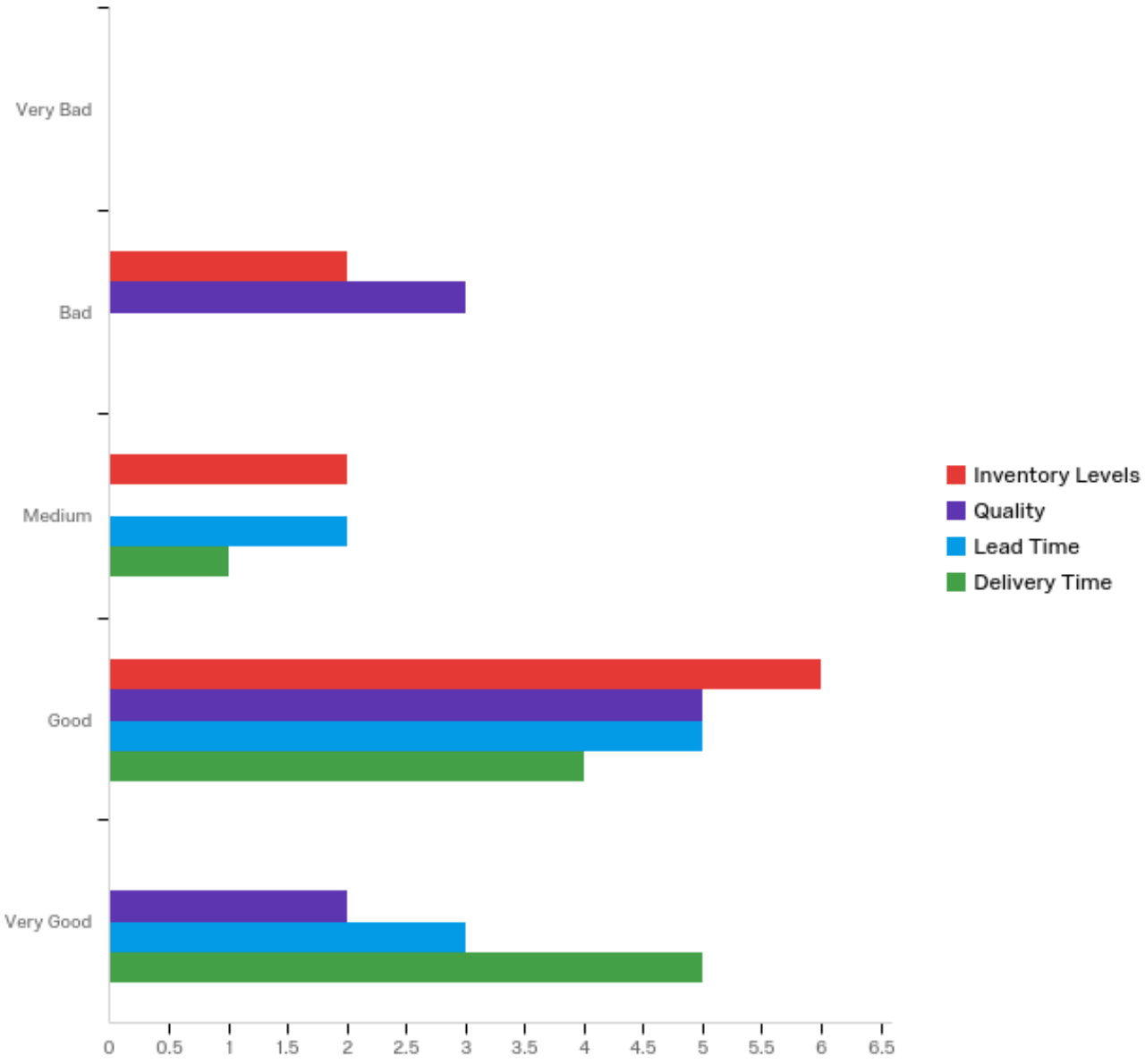
Q15 - 9. Please rate the level of efficiency of the company's scheduling system or scheduling tools in these issues.



#	Question	Very bad		Bad		Medium		Good		Very Good	
1	Problem Modelling	0.00 %	0	0.00%	0	26.67%	4	33.33 %	6	0.00%	0
2	Problem Solving	0.00 %	0	33.33 %	1	26.67%	4	16.67 %	3	50.00 %	1

3	Solution Evaluation	0.00 %	0	66.67 %	2	26.67%	4	16.67 %	3	0.00%	0
4	Schedule Presentation	0.00 %	0	0.00%	0	20.00%	3	33.33 %	6	50.00 %	1
	Total	Total	0	Total	3	Total	15	Total	18	Total	2

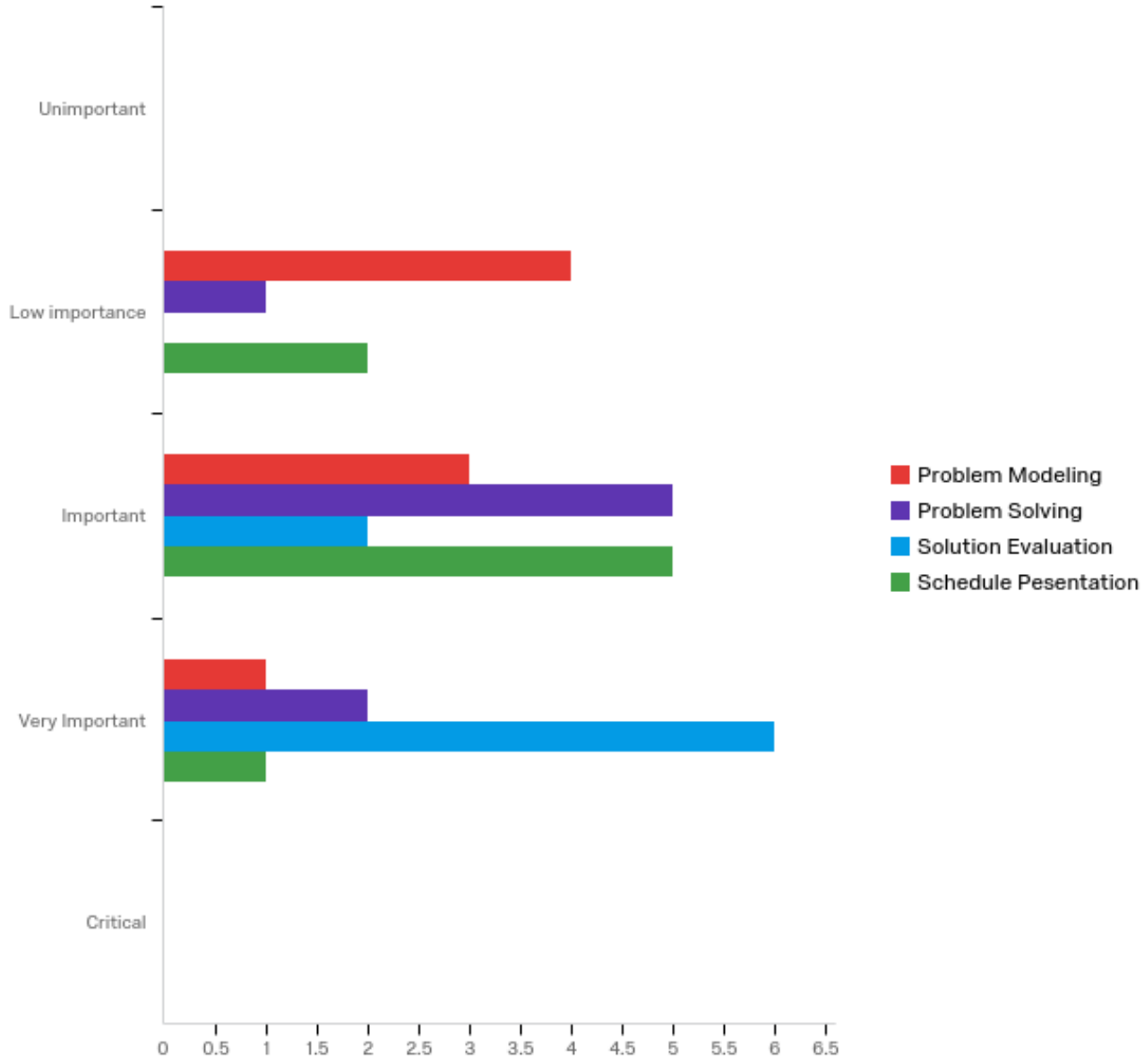
Q16 - 10. Please rate the company's scheduling system efficiency on these performance indicators.



#	Question	Very Bad		Bad		Medium		Good		Very Good	
1	Inventory Levels	0.00%	0	40.00%	2	40.00%	2	30.00%	6	0.00%	0
2	Quality	0.00%	0	60.00%	3	0.00%	0	25.00%	5	20.00%	2
3	Lead	0.00%	0	0.00%	0	40.00%	2	25.00%	5	30.00%	3

	Time										
4	Delivery Time	0.00%	0	0.00%	0	20.00%	1	20.00%	4	50.00%	5
	Total	Total	0	Total	5	Total	5	Total	20	Total	10

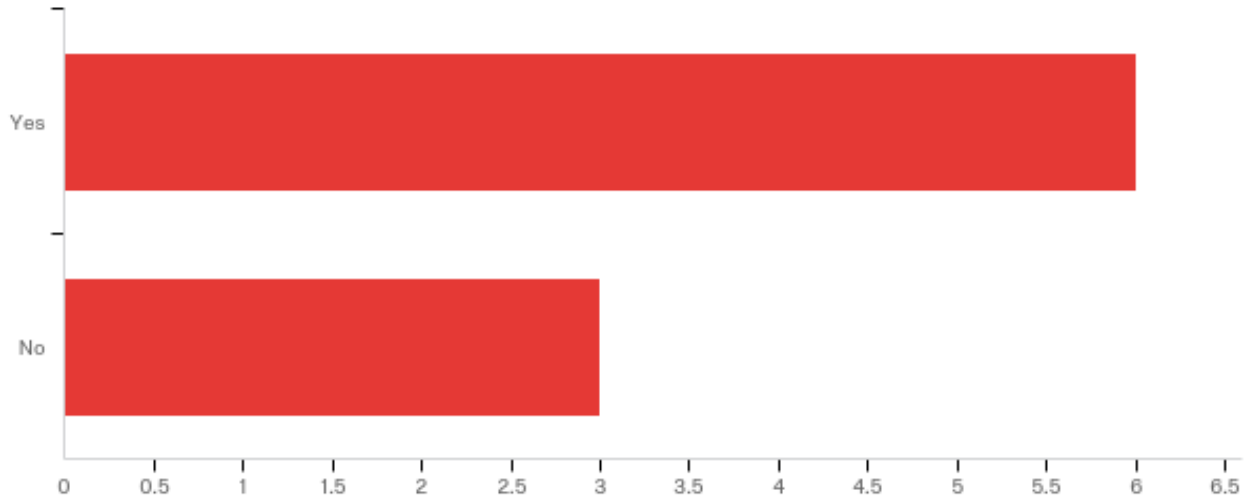
Q17 - 11. For better results in the previous indicators that were bellow "Good", what do you believe that would be the main drivers for selecting a scheduling tool? Please rate the level of importance of these categories.



#	Question	Unimportant		Low importance		Important		Very Important		Critical	
1	Problem	0.00%	0	57.14%	4	20.00%	3	10.00%	1	0.00	0

	Modeling									%	
2	Problem Solving	0.00%	0	14.29%	1	33.33%	5	20.00%	2	0.00 %	0
3	Solution Evaluatio n	0.00%	0	0.00%	0	13.33%	2	60.00%	6	0.00 %	0
4	Schedule Pesentati on	0.00%	0	28.57%	2	33.33%	5	10.00%	1	0.00 %	0
	Total	Total	0	Total	7	Total	1 5	Total	1 0	Total	0

Q18 - 12. If your company uses both a scheduling system and a data management system, please indicate if they "share" information.



#	Answer	%	Count
1	Yes	66.67%	6
3	No	33.33%	3
	Total	100%	9

Q19 - 13. Please select the level of importance of these drivers, when accepting manufacture orders.

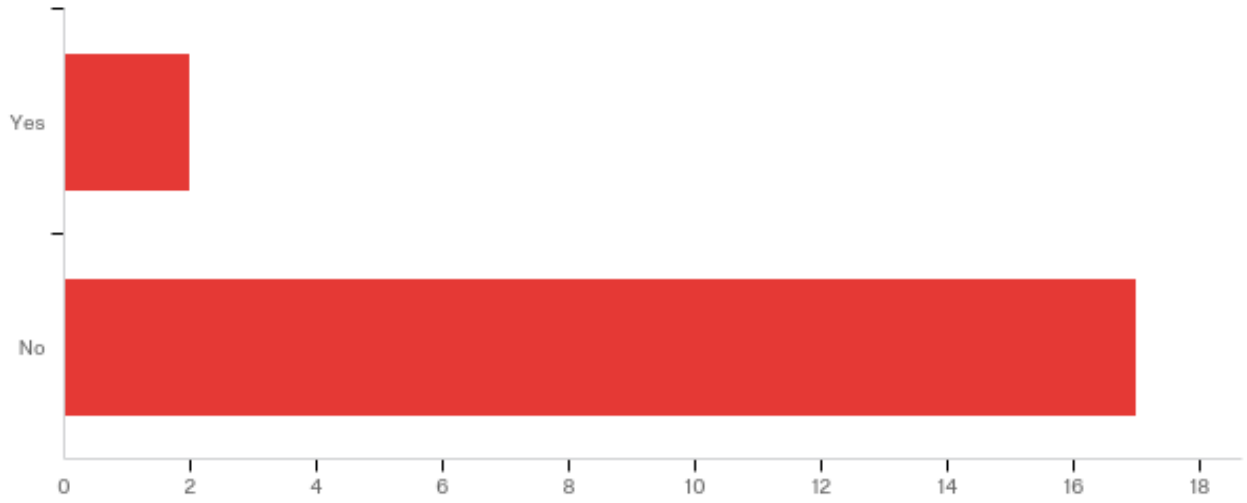
	Unimportant	Low Importance	Important	Very Important	Critical
Price		1	3	12	4
Quantity	1	1	9	8	1
Quality		1	2	12	5
Lead Time		2	11	4	5

Data source misconfigured for this visualization

Other:

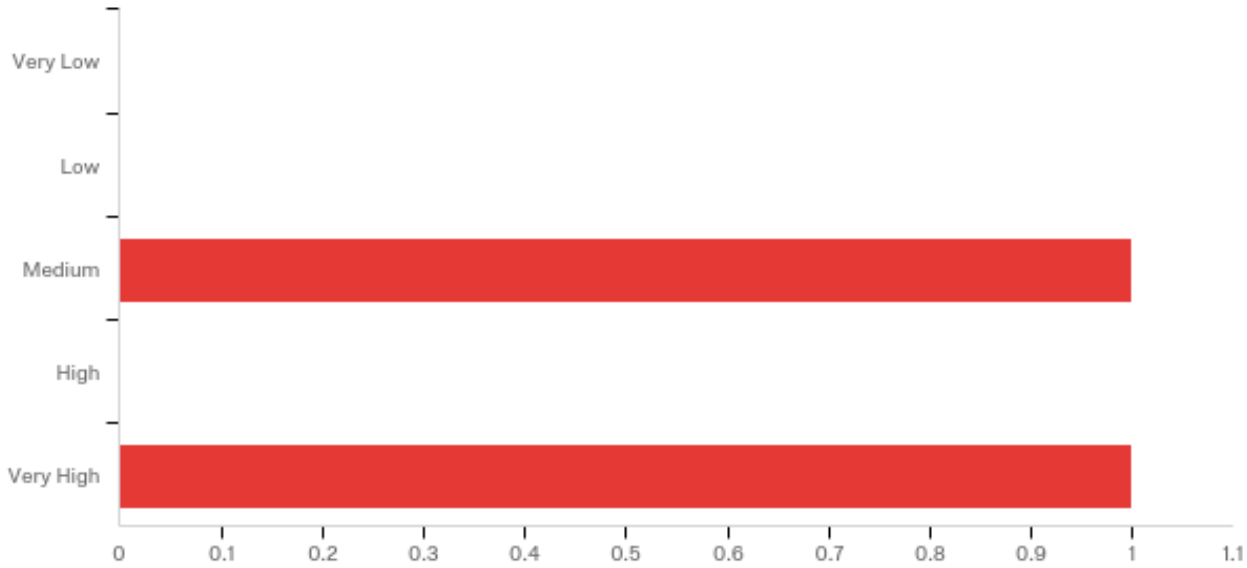
Other:

Q20 - 14. Regarding manufacturing orders, does the company's data management system communicates directly with Customers and/or Suppliers?



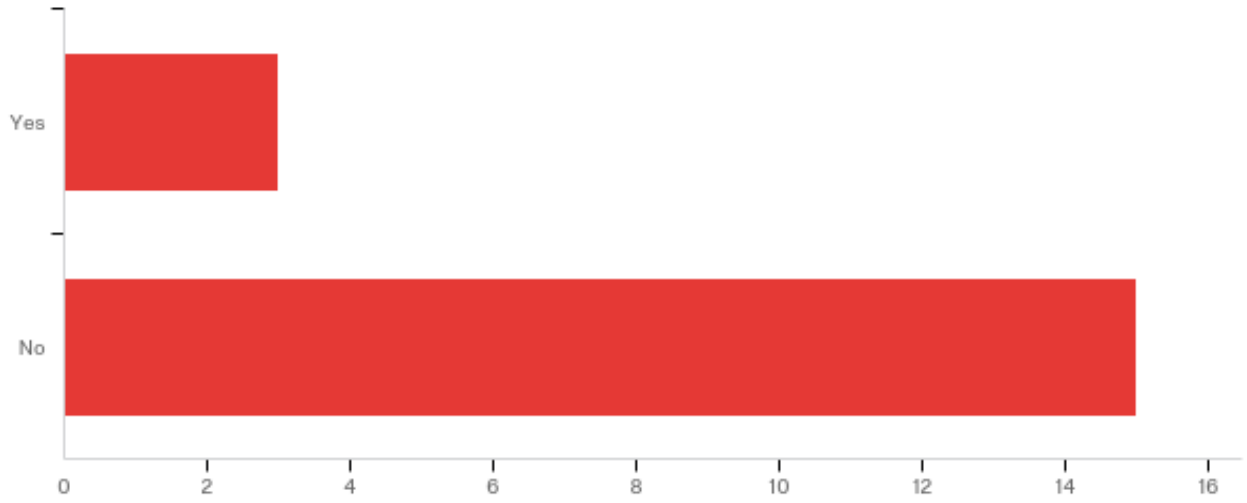
#	Answer	%	Count
1	Yes	10.53%	2
2	No	89.47%	17
	Total	100%	19

Q21 - 15. If the previous answer was "Yes", please rate the level of efficiency of the company's data management system with the Customer and/or Supplier relationship.



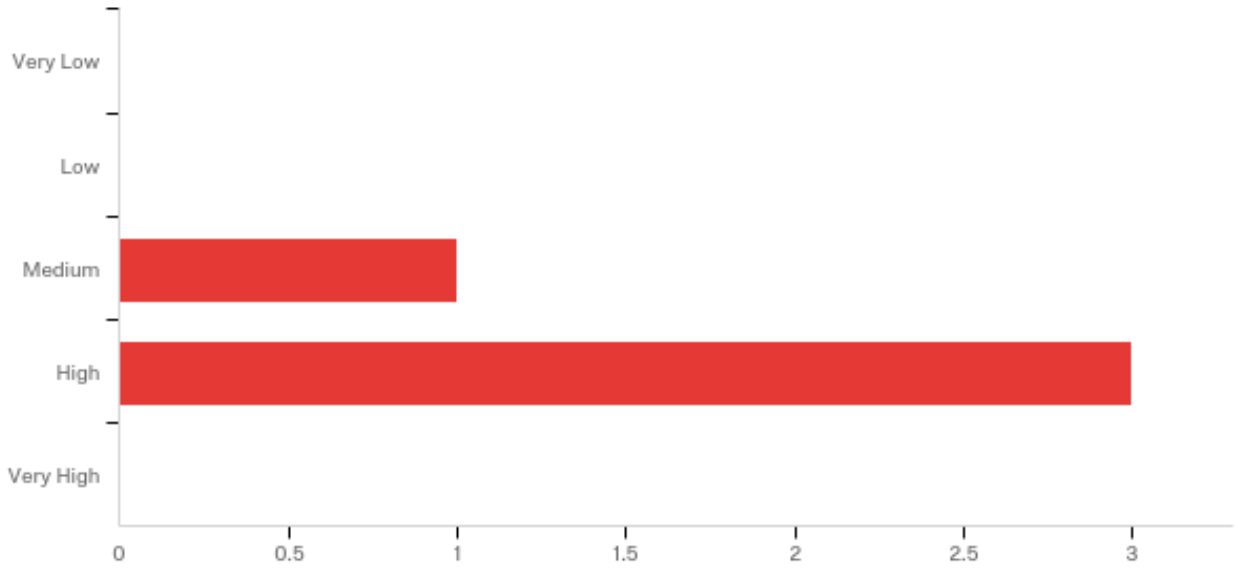
#	Answer	%	Count
1	Very Low	0.00%	0
2	Low	0.00%	0
3	Medium	50.00%	1
4	High	0.00%	0
5	Very High	50.00%	1
	Total	100%	2

Q22 - 16. Regarding manufacturing orders, does the company's scheduling process communicates directly with Customers and/or Suppliers?



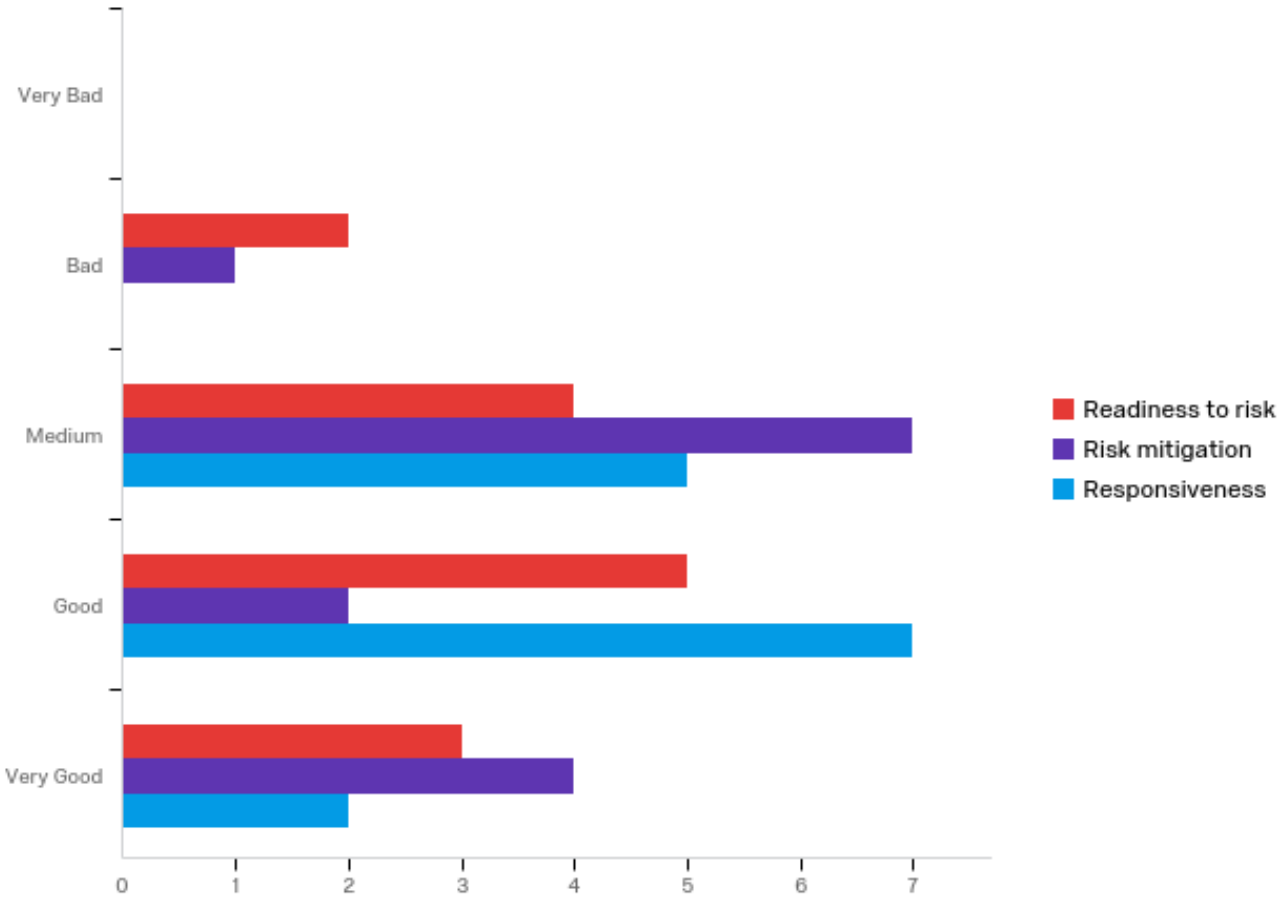
#	Answer	%	Count
1	Yes	16.67%	3
2	No	83.33%	15
	Total	100%	18

Q23 - 17. If the previous answer was "Yes", please rate the level of efficiency of the company's scheduling system with the Customer and/or Supplier relationship.



#	Answer	%	Count
1	Very Low	0.00%	0
2	Low	0.00%	0
3	Medium	25.00%	1
4	High	75.00%	3
5	Very High	0.00%	0
	Total	100%	4

Q24 - 18. Regarding the impact that Brexit will have on the British economy, please rate how do you believe that your company is ready to react to these issues?



#	Question	Very Bad		Bad		Medium		Good		Very Good	
1	Readiness to risk	0.00 %	0	66.67 %	2	25.00 %	4	35.71 %	5	33.33 %	3
2	Risk mitigation	0.00 %	0	33.33 %	1	43.75 %	7	14.29 %	2	44.44 %	4
3	Responsiveness	0.00 %	0	0.00%	0	31.25 %	5	50.00 %	7	22.22 %	2
	Total	Total	0	Total	3	Total	16	Total	14	Total	9

Q25 - 19. Please outline at the most, three positive and three negative impacts you believe that Brexit will have on your company.

21. Please outline at the most, three positive and three negative impacts y...

Negative Input price rises Positive Exporting competitiveness

negative: increased costs for buying from EU availability of workforce positive: open other trade opportunities

Positive FX rate Lower tariffs outside EU Negative Tariffs to export to EU

Negative : exchange rates : movement of raw materials through europe: general bad feeling . Positive : probable new markets:

Our work is entirely dependant on demand by all British Utility companies

European opportunity Uk focus - UK Spend Personnel for both

Positive - potential for reduced bureaucracy with extra EU markets Negative - currency volatility. Potential for increased bureaucracy within EU market.

One of the most positive/negative facts is that our company has been purchased and rather than keep us running we are being closed down and everyone is being made redundant. Whether that is a direct result of Brexit is hard to tell. Currently our company grosses around £1.4 million per month but apparently that is not enough to keep us running. Is this in relation to Brexit? I don't know.

Negative 1. Uncertainty undermines confidence to invest 2. Skilled labour reduction from Europe by alienation of our partners. 3. Importation costs rise due to current exchange rate and potential trade barriers Positive 1. Export costs lower due to current exchange rate.

Appendix C

Interview questions

1.1 - What is your position in the company?

1.2 – Number of employees?

1.3 – What is your company's strategy?

1.4 – In average, how many levels does your product bill of materials have?

2.1 – Do you have a data management system in your company?

2.2 – What type of software?

2.2.1 – Can you please give positive and negative remarks?

2.2.2 – Can you please rate the software on these categories from 1 to 5? 1 being very bad and 5 being very good:

- Level of ease
- Information exchange
- Cost reduction
- Inventory management

3.1 – Do you have a scheduling process in your company?

3.2 – What type of software or tools?

3.2.1 - Can you please give positive and negative remarks?

3.2.2 – Do the scheduling software and tools share information?

3.3 - Can you please rate the company's performance on these categories from 1 to 5? 1 being very bad and 5 being very good:

- Inventory levels
- Quality

- Lead time

3.4 – Does the data management system and scheduling system share information?

4.1 – When accepting manufacturing orders, what are the main drivers for the company?

4.2 – Does the data management system communicates directly with customers or suppliers?

4.3 – Does the scheduling system communicates directly with customers or suppliers?

5.1 – Regarding the impact that you believe that “Brexit” will have on your company, please rate from 1 to 5, 1 being very bad and 5 being very good, how you believe your company will react to these issues:

- Readiness to risk
- Risk mitigation
- Responsiveness

5.2 – Can you please indicate, at the most, 3 positive and 3 negative impacts that you believe “Brexit” will have on your company?

Appendix D

Company A

Position: Operations Manager

Number of employees: 42 (Small enterprise)

Production strategy: MTO

Type of products: Adhesive Tapes

Company B

Position: Managing Director

Number of employees: 20 (Small enterprise)

Production strategy: MTS / MTO

Type of products: Fibre Optics for Telecommunications

Company C

Position: Production Supervisor

Number of employees: 180 (Medium enterprise)

Production strategy: MTS / MTO

Type of products: Water Softener

Company D

Position: Operation Manager

Number of employees: 140 (Medium enterprise)

Production strategy: MTO / ETO

Type of products: Packaging Machines

Company E

Position: Managing Director

Number of employees: 3 (Micro enterprise)

Production strategy: MTO / ETO

Type of products: Plastic Fabrication

Company F

Position: Engineering Manager

Number of employees: 4 (Micro enterprise)

Production strategy: MTO / MTS

Type of products: Roof Racks

Company G

Position: Managing Director

Number of employees: 14 (Small enterprise)

Production strategy: MTO

Type of products: Signs

Company H

Position: Technical Sales Manager

Number of employees: 80 (Medium enterprise)

Production strategy: MTO / ETO

Type of products: Plastic Mouldings

Company I

Position: Production Manager

Number of employees: Over 300 (Large enterprise)

Production strategy: MTO

Type of products: Amplifiers and Percussion Instruments

Company J

Position: Project Manager

Number of employees: 20 (Small enterprise)

Production strategy: MTO

Type of products: Structural Steel Frames

Appendix E

Company A – Lohman Technologies

Position: Operations Manager

Number of employees: 42 (Small enterprise)

Production strategy: MTO

Type of products: adhesive tapes

Data management

ERP: Sage system

Positive: levels of stock accuracy; good at batches traceability.

Negative: system needs to be updated (the company grew) realizes that the system needs to be updated; slow; loses data between account package (sales orders) and manufacturing package, – bad management reports. Runs slowly when MRP is being run.

Scheduling

Used preactor software for a few months

negative: wasn't fast enough to cope with changes. Because of the nature and speed of the business, employed a person just for do the scheduling

started than to use excel sheet for the more lengthiest jobs, found out that it would be easier to just send orders directly to the shop floor, they would sequence them by due date.

MRP

Negative: not many transparency in the company, if someone needs information they have to talk with operators, have a look, hard to know how production "is".

MRP – gives make or by (production and manufacturing orders); sends information to shop floor;

KPI

Inventory: 3

Quality: 3

Lead time: 4

Share information

MRP and sage share information

Customer/supplier

Manufacturing orders: Lead time

Contact: phone or email

Brexit

Readiness to risk: 5

Risk mitigation: 5

Responsiveness: 3

Negative: exchange rate, uncertainty.

Positive: none.

Company B - Opti fab international

Position: managing director

Number of employees: 20 (Small enterprise)

Production strategy: MTS / MTO

Type of products: fibre optics – for telecommunications

Data management

ISO

Positive: it has been design specifically for the company's requirements, so it runs perfectly

Negative: none.

Scheduling

Kanban system

Positive:

Negative: Not accurate for full cost for new products. Cost based in historic events (done by ISO)

Share information

ISO and Kanban system shares information

KPI

Inventory: 5

Quality: 5

Lead time: 5 (fixed times)

Customer/supplier

Manufacturing orders: none

Contact: phone or email

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 4

Negative: unit costs might increase if the EU inflicts a duty

Neutral: Company has customers outside Europe

Positive: the UK won't just simply stop selling, since it is a wide nation, meaning that lots of products are exported for dependent countries.

Company C - Harvey water softeners

Position: production supervisor

Number of employees: 180 (Medium enterprise)

Production strategy: MTS / MTO

Type of products: water softener

BOM: 250 components

Data management

FileMaker

Level of ease: 4

Information exchange: 4

Cost reduction: -

Inventory management: 4

Positive: easy to use,

Negative:

Scheduling

Kanban system (Tickets done manually), by excel sheet (done by the company)– based on sales forecast – gives production in order to refill the stock

Positive: good transparency, inventory management (“live feed”) traceability

Neutral: gantt chart used in other parts of the company

Negative: slow process (manually)

Share information

Excel gets production orders from filemaker

KPI

Inventory: 4

Quality: 4

Lead time: 3

Customer/supplier

Manufacturing orders: lead time, quality

Contact: phone call or email

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 5

Negative:

Neutral:

Positive:

Company D - Atlas converting

Position: operation manager

Number of employees: 140 (Medium enterprise)

Production strategy: ETO / MTO

Type of products: packaging machines

BOM: 4 levels

Data management

ERP: IFS

Level of ease: 4

Information exchange: 4

Cost reduction: 4

Inventory management: 4

Positive: it’s a benefit

Neutral: early stage of implementation (took 1 year to install, been running for 1 year)

Negative:

Scheduling

Excel sheet

Positive:

Neutral: trying to connect ERP with scheduling

Negative: manually, takes time, prone to mistakes

Share information

KPI

Inventory: 5

Quality: 5

Lead time: 3 (the ones that are ETO)

Customer/supplier

Manufacturing orders: risk, cost

Buying and selling (25% supplier): ERP(IFS)

Contact (Customer): phone or email, fax

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 4

Negative: exchange rate (the company is a big exporter and importer)

Positive: other customers

Company E - Plastic systems

Position: managing director

Number of employees: 3 (Micro enterprise)

Production strategy: MTO / ETO

Type of products: plastic fabrication

BOM: 5 levels

Data management

no

Scheduling

No scheduling system

Positive: no need since it is a small business

KPI

Inventory: 4

Quality: 5

Lead time: 4

Customer/supplier

Manufacturing orders: lead time, cost

Contact (Customer): phone or email, fax

Brexit

Readiness to risk: 5

Risk mitigation: 4

Responsiveness: 4

Negative: losses of foreign labour

Neutral: believes that it will not have any impact

Positive:

Company F - Hogarth engineering

Position: Engineering manager

Number of employees: 4 (Micro enterprise)

Production strategy: MTO / MTS

Type of products: roof racks

BOM: 100 components

Data management

Scheduling

Note board

Positive: everyone can see

Neutral:

Negative:

Share information

KPI

Inventory: 4

Quality: 5

Lead time: 4

Customer/supplier

Manufacturing orders: quantity (low number), price

Contact (Customer):

Brexit

Readiness to risk: 4

Risk mitigation: 5

Responsiveness: 5

Negative: none

Neutral:

Positive: open up no markets

Company G – Signs Express

Position: Managing director

Number of employees: 14 (Small enterprise)

Production strategy: MTO

Type of products: signs

BOM: 3 components

Data management

Excel sheet

Level of ease:

Information exchange:

Cost reduction:

Inventory management:

Positive: easy to access

Neutral: a lot of data to handle in the company (cannot use cloud)

Negative: doesn’t a handle all the data (to much)

Scheduling

Sign lab / White board

Positive: ease to see (white board)

Neutral:

Negative: clash between manually and electronic, electronic - not accessible to the hole company, only in computer screen; Manual – time consuming

Share information

Done manually

KPI

Inventory: 3

Quality: 4

Lead time: 4

Customer/supplier

Manufacturing orders: time, price

Contact: phone, email

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 4

Negative: believes that there will be a recession, harder to find labour, prices are gonna go up

Neutral:

Positive:

Company H - Midas Pattern

Position: technical sales manager

Number of employees: 80 (Medium enterprise)

Production strategy: MTO/ETO

Type of products: plastic mouldings

BOM: 10 levels

Data management

Excel sheet

Level of ease:

Information exchange:

Cost reduction:

Inventory management:

Positive:

Neutral:

Negative:

Scheduling

Excel sheet – the company does low number of products but in high mix

Positive: simple to use, only managed by one person, jobs allocation

Neutral: MRP would be to complicate

Negative: prone to mistakes

Share information

Done manually

KPI

Inventory: 4

Quality: 5

Lead time: 4

Customer/supplier

Manufacturing orders: price, quality

Contact: email. phone

Brexit

Readiness to risk: 3

Risk mitigation: 3

Responsiveness: 4

Negative: may lose European staff, trade deals (depends on what they negotiate)

Neutral: the company trades globally

Positive:

Company I - Marshall Amplification

Position: production manager

Number of employees: over 300 (Large enterprise)

Production strategy: MTO

Type of products: amplifiers, percussion instruments

BOM: 8 levels

Data management

Yes – doesn't know which one (not ERP)

Positive: easy to manage data, helps to make decisions

Neutral:

Negative:

Scheduling

MRP

Positive: good manufacturing control from raw material to final product

Neutral:

Negative: if BOM not correct it can cause problems down the line

Share information

Manually

KPI

Inventory: 4

Quality: 5

Lead time: 4

Customer/supplier

Manufacturing orders: quantity, price, quality

Contact: email, phone

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 4

Negative:

Neutral: no comment

Positive:

Company J - Tubular Erectors

Position: project manager

Number of employees: 20 (Small enterprise)

Production strategy: MTO

Type of products: structural steel frames

BOM: 10-300 components

Data management

Excel sheet

Level of ease:

Information exchange:

Cost reduction:

Inventory management:

Positive: easy to access

Neutral:

Negative: out dated

Scheduling

Microsoft project – gant charts

Positive: familiar, easy to use

Neutral: trying to implement a new system – Easyprojects (going to use soon)

Negative: limited to one user

Share information

manually

KPI

Inventory: 4

Quality: 5

Lead time: 4

Customer/supplier

Manufacturing orders: quality, lead time

Contact: email

Brexit

Readiness to risk: 4

Risk mitigation: 4

Responsiveness: 3

Negative: prices will go up, transportation costs, availability of materials

Neutral:

Positive: materials quality will go up, easy to get British labour, work may increase do to not having access to European work.