The Applicability and Impact of Enterprise Resource Planning (ERP) Systems: Results from a Mixed Method Study on Make-To-Order (MTO) Companies

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Abstract

The effect of a Make-To-Order (MTO) production strategy on the applicability and impact of Enterprise Resource Planning (ERP) systems is investigated through a mixed method approach comprised of an exploratory and explanatory survey followed by three case studies. Data on Make-To-Stock (MTS) companies is also collected as a basis for comparison. The exploratory data demonstrates, for example, that MTO adopters of ERP found the system selection process more difficult than MTS adopters. Meanwhile, a key reason why some MTO companies have not adopted ERP is that it is perceived as unsuitable. The explanatory data is used to test a series of hypotheses on the fit between decision support requirements, ERP functionality, and company performance. In general, a poor fit between the decision support requirements of MTO companies and ERP functionality is identified, although certain modules can lead to performance improvements – most notably for Customer Enquiry Management (CEM). MTS companies make more use of planning tools within ERP systems, and it is concluded that production strategy is an important contextual factor affecting both applicability and impact. Follow-up cases with two MTO adopters and one MTO non-adopter develop a deeper understanding of the survey results. For example, in one adoption case, a system was rented to minimise the consequences of making a poor selection decision. Future research could explore how more MTO-specific planning concepts can be embedded within ERP systems to improve alignment.

Keywords: *Enterprise Resource Planning (ERP) systems; Make-To-Order (MTO); Mixed method study; Survey; Case study.*

1. Introduction

Many vendors of Enterprise Resource Planning (ERP) systems claim that their software is universal − configurable to the needs of any business. Yet the academic literature suggests that contextual factors, such as company size (e.g. Mabert et al., 2003; Muscatello et al., 2003; Snider et al., 2009) and location or nationality (e.g. Olhager & Selldin, 2003; Morabito et al., 2005; Argyropoulou et al., 2007), play important roles in the system selection and adoption process. The production strategy of a company is also likely to be influential (Aslan et al., 2012). For example, whether a company is a low-volume/high-variety Make-To-Order (MTO) producer or a high-volume/low-variety Make-To-Stock (MTS) producer may have a significant bearing on its internal decision making processes and, therefore, on any functionality it requires from an ERP system. Although the applicability of ERP systems to MTO companies has been questioned (e.g. Bertrand & Muntslag, 1993; Stevenson et al., 2005; Aslan et al., 2012), the empirical research which investigates this is limited (e.g. Deep et al., 2008). Deep et al. (2008) conducted a case study on the ERP selection process by a MTO company and concluded that more research is required to assist firms in determining the applicability of ERP. In addition, the impact of ERP on MTO company performance has not been investigated. Hence, even for those companies that have adopted ERP, research is needed to identify the extent to which adoption has had a positive impact on performance. Most recently, Aslan et al. (2012) presented a literature review on the applicability of ERP systems to MTO companies – this questioned the fit between ERP systems and MTO company requirements before the authors outlined a future research agenda, including gathering empirical evidence on the applicability and impact of ERP systems on MTO companies.

We take a contingency-based approach (e.g. Drazin & van de Ven, 1985; Sousa and Voss, 2008) to investigate the effect of a MTO production strategy on the applicability and impact of ERP systems through a mixed method study, consisting of an exploratory and explanatory survey followed by three case studies. Thus, we provide empirical evidence which responds to the research agenda outlined by Aslan et al. (2012). While our primary focus is on MTO companies, we also include MTS firms in our survey frame as a basis for comparison. Furthermore, we include both ERP adopters and non-adopters. Although non-adopters tell us very little about the impact of ERP, they are important for understanding applicability. Despite this, many previous studies have neglected non-adopters – for example, they represented only 16% of respondents in Olhager & Selldin (2003), while Stratman (2001) focused exclusively on ERP adopters.

We take a detailed and systematic approach to assessing the applicability and impact of ERP systems by examining the fit between the decision support requirements of MTO companies and specific ERP modules and add-ons, e.g. for Supply Chain Management (SCM). In doing so, we also build on Bendoly & Jacobs' (2004) study on the alignment of ERP solutions with operational needs. The authors showed that overall company performance/satisfaction becomes weaker if the operational strategy of a firm is misaligned with its ERP adoption strategy, but they did not identify which modules within ERP solutions show adequate fit with which operational needs. Moreover, the functionality of ERP systems has continued to evolve since Bendoly & Jacobs' (2004) study meaning it is important to take an up-to-date view of the current fit between ERP functionality and company requirements.

In the next section of this paper – Section 2 – we seek to align decision support requirements with the functionality of ERP systems by using the literature to identify the key planning and control stages of relevance to MTO companies. For example, one planning and control stage is the Customer Enquiry Management (CEM) stage where a due date (or lead time) and price are quoted. This suggests certain decision support requirements, e.g. support for due date setting. We also use the literature to identify key ERP modules and add-ons that are potentially helpful. For example, decision making at the customer enquiry stage may be aided by product configurator or CEM software. Section 3 builds a theoretical framework based on three constructs – company decision support requirements, ERP functionality, and company performance – and uses these to develop a set of hypotheses. The research method is described in Section 4 before Section 5 presents the results of the survey, including the results of testing the hypotheses to assess the applicability of ERP system functionality to MTO companies and the impact of ERP systems on company performance. Three follow-up case studies are then presented in Section 6 to dig deeper into the survey findings. Two of the cases are MTO adopters of an ERP system, the other is a MTO non-adopter. Finally, conclusions are drawn in Section 7, where the limitations of the study are also acknowledged and future research directions suggested.

2. Literature Review

Sections 2.1 to 2.5 below do the following: (i) define the five key planning stages of relevance to MTO companies (see e.g. Stevenson et al., 2005; Land & Gaalman, 2009; Aslan et al., 2012), thereby identifying the key decision support requirements of MTO companies; and, (ii) link these requirements to the functionality of ERP systems and add-ons. This approach is in accordance with the concept of fit (Drazin & van de Ven, 1985; Venkatraman, 1989), which is conceptualised in the contingency theory literature (e.g. Sousa & Voss,

2008). In addition, decision support requirements and ERP functionality for Customer Relationship Management (CRM) and Supply Chain Management (SCM) tasks are outlined in Section 2.6. Note that generic aspects like financial modules are ignored as we assume that production strategy would not affect whether a firm is able to use or benefit from such functionality. Finally, Section 2.7 provides an assessment of the literature and presents our core research question. For a more comprehensive review of the literature on MTO companies and ERP, see Aslan et al. (2012).

2.1 MTO Requirements and ERP Functionality for Customer Enquiry Management

The CEM stage is where a customer provides an invitation-to-tender for a particular product to prospective suppliers, requiring the determination of a price and due date. This may involve the estimation of lead times, the archiving and retrieval of product data, the assessment of available design/production skills and facilities, the estimation of costs/profit margins, and require effective coordination and communication between departments (e.g. Hendry & Kingsman, 1993; Kingsman et al., 1996; Cakravastia & Nakamura, 2002; Zorzini et al., 2008). This is a key planning stage for MTO companies as orders can vary greatly from one to the next, hence standard or default lead times cannot be quoted (Kingsman & Hendry, 2002).

According to the literature, there are potentially four aspects of ERP functionality that are relevant to the CEM stage. First, the CEM tools contained in many ERP systems have been used by MTO companies for entering orders and automating certain transactions (Xiong et al., 2006). In addition, Available-To-Promise (ATP) and Capable-To-Promise (CTP) functionality may be used. ATP determines the amount of 'uncommitted' finished goods inventory available, and CTP identifies slack capacity after available capacity has been matched to committed orders (Ball et al., 2004). Finally, Product Lifecycle Management (PLM) software combines estimating and product development with a product database to enable a company to bring innovative products to market effectively (Møller, 2005). PLM software has been shown to have promise for helping manufacturers of highly customised products (Hicks & McGovern, 2009), but there remains doubt about how effective it can be when enquiries/products are truly bespoke and lifecycles extremely short.

2.2 MTO Requirements and ERP Functionality at the Design & Engineering Stage

This stage is where detailed design & engineering planning takes place. It is of particular relevance to Engineer-To-Order (ETO) companies – which we consider to be 'extreme cases' of a MTO strategy – yet little research has been conducted into this stage despite its impact on the total lead time (Land & Gaalman, 2009). Wortmann (1995) highlighted an ability to

document aspects of product development throughout the order processing cycle as a key feature required from an ETO-compliant system. In addition, Rudberg & Wikner (2004) indicated that forecasting and order fulfilment mechanisms are needed when designing and specifying products.

At this stage, both product configurator (or variant generator) and, again, PLM software may be relevant. PLM software was briefly discussed above, hence the following focuses on product configurator software. Product configurator software is described as combining well-defined building blocks governed by rules and constraints into a product (Hvam et al., 2006). Olsen & Sætre (2007) conducted an action research project to identify an appropriate ERP system for a growing ETO company. A suitable system could not be found, with a key reason being the degree of product customisation offered by the company at the design & engineering stage. A vendor offered to provide product configurator software, but the company developed its own in-house solution. In Deep et al.'s (2008) case study, product configurator software was similarly judged as ineffective for the firm's bespoke production activities.

2.3 MTO Requirements and ERP Functionality at the Order Entry Stage

The order entry stage is where the production of a confirmed order is planned, including material requirements, purchasing and shop floor routing. Here, the ability to incorporate the effect of forecasts on actual plans is essential, given that many MTO companies deal with a mix of not only repeat but also one-off orders (Knolmayer et al., 2002; Deep et al., 2008). It is also essential to plan capacity, taking into account any constraints to ensure due dates are feasible. In some cases, it may be necessary to renegotiate due dates with customers, particularly if there has been a delay between the bid being made and the order being confirmed (Stevenson et al., 2005). In addition, ETO firms may require project management techniques, e.g. if the majority of orders are for large scale orders (Bertrand & Wortmann, 1992; Bertrand & Muntslag, 1993; Knolmayer et al., 2002).

MRP and Advanced Planning and Scheduling (APS) functionalities are potentially relevant at the order entry stage; however, Stevenson et al. (2005) argued that the former – MRP – does not provide sufficient support in a MTO context. The latter – APS software – overcomes some of the shortcomings of Manufacturing Resource Planning (MRP II) and uses hierarchical planning principles to analyse company and supply chain planning and scheduling problems (Stadtler and Kilger, 2002). Deep et al. (2008) found APS to be relevant to their MTO case company due to its capacity management structure and analytical planning functionality, although the authors did not explicitly discuss its fit with the order entry stage.

2.4 MTO Requirements and ERP Functionality at the Order Release Stage

Order release is a decoupling phase at which a company decides when to start production, i.e. when to release a job to the shop floor. Further planning and control may be needed here to ensure sufficient capacity is available to allow jobs to be released in time to meet their due dates. The need to control this stage was identified by Wight (1970) to avoid the 'untimely' release of jobs, which can result in a 'vicious cycle' of work-in-process accumulation known as the lead time syndrome (Mather & Plossl, 1978). This stage has received far more attention in the literature than the preceding stages (e.g. Wisner, 1995; Bergamaschi et al., 1997).

Breithaupt et al. (2002) reported that the order release mechanism of load-oriented manufacturing control (see Bechte, 1988) was previously included in the SAP R/2 system and the systems of some domestic ERP vendors in Germany. However, to the best of our knowledge, contemporary ERP systems do not contain this mechanism and no further information on this is available in the literature. Hence, it remains unclear what functionality is available to support order release. Such a decoupling stage may not be required in standardised production environments – hence this planning and control stage may not be explicitly addressed within the design of contemporary ERP systems.

2.5 MTO Requirements and ERP Functionality at the Shop Floor Dispatching Stage

At this stage, a detailed shop floor schedule is determined and jobs are sequenced on the shop floor. This is a well-researched area for which many algorithms have been developed and reviews published (e.g. Blackstone et al., 1982; Błażewicz et al., 1996). In MTO companies – which often operate as job shops with high routing variability – detailed scheduling can be complex as, for example, it can be difficult to predict the arrival times of jobs at particular machines. Hence, some authors have argued that simple sequencing rules (e.g. first-in-first-out) may be preferred with control left to highly skilled labour, particularly if the preceding planning stages are appropriately executed (Kingsman, 2000).

It seems reasonable to assume that APS functionality is potentially relevant to MTO companies for scheduling orders on the shop floor. However, from Kingsman's (2000) argument above it follows that dispatching may be the least important stage in the planning and control hierarchy for MTO companies. Jonsson & Mattsson (2003) agreed with this, but also suggested implementing a 'dispatching list' method, where advised priorities are given to the shop floor. On planning for the use of capacity at the dispatching level, Tenhiälä (2011) concluded that rough-cut methods – as featured in many ERP systems – can be used by

companies utilising job-shop environments (i.e. MTO and ETO companies). Moreover, MRP functionality may also be relevant to shop floor dispatching (Aslan et al., 2012).

2.6 MTO Requirements and ERP Add-ons for SCM and CRM

Many MTO companies operate towards the upstream end of supply chains, serving large customers at short notice (Stevenson et al., 2011). As a result of the typical supply chain positioning and leverage of MTO companies, short-notice requests are commonplace. This requires responsive supply chain practices, including in purchasing, and a system capable of handling rush orders. Many ERP systems offer SCM add-ons which facilitate information integration with supply chain partners, aiding cost reduction and both improved efficiency and relationships (Davenport & Brooks, 2004), but further research is needed to assess the effectiveness of SCM add-ons for MTO companies.

The one-off nature of some MTO production means companies have a wide customer base and are constantly negotiating contracts with new and existing customers. CRM software – which focuses on customer needs, incorporating sales & distribution and service applications to retain and develop existing relations and explore new customers (Chen, 2001) – may help MTO companies develop longer term relationships with customers and increase their order winning performance. However, there is no evidence in the literature on the effectiveness of CRM add-ons for such purposes.

2.7 Assessment of the Literature

The above review has identified the key planning and control stages and decision support requirements of relevance to MTO companies and the functionality of ERP systems and add-ons potentially useful at each stage, as summarised in Table 1. The table also serves as a glossary for the majority of acronyms used throughout this paper.

[Take in Table 1]

Bendoly & Jacobs (2004) highlighted the importance of aligning an ERP system with operational needs. More recently, Tenhiälä (2011) investigated this fit in terms of capacity planning from a contingency-based view, yet few studies have explored the fit between a MTO production strategy and ERP functionality. The study by Deep et al. (2008) provided a starting point but focused on one company only and on applicability – it therefore lacked generality and did not consider the impact of ERP. Hence, further research is required to improve our understanding of the applicability and impact of ERP systems in the context of MTO companies. In particular, it is argued here that detailed research is required which

investigates which modules within ERP solutions show adequate fit with which operational needs.

In response, the research question driving the mixed method study described in the remainder of this paper is as follows:

How does a MTO production strategy affect the applicability and impact of ERP systems?

The following section presents a theoretical framework which is used to build hypotheses to test the relationships between decision support requirements, the use of ERP and company performance before Section 4 outlines the research method in full.

3. Theoretical Framework

The theoretical framework links together three constructs: decision support requirements; the functionality provided by ERP systems; and, company performance. The decision support requirements relate to the needs of companies at the various planning stages (e.g. order entry); the functionality of ERP systems relates to the various ERP modules and add-ons (e.g. MRP and CRM); and, company performance explores the impact of using the software. The literature review above identified company requirements and ERP functionality; similarly, company performance is based on relevant metrics from the literature, e.g. due date adherence, order winning performance, etc.

A general theoretical framework is illustrated in Figure 1, where the connections between constructs relate to the hypotheses tested in this study. The figure shows that the fit between requirements (1) and performance (3) is tested both directly and through the mediating effect of system use (2); hence, both applicability and impact are evaluated. This type of three-construct theoretical framework between characteristic, mediator and performance – also known as a "mediational model" – has been used in similar studies in the operations management literature (Bozarth & Edwards, 1997; Bozarth & McDermott, 1998; Choi & Eboch 1998; Cao & Zhang, 2011). Going from Construct (1) through the use of Construct (2) to Construct (3), that is from H_a to H_b, seems a logical way of testing the relationships among company requirements, via the use of corresponding ERP functionality, and company performance. Meanwhile, having significant support for a link between Construct (1) and Construct (3), that is H_c, indicates indirect benefits from adopting any practices. Each construct is multi-dimensional and each dimension consists of at least one variable. For example, the first construct includes the dimension of decision support at the customer enquiry stage, which includes variables such as support for pricing and due date setting. The

following subsection focuses specifically on the CEM stage to provide an example of how the hypotheses have been constructed.

[Take in Figure 1]

3.1 Example Hypothesis Development: The Customer Enquiry Management Stage

The theoretical framework in the context of the CEM stage consists of: (1) CEM decision support requirements (e.g. for due date setting and price determination); (2) the use of CEM-relevant functionality (e.g. the CEM functionality of ERP), and; (3) CEM performance (e.g. order winning performance). Using this framework, we seek to determine the extent to which ERP systems and add-ons can satisfy the CEM decision support requirements of MTO companies; and, the effect of ERP on company performance for CEM. As an example, the hypotheses that follow are the relationships anticipated between the three constructs for the CEM module of an ERP system:

H1a: The level of decision support requirements has a positive impact on the intensity of use of ERP's CEM functionality.

H1b: The intensity of use of ERP's CEM functionality has a positive impact on performance at the CEM stage.

H1c: The level of decision support requirements has a positive impact on performance at the CEM stage.

The above hypothesis structure has been repeated to develop similar sets of hypotheses for the other functionality identified in the literature review as potentially relevant at this stage (i.e. ATP, CTP and PLM). Hence, a total of 12 hypotheses have been developed for the CEM stage (i.e. 3 for CEM, 3 for ATP, 3 for CTP and 3 for PLM). In total, 39 hypotheses have been developed across all the planning and control stages plus SCM and CRM (12 for CEM, 6 for design & engineering, 6 for order entry, 3 for order release, 6 for dispatching, 3 for CRM and 3 for SCM). But insufficient data was obtained from the survey to test hypotheses at the order release (3) and dispatching stages (6), hence these two stages are not investigated further in this study and we concentrate on testing the remaining 30 hypotheses. The absence of data may be due to the lack of support provided by ERP systems for order release and the low level of importance attributed to shop floor dispatching in MTO companies, but further research is required to confirm this.

The following section describes the research method adopted in this study. The full set of 30 hypotheses is given later in the results section (see Section 5.2, Table 11), together with an indication as to whether they are supported or otherwise by the survey data.

4. Research Method

A mixed method approach has been adopted, consisting of an exploratory and explanatory survey followed by 3 case studies. Adopting a mixed method approach has recently been advocated and encouraged in the operations management literature (e.g. Burgess et al., 2006; Boyer & Swink, 2008; Taylor & Taylor, 2009). It provides methodological triangulation (Denzin, 1970) and allows for the use of complementary strengths while compensating for the weaknesses of individual approaches (Jick, 1979). Our mixed method approach obtains the power and generality of a survey while overcoming the depth problem of surveys through the richness of cases. Employing the case study method after the survey work provides a means of examining the results in more depth and of validating the findings (Voss, 2009). Section 4.1 below focuses on the design of the survey research, which is the primary method used in this paper, before Section 4.2 briefly describes the case study research design.

4.1 Survey Research Design

Forza's (2009) checklist of 37 attributes for a rigorous survey – which is a more detailed and extended version of the 17 attributes contained in Malhotra & Grover's (1998) earlier framework – has been a major influence on our survey design. We have also paid close attention to the approach adopted in the most relevant surveys from the ERP literature, e.g. Mabert et al. (2000 and 2003) and Olhager & Selldin (2003). Note that no study has been able to fulfil all 37 of Forza's (2009) attributes, but giving them explicit consideration and satisfying as many as possible is nonetheless important. Moreover, documenting them allows the limitations of a study to be acknowledged. Table 2 summarises key attributes from Forza's (2009) checklist and briefly comments on how each has been accommodated or addressed. Further detail is also provided in the following discussion on instrument development, data collection, and data quality.

[Take in Table 2]

4.1.1 Instrument Development

The survey included exploratory questions to gain an overview of the respondents, their firms and their (non-)adoption of ERP; and, explanatory questions to test the hypotheses. The exploratory questions were based on those used in previous studies for similar purposes (e.g. Mabert et al., 2000 and 2003; Stratman, 2001; Olhager & Selldin, 2003) and thus had been pre-validated. These questions were split into four sections. The first two sections were fully answerable by both adopters and non-adopters and by both MTO and MTS companies,

covering background information (e.g. company size, production process, etc) and decision support requirements (based on a 7-point Likert scale, which reduces bias against extreme responses more than 3 or 5-point scales: Dillman, 2007). Sections 3 and 4 were for adopters only and measured the intensity of use of ERP functionality and performance, respectively – again, largely based on 7-point Likert scales. Note that our core focus is on MTO companies, but data on MTS companies was also collected as a basis for comparison.

As no existing instruments for the explanatory part were available, the questions had to be developed and then validated through a content validity assessment and pilot study. Content validity was assessed based on the opinions of ten experts (academics and practitioners) using the manual sort technique (Nunnally & Bernstein, 1994; Rungtusanatham, 1998; Forza, 2009). This consisted of three rounds, involving 3, 4 and 3 expert judges, respectively who were asked to sort randomised questions into relevant categories, with the number of correct and incorrect matches assessed. Different experts were used in each round to avoid learning effects. Validity measures applied included Cohen's Kappa (κ) ratio (Cohen, 1960), Perreault & Leigh's (1989) reliability index (I_r) and the Proportional Reduction in Loss (PRL) measure (e.g. Rust & Cooil, 1994). The measures were assessed after each round, with misunderstood and superfluous questions either rewritten or discarded, whilst ensuring full coverage of the construct (e.g. Venkatraman & Grant, 1986). The final value obtained for each measure was well above that suggested in the literature (>0.7 for κ; >0.8 for I_r; and, >0.85 for PRL), indicating readiness for a pilot study. A summary of the three rounds is provided in Table 3.

[Take in Table 3]

The number of items or questions was reduced from 127 to 89 and the number of variables from 58 to 46; the number of constructs and dimensions were unchanged. The questionnaire was long, but this procedure had reduced its length – and this was likely to improve the response rate (Jobber, 1986; Dillman, 2007). A copy of the survey instrument is provided in Appendix A.

For the pilot study, the survey was emailed to 37 managers enrolled on an executive programme at the authors' university; 19 managers completed the survey – greater than the minimum of 15 recommended for a pilot by Forza (2009) – resulting in a response rate of 51.4%. As in Menor & Roth (2007), the pilot tested the 'ready-to-send' survey instrument. This allowed us to experience handling the administrative procedure, to explore non-response bias issues, and conduct preliminary data analysis. Only 4 responses were provided in the first week, highlighting the importance of sending reminders. In addition, data analysis identified some unusual responses, leading to a number of questions being further revised.

Four respondents provided contact details and were called to provide feedback. The instrument was considered clear, although it was too long and so several questions were removed. A monetary incentive (a prize draw for a shopping voucher) and an executive summary of results had been offered and these were well-received, so also used in the full scale survey. Finally, it was suggested that the full scale survey be sent via by both mail and email (as described in the next subsection).

4.1.2 Full Scale Survey Data Collection

The survey was posted to 1,634 companies listed in a database purchased for this research. The database of contacts does not indicate whether a company has implemented an ERP system nor does it indicate the dominant production strategy; the only controllable strata are company size, industry/sector and the role/position of the respondent. Several commercially available company contact databases were considered at the start of this study and all were found to provide only one potential respondent per organisation. All firms are in the UK. The database contained email addresses for 1,088 of the 1,634 firms – these firms were also emailed and invited to submit their responses online if they wished. The email addresses were also used to send an advance notice and three follow-up reminders. However, some of the email addresses were generic or non-personal (i.e. sales@company.com or info@company.com), reducing the effectiveness of this technique, while approximately 300 emails 'bounced back'. This prompted us to check the reliability of the database. The websites of 100 companies randomly sampled from the database were therefore visited and the details of 38% were found to be inaccurate (e.g. incorrect address, company no longer trading, etc). It is therefore reasonable to assume that around 38% of the questionnaires did not reach their intended target, reducing the number of potential respondents to 1,013. Overall, a total of 111 fully complete responses were received, giving a response rate of 10.96%. Such a response rate is not uncommon (Alreck & Settle, 1995), including in the ERP literature, e.g. 9.6% in Mabert et al. (2000 and 2003) and 13.0% in Stratman (2001). For the exploratory analysis, the responses increase to 126 (12.4%) as 15 respondents completed the exploratory questions online but abandoned before completing the explanatory part. This is well above the minimum of 52 responses advised by Forza (2009) for exploratory data analysis.

In total, 60.3% of respondents had adopted, were implementing or intended to adopt ERP (76 of 126 companies), while 47.6% of respondents were MTO companies (60 of 126 companies). All respondents were senior managers or directors, e.g. Managing Director (29%), Director (20%), or Production/Manufacturing Director (9%). In addition, a wide range

of industrial sectors were represented, with the most common being: industrial machinery and equipment (15%); automotives (14%); aerospace and defence (13%); computers and electronics (9%); consumer goods (8%); chemicals (7%); raw materials (metals, woods and plastics: 7%); ship building (6%); and, pharmaceuticals (6%). Characteristics of the companies are summarised in Table 4, where the number of employees, turnover, production strategy, and supply chain position are given. Note that we focus on a broad MTO *vs*. MTS comparison, but clearly there are many other potential points on the production strategy continuum. Thus, firms where an Assemble-To-Order (ATO) strategy is dominant are included in the MTS category and firms where ETO is the dominant strategy are included in the MTO category.

[Take in Table 4]

4.1.3 Assessing Non-Response Bias and the Measurement Quality of the Data

Non-response bias was checked by comparing first wave data with late returns, i.e. respondents convinced to reply by reminder notices that would otherwise have been non-respondents (e.g. Armstrong & Overton, 1977). This was done using a non-parametric chi-squared test as some of the data violated normality assumptions. The tests were based on responses to eight exploratory questions relating, e.g. to the number of employees, turnover, production strategy, and ERP efforts (adoption/non-adoption). Table 5 shows that the results for first wave and late returns do not differ significantly, since all asymptotic significance values are above 0.05. Hence, there is no evidence of non-response bias in the data.

[Take in Table 5]

Finally, and before the results can be presented in Section 5, the measurement quality of the relevant data must be evaluated (Biemer et al., 1991; Malhotra & Grover, 1998). This was assessed based on five measures which confirmed the reliability and validity of the data:

1. Unidimensionality was checked (Stratman & Roth, 2002; Forza, 2009) to ensure consistency between items grouped under the same construct, as suggested by Ahire et al. (1996), Exploratory Factor Analysis (EFA) was used to gain a preliminary insight before Confirmatory Factor Analysis (CFA) was applied for each dimension, with a benchmark comparative goodness of fit index of 0.9 used to determine which items to drop (Bollen, 1989). The CFA test was then reapplied with a reduced model until adequate fit was obtained.
2. Reliability procedures were applied to test the consistency of the results and the repeatability of measurements (Carmines & Zeller, 1979). Cronbach's alpha (Cronbach,

1951) reliability estimation was evaluated, with all variables above 0.6, most above 0.8 and some above 0.9. This indicated that a reliable set of variables had been used in the instrument (Nunnally, 1978; Robinson et al., 1991). The Wers-Linn-Jöreskog (WLJ) and Average Variance Extracted (AVE) tests of reliability also reported acceptable values.

3. Convergent validity (part of construct validity) was assessed according to the technique presented in Krause et al. (2000) to determine the extent to which different approaches to construct measurement yield the same results (Campbell & Fiske, 1959). Krause et al.'s (2000) technique is based on the magnitude and sign of the factor loadings of items onto their respective latent constructs in the CFA measurement models previously run in the unidimensionality assessment. In addition, the Proportional Reduction in Loss (PRL) technique was used. Both showed adequate fit between the model and data.
4. Discriminant validity using CFA assessed the degree to which measures of different concepts were distinct (Bagozzi & Phillips, 1982). CFA of all possible pairs of latent variables was produced twice, with the difference between the $\chi 2$ values of two results tested for the significance of the statistic (constrained $\chi 2$ minus unconstrained $\chi 2$) for each pair (Venkatraman, 1989). All differences were significant at $p < .05$ and 33 out of 42 were significant at $p < .001$, suggesting strong discriminant validity (Bagozzi et al., 1991).
5. Criterion-related validity was assessed using Structural Equation Modelling (SEM; see Ahire et al., 1996) to measure how well variables representing various decision support requirements related to measures of performance (Flynn et al., 1994). Only the relationships amongst the inter-construct latent variables in the order entry model were non-significant – hence, there may not be a direct relationship between decision support requirements and performance at this stage.

4.2 Case Study Research Design

Three case studies were conducted to confirm and follow up on the findings of the survey. All interviews were in MTO companies, as our primary focus was on understanding the applicability and impact of ERP systems on MTO companies. Two were MTO adopters of ERP; the third was a MTO non-adopter. The two MTO adopters are hereafter referred to as MA1 and MA2 and the MTO non-adopter as MNA.

Survey respondents were invited to provide their contact details if they wished to participate in follow up cases – MA1, MA2 and MNA were selected from this subset of respondents. In total, 19 respondents had shown an interest in participating in case work and 14 of these were MTO companies. In addition, the case selection logic involved re-examining the survey responses of candidate cases and deliberately choosing companies that had

provided ‘interesting’ answers or it appeared would be in a good position to help answer any outstanding questions that we had after the survey data analysis. For example, we became interested in why MTO companies found ERP system selection difficult, so we ensured that at least one of the selected cases had indicated in their survey response that they found system selection either very difficult or extremely difficult.

The interviews were semi-structured, supported by a case study protocol (Yin, 2009) developed after the survey data analysis. The protocol included high-level open-ended questions and more detailed specific questions to check the survey responses and dig deeper into the “why” (Voss, 2009). As an example, the interview protocol prepared for a MTO non-adopter is provided in Appendix B. Three interviews were conducted in MA1, with the Managing Director, Manufacturing Manager, and IT Coordinator & Purchasing Manager; in MA2, only the Operations & IT Director was interviewed; finally, in MNA, the Managing Director was interviewed. All interviews were audio-recorded and fully transcribed; notes were also taken during the interviews. Two researchers were present at the interviews with MA1 and MNA and were able to compare their notes and interpretations of the interviewee responses. Summaries of the interviews were returned to the interviewees for validation (Miles & Huberman, 1994), with any vague or misinterpreted responses clarified. An overview of the three companies is provided in Table 6 – we will return to the case study data in Section 6 after presenting the survey results.

[Take in Table 6]

5. Survey Results

Section 5.1 presents the exploratory results based on univariate and bivariate tests before Section 5.2 presents the explanatory results based on multivariate tests. Statistical analysis has been conducted – for the majority of data, parametric tests were appropriate, e.g. t-tests and ANOVA; where test assumptions do not hold – non-parametric tests have been applied, e.g. Mann-Whitney U, Chi-squared and Kolmogorov-Smirnov tests. A brief discussion of the results then follows in Section 5.3 before Section 6 provides the case study evidence.

5.1 Exploratory Survey Results

Section 5.1.1 presents univariate analysis of the sample as a whole, detailing the percentage of firms adopting ERP, the reasons behind adoption, the choice of vendor, and the use and customisation of specific modules before the reasons behind non-adoption of ERP are outlined. Section 5.1.2 then presents bivariate analysis, exploring the effects of production strategy (MTO *vs.* MTS) on ERP adoption/non-adoption.

5.1.1 Univariate Analysis

Almost 51% of respondents indicated that their company had adopted an ERP system; a further 8% were currently installing ERP and 2% planned to install ERP. Most adopters had obtained their system from a single vendor (82%), in some cases with add-ons from the same provider. The reasons why firms implemented an ERP system are given in Table 7, where the mean score is based on respondents indicating their level of agreement with the importance of factors on a Likert scale from 1 (strongly disagree) to 7 (strongly agree). The top three reasons were to standardise processes, replace legacy systems and improve integration.

[Take in Table 7]

In total, 39 different vendors have provided ERP systems to the adopters, plus 3% of firms have developed their own in-house system. The three most widely used systems are provided by international vendors – SAP (18%), Microsoft (11%) and Sage (9%) – but many vendors are UK/domestic providers. Interestingly, most of the firms that have implemented SAP are medium or large-sized MTS companies. A wide range of modules are in use, with the most popular being order entry (88%), purchasing and logistics (88%), sales & delivery (84%), materials management (83%) and production planning (82%). Interestingly, the production planning and sales & delivery modules were also amongst the modules that respondents had to customise the most. The most frequently implemented add-ons included CRM (28%), APS (26%) and SCM (21%) functionality. The least implemented add-ons were the PLM (13%) and product configurator (14%) modules, which we had previously questioned in the context of customised production (see Section 2).

Of the remaining respondents, approximately 37% were non-adopters with no plans to install, while approximately 2% (2 firms) had used and abandoned an ERP system. One of these firms had abandoned ERP because of: the costs of implementation, maintenance and training; a lack of payback from implementation; and, a lack of in-house expertise on how to use the system. Interestingly, a key reason why the other firm had abandoned ERP was because – after beginning to implement and use the system – it became clear that the software could not meet the needs of the company. Finally, the reasons why firms have not adopted ERP are given in Table 8, where the most cited reason is that, again, it was thought that ERP would not suit the needs of the company.

[Take in Table 8]

5.1.2 Bivariate Analysis

Correlation analysis, cross-tabulations and group-wise comparisons have been used to explore links between the responses to individual exploratory questions from the survey. Of most interest are any differences between: MTO adopters and MTS adopters; MTO adopters and MTO non-adopters; and, MTO non-adopters and MTS non-adopters.

MTO Adopters *vs.* MTS Adopters

Using ANOVA, some significant differences are evident between MTO and MTS firms with respect to the reasons to adopt an ERP system. In other words, what motivates MTO companies to adopt ERP differs from what motivates MTS companies. Figure 2 shows the mean response on a 7-point Likert scale for the reasons to adopt an ERP system. For example, a significant difference was found between the responses for item 14e (adoption linked to global activities or to support globalisation activities) – MTS firms have a significantly higher mean and therefore see this as being a more important factor motivating ERP adoption than MTO companies. While most firms in the sample were small or medium sized, the few large firms were MTS companies and this may explain the result. Both MTO and MTS firms link ERP adoption to generic issues like standardising business processes, integration, and replacing legacy systems (14b, 14c, and 14d in particular) while the mean response by MTO and MTS companies is also high for 14g – to improve production planning effectiveness. Adoption is less influenced, for example, by e-commerce considerations (14f) or customer pressure to adopt ERP (14j).

[Take in Figure 2]

There are also significant differences between MTO and MTS firms with respect to the system selection process. On average, ERP adopters found it "difficult" (3) to identify the most appropriate ERP system (based on a rating between 1-extremely difficult and 7-extremely easy). But MTO companies found system selection more difficult on average than MTS companies. As the production strategy of a firm shifts from standard towards bespoke products, selecting an appropriate ERP system becomes increasingly difficult. Thus, there is evidence that production strategy has a major bearing on the system selection process.

Comparisons have also been made between the modules and add-ons implemented by MTO and MTS companies (see Figure 3 and Figure 4, respectively). The only significant differences between the modules/add-ons adopted by MTO and MTS companies are with respect to Quality Management and Computer Aided Design (CAD) systems. Quality Management is not used by the majority of ERP adopters, but it is used much more by MTO

than MTS firms. CAD is the most frequently adopted add-on by MTO companies, and there is a significant difference between the use of CAD systems by MTO and MTS firms ($p<0.01$). The reason for ocular but non-significant differences is that the sample size decreased for other add-ons as users tend to first decide to adopt ERP then later adopt add-ons if necessary. The importance of a CAD system add-on was not, however, identified from our literature review.

[Take in Figures 3 and 4]

MTO Adopters *vs.* MTO Non-adopters

The data on MTO adopters *vs.* non-adopters suggests that industry and company size characteristics may affect a MTO company's decision to adopt ERP. Many of the MTO companies that have adopted ERP are in the automotives and aerospace & defence industries; in contrast, raw material manufacturers and industrial machinery & equipment manufacturers appear less likely to implement ERP. It is also noticeable that the MTO adopters tend to be larger than the MTO non-adopters.

MTO Non-Adopters *vs.* MTS Non-Adopters

Using ANOVA, there was only one significant, but important, difference evident between MTO and MTS firms with respect to the reasons not to adopt an ERP system – that "ERP would not suit the needs of the company". Overall, this was the most highly cited reason not to adopt ERP but MTO non-adopters significantly agreed with this reason much more so than MTS non-adopters ($p = 0.0016$ and 0.0031, which is less than 0.01 for t-tests assuming equal or unequal variances).

5.2 Explanatory Survey Results

Structural Equation Modelling (SEM) has been used in accordance with Shah & Goldstein's (2006) guidelines to assess the fit between the data and the theoretical framework. Because the sample size is relatively small, partial aggregation has been used as an approximation to the full SEM model (Carter et al., 2008; Koufteros et al., 2009). The hypotheses developed are in sets of three, thus the 30 hypotheses required 10 structural models. All 10 models were solved using the maximum likelihood ratio method. A good fit between the predetermined model and the data was identified for all but the two latent variables loading on decision support requirements in the SCM model. Thus, the values of the path coefficients (loadings) were statistically significant to use for all but the SCM model.

Table 9 summarises the results for the overall model fit (first four columns) and causal path values together with their significance (remainder of the table). The three causal paths

are between Decision Support Requirements (DSR) and the use of ERP (USE); USE and performance (PERF); and, DSR and PERF. Two of the models – Design & Engineering through the use of PLM and the SCM model – do not show adequate fit with the data (p values are less than 0.05; in fact, both are less than 0.01) and, therefore, cannot be used to test their corresponding hypotheses. When model fit is assessed separately for MTO and MTS companies, as shown in Table 10, most of the models using only the MTS data resulted in a poor model fit. In contrast, the MTO data resulted in quite a good fit with all the models except SCM. Therefore, the focus in what follows is largely on the complete data and on our main interest – MTO companies only.

[Take in Tables 9 and 10]

Table 11 presents the full set of 30 hypotheses tested using the survey data and indicates whether each is supported, not supported or if there is insufficient data/model fit to evaluate the degree of support. The presentation of results is organised around the planning and control stages for which sufficient data was obtained plus CRM and SCM.

[Take in Table 11]

5.2.1 Customer Enquiry Management (CEM) Stage

All three hypotheses on the use of an ERP system's CEM functionality at the CEM stage are supported for the data as a whole. As shown in Figure 5 (see also tables 9 and 11 for this and the other hypotheses), high CEM decision support requirements lead to intensive use of the system (R_1 = 0.370) and improved performance (R_3 = 0.691) at the CEM stage. In addition, the use of CEM tools has a significant impact on improving performance at this stage (R_2 = 0.374). In other words, when CEM decision support requirements are high, a company is able to utilise the system for CEM purposes, and as a mediating effect this use also leads to improved CEM performance. Similar significant results and impact values are obtained when only the MTO data is used (see tables 10 and 11). In other words, the data fit and the significance of the relationships in the model are valid and powerful when both complete data and only the MTO data is used. This is not true for the MTS data for which model fit is inadequate, showing that it is the MTO data that is the actual factor in this convergence. Thus, when CEM decision support requirements are high, a MTO company is able to use the CEM functionality of its ERP system to help and, as a mediating effect, this use leads to improved CEM performance.

[Take in Figure 5]

There are also two significant relationships in the CEM-ATP model (see tables 9 and 11). The model's second and third hypotheses are supported such that both decision support requirements and the use of ATP functionality have positive and significant impacts on improved performance at the CEM stage. However, a significant link between the need for decision support and the intensity of use of ATP functionality could not be established. The MTO data on its own also has good model fit and two significant causal links amongst the constructs (see tables 10 and 11). But this time, the second hypothesis which was supported by the overall data set is not significant, while the first one is significant. In other words, the CEM decision support requirements of MTO companies seem to have an impact on the use of ATP functionality and on CEM performance.

The results for the two remaining CEM models (CTP and PLM) support only the third hypothesis. Thus, in all four CEM models for the data as a whole and for the MTO data only, the impact of decision support requirements on performance is supported. In other words, when firms indicate high CEM decision support requirements, they get high CEM performance without considering the mediating effect of the use of ERP tools.

5.2.2 Design & Engineering Stage

The results for the two design & engineering models (Product Configurator and PLM software) support only the third hypothesis for the data as a whole. Thus, the usefulness of this functionality could not be convincingly shown. Although the literature has reported successful examples of product configurator usage (e.g. Forza & Salvador, 2002; Hvam et al., 2006; Olsen & Saetre, 2007), especially in SMEs, to the best our knowledge PLM functionality has not been subject to any relevant prior analysis. Hence, further research is required with a larger sample to confirm or refute the claims regarding product configurator software and to provide an initial contribution on PLM.

5.2.3 Order Entry Stage

At the order entry stage, the data as a whole demonstrates a significant relationship for both the MRP and APS models between the intensity of use of the system and order entry performance. This suggests that MRP and APS have a positive and significant impact on planning performance. For the APS model, this is also true for both the MTO and MTS data separately, but this is not the case for MRP. While there are two significant causal links in the Order Entry-MRP model for the MTO data, only one of these is positive – the path from the use construct to the performance construct (i.e. R_2). The second significant link – from decision support requirements to performance (i.e. R_3) – is negative. In other words, the estimation tells us that the use of MRP within a MTO company's ERP system improves order

entry performance but that this is not supported by considering the level of decision support requirements at the order entry stage. That is, the use of MRP does not behave as a performance enhancing mediator from company requirements to customer satisfaction. If high operational and tactical planning system support is needed, low planning performance is observed in the short and medium term. Thus, there remains no evidence to refute the claim that MRP is unsuitable for MTO companies (e.g. Stevenson et al., 2005). Therefore, an ERP system, which stems from MRP and comprises it as the core planning module, can be helpful to a MTO company when an alternative, robust (i.e. less sensitive to change) and capacity-concerning mechanism is provided for its use at the order entry stage. Due to a lack of data on order release and dispatching, the analysis now turns to CRM and SCM.

5.2.4 Customer Relationship Management (CRM)

Like the CEM-ERP model, the CRM model is fully supported for the data as a whole. In other words, high CRM decision support requirements lead to intensive use of the CRM add-on ($R_1 = 0.550$) and improved CRM performance ($R_3 = 0.499$). In addition, the use of CRM has a significant impact on improved CRM performance ($R_2 = 0.344$). In other words, when CRM decision support requirements are high, a company is able to use its CRM system to help and, as a mediating effect, this use leads to improved CRM performance. It is not possible, however, to draw specific conclusions for MTO companies because so few firms have implemented CRM.

5.2.5 Supply Chain Management (SCM)

The overall results for the SCM model are totally inconclusive. Few of the path coefficients are significant, the model fit is inadequate, and none of the hypotheses are supported. Interestingly, the MTS data actually fits the SCM model well, while the MTO data does not. This suggests that MTS companies may benefit from a SCM add-on to their ERP system, particularly those that are part of complex supply networks.

5.3 Brief Discussion of Survey Findings

Overall, it can be concluded that production strategy is an important contextual factor that affects ERP adoption. It affects the level of difficulty in selecting an ERP system and the impact of using certain modules or add-ons. At the CEM stage, all hypotheses were supported for the CEM module of ERP – both for the data as a whole and for MTO companies separately. But, at the design & engineering stage, no benefits were observed from the use of either product configurator or PLM software. Meanwhile, an important negative link between decision support requirements and performance was obtained for the use of MRP in MTO

companies, suggesting MRP is unsuitable for MTO companies. More specifically, when a MTO company requires a high level of decision support at the order entry stage, it shows poor planning performance. CRM is a key add-on for both MTO and MTS companies and can lead to improved CRM performance – indeed, significant results were obtained between CRM decision support requirements, the use of the CRM add-on and improved CRM performance.

Some of the survey data warrants further investigation. For example, many adopters indicated that they make only limited use of ERP – but it is unclear why. Similarly, many non-adopters identified the unsuitability of available systems as the main reason for non-adoption, but how they came to this conclusion is unclear. Hence, three follow-up case studies have been conducted to further unpack: the reasons behind ERP adoption and non-adoption by MTO companies; why MTO companies find system selection difficult; and, why they do not appear to benefit from ERP planning tools, as described in the next section.

6. Case Study Findings

The following subsections present a brief discussion of the cases organised around the applicability, use, and impact of ERP. MA1 and MA2 – the two MTO adopters – contribute to all three sections (6.1 to 6.3), while MNA – the MTO non-adopter – is important for understanding applicability (Section 6.1).

6.1 Applicability of ERP: The Adoption and Non-Adoption of ERP by MTO Companies

Although MA1 and MA2 had adopted ERP, their survey responses indicated that they found ERP selection either very difficult (MA1) or extremely difficult (MA2). MA1 is a small company with a risk-averse Managing Director concerned about the impact of a failed implementation. He explained that "*getting the wrong system would be a business threatening decision*". A lack of trust in the information provided by vendors was also a key issue affecting the selection process. The Managing Director of MA1 argued that vendors can mislead potential users, e.g. by directing them to the most positive of vetted reference sites. He also explained that: "*lots of vendors tell you things that they think you want to hear ... you don't know who to trust ... and there are lots of high-profile examples of companies buying systems that don't work for them*". However, the company's existing software was no longer maintainable and had to be replaced. Two years were spent searching for an appropriate solution before opting for a rentable system. The Managing Director explained that they chose to rent a system rather than to purchase one outright to reduce the impact of making a poor selection decision. He agreed that system selection was difficult but, by renting the

software, he was able to minimise the consequences of making a poor system selection decision. He also suggested that SMEs can lack the in-house expertise needed to implement an ERP system but that selecting an external implementation partner is also difficult, i.e. system selection is not the only problem. Meanwhile – and following its recent acquisition by another company – MA2 had been 'forced' to implement a particular ERP system used across the group. The earlier survey response referred to its extreme difficulty in selecting the previous ERP system that was now being replaced. The Operations & IT Director listed high software prices, a limited budget and few suitable vendors as the main reasons why system selection had been difficult.

MNA had not implemented ERP because it was considered unsuitable for the company. Interestingly, MNA is a low-volume, high-value project-dominated company where design & engineering is key. The company uses separate specialist software solutions to manage the various tasks at each planning and control stage. The Managing Director stated that he would like to improve both capacity planning & control and visibility of its suppliers, but that no ERP vendor "*had walked through the door offering a solution*". He also claimed that no single ERP system would be able to meet their needs.

The above supports the suggestion from the survey data that the selection process is indeed difficult. Part of this difficulty is with a lack of communication and information available to help make the right system selection decision, meaning implementing ERP is either not explicitly considered or is a risky decision. Company size also plays a role, as SMEs appear to be reluctant to adopt an expensive solution that is not conclusively suitable to their needs. Neither point is about production strategy, but this is also relevant – the case with the highest level of customisation and lowest volume was the one where ERP had not been implemented.

6.2 Use of ERP: Why and How do MTO Companies Use ERP?

Although MA1 and MA2 have both implemented ERP, neither makes extensive use of the software for detailed planning. Instead, they largely use their systems to standardise processes, integrate operations, and provide greater information visibility – which are generic functions relevant to any business. Overall, the most important feature of ERP in both cases is providing visibility so users can continue to plan manually. In MA1, ERP provides real-time data on the status of jobs progressing through the factory and on material inventories. This helps managers to react before any overload occurs on machines and to anticipate 'dangerously low' inventory levels for critical raw materials. But MA1's legacy system, which was developed in-house, also provided a list of priority orders for the next few days,

akin to the idea of a list of key orders for release. Its new ERP system did not have this functionality and so custom code had to be written.

When asked why the system was hardly used for detailed planning, the Managing Director of MA1 explained that the firm "*survives on being flexible*" – he was sceptical that standardised software could be used to directly support detailed planning and control functions in a MTO company. As an example, he explained that ERP cannot automate customer enquiries if products are made to customer specification. He stated that "*We are not Amazon – we can't have an online catalogue of standard products*", i.e. from which a customer can select a product, choose a delivery date and pay. The Managing Director did, however, think that the process standardisation that results from using ERP can be of benefit when quoting for new business – as it makes users go through the discipline of collecting all the information relevant to providing a quotation. But, ultimately, the lead time and price of each order involves interaction and negotiation in-house between manufacturing and sales and externally with the customer. Thus, sales staff – and not software – is considered key to the firm for supporting negotiations and building relationships with customers. The Managing Director argued that: "*you cannot rely on a system to do these things – people are more important*". Nonetheless, the system does mean that sales staff can combine their experience and understanding of the business with up-to-date information from the system. Similarly, detailed functionality is not used in MA2. The Operations & IT Director confirmed that "*team leaders manually schedule all our orders*" when they have been confirmed at the order entry stage. Most processes are low-skilled, so planners can simply manually redistribute people and capacity across work centres to reflect the current mix of orders. CEM tools are not used either, but this time because lead times are typically dictated by the customer. The Operations & IT Director explained that: "*there are no negotiations on lead time – we have to adjust capacity accordingly*".

From the above it follows that although MA1 and MA2 have implemented an ERP system, its use arguably goes little beyond being an integrated database. There is no overwhelming evidence from the two adopters that there is a strong alignment between the detailed functionality of the software and the needs of MTO companies. Neither firm is using ERP in a very sophisticated manner to provide direct and detailed decision support. This may be because firms either cannot or do not want to use the software for these purposes, but it could also be that firms are unaware of how to go about doing so. Thus, communication and training on how to make more effective use of ERP may be necessary, while MTO-specific functionality may also be required.

6.3 Performance Impact: What Impact does ERP have on MTO Companies?

The Managing Director of MA1 explained that he had not seen a dramatic improvement in performance since implementing ERP, although on-time delivery had improved from 90 to 95%. This improvement is attributed to having better information on supplier performance and a better 'big picture understanding' of the company, allowing it to take a more proactive approach to situations that may otherwise affect the company's ability to deliver to customers on time. The Managing Director explained that: "*the system provides a helicopter view of what is going on in the business*". It is claimed that it is this transparency and the availability of information that has brought about improvements and not the use of detailed functionality to support specific planning and control tasks. Similarly, MA2 claims to have received hardly any benefits from their system at the individual planning stages (e.g. order entry).

Overall, the interviews suggested that the two adopters have received some benefits from ERP, but that these benefits are attributed to general aspects of ERP and not to the use of detailed and specific functionality. Implementation does not appear to have led to dramatic improvements in performance in either company.

7. Conclusion

This paper adds to the available literature on how contingency factors affect the applicability and impact of Enterprise Resource Planning (ERP) systems. While research has investigated factors like company size (e.g. Mabert et al., 2003) and nationality (e.g. Olhager & Selldin, 2003), production strategy has been neglected (Aslan et al., 2012). Indeed, Aslan et al.'s (2012) literature review and research agenda called for more empirical evidence on the applicability and impact of ERP systems on MTO companies. The most relevant recent contribution was by Deep et al. (2008), but the authors focused on one Make-To-Order (MTO) company only and investigated applicability without assessing impact. This paper has studied the effect of a MTO production strategy on the applicability and impact of ERP systems through an exploratory and explanatory survey followed by three case studies. The primary focus has been on MTO companies, but Make-To-Stock (MTS) companies have also been surveyed as a basis for comparison.

Our research question was: *How does a MTO production strategy affect the applicability and impact of ERP systems?* The exploratory part of the survey found, for example, that production strategy does not affect the decision to adopt ERP – as both MTS and MTO companies have implemented ERP – but does affect the difficulty of selecting an ERP system. MTO companies found selection more difficult on average than MTS companies. The most outstanding reason why some firms had not implemented ERP was that it would

not suit the needs of the company. MTO non-adopters in particular highlighted this issue, suggesting a perceived or actual misalignment between MTO companies and ERP functionality.

This lack of alignment is generally supported by the results of the explanatory part of the survey in which a series of hypotheses were tested using a theoretical framework that included three constructs: decisions support requirements, ERP functionality, and company performance. This built on Bendoly & Jacobs' (2004) paper by identifying which ERP modules and add-ons show adequate fit with which operational needs. For example, the use of the Customer Enquiry Management (CEM) functionality of ERP was linked to improvements in CEM performance. This was true of the data as a whole and of the MTO data separately. Customer Relationship Management (CRM) software was also found to be an effective solution across the whole sample. But overall, for the data as a whole, only two of the ten models were fully supported (CEM and CRM), seven were partially supported, and the results for one model were inconclusive (SCM). All of the partially supported models show a significant impact on performance, but mainly without demonstrating a link between particular functionality and improved performance. In other words, companies using ERP that have high decision support requirements performed well without intensively using specific corresponding tools from their system. Thus, improvements may result from general aspects of ERP like standardisation and integration or from the process of implementation – which involves analysing and evaluating a company's business processes in order to fit them to, and configure, the system – rather than from the use of specific modules or add-ons.

The follow-up cases shed light on why system selection is so difficult, and why MTO companies only partially use the functionality of ERP systems. Although two of the three companies had implemented ERP, the software was used as a means of centralisation and integration – with only high-level functionality used to get an overview of the status of company resources and processes – rather than to directly inform or automate decision making. All three companies were MTO SMEs, where an expensive implementation failure could have proven fatal. Evidence from the cases suggested a lack of trust in vendors and consultants, and a lack of confidence in the fit between ERP systems and the needs of MTO companies. As a solution, one firm had chosen to rent an ERP system, arguing that this provided a low-risk solution. Yet the company still had to commission some custom code to improve the fit between the software and the business' needs. The cases generally support the suggestion from the survey data that there is a misalignment between ERP functionality and the needs of MTO companies. Moreover, there appears to be a gap between the expertise required to utilise the software and that found in small MTO companies in practice.

In conclusion, the most relevant solutions for MTO companies are the CEM and, to a lesser extent, CRM tools. This supports the suggestion that production strategy does indeed affect the use of ERP. MTO companies typically have to cope with high-variety, customised and sometimes one-off production, meaning each order must be quoted for individually; and, MTO companies often have to track and handle a wide range of customers, made up of both one-off and repeat purchasers. These challenges – that are particular to MTO companies – require support from CEM and CRM functionality. Similarly, the high variety, often one-off nature of production may also explain why the effectiveness of product configurator and production life cycle management software could not be demonstrated.

7.1 Practical Implications

The findings have implications for ERP vendors in terms of improving the fit between their systems and company needs, and in terms of marketing their products and raising awareness about the detailed functionality. For example, although there are elements of ERP systems that do work well for some MTO companies, there are others that currently do not and there are companies of the opinion that ERP is unsuitable for their needs. Thus, software development and communication strategies should reflect these findings. While it is noted that vendors may not wish to make information about detailed functionality available to their rivals, it somehow needs to be communicated to potential users.

The findings are also of relevance to managers looking to identify an appropriate planning solution. Although some MTO companies have been able to successfully implement and use an ERP system, managers must note the importance of the system selection process and of having the right skills available. One strategy for reducing risk may be to adopt an on-demand solution where the software is rented or accessed as a service.

7.2 Limitations and Future Research Implications

Three limitations to the research described in this paper are acknowledged:

1. Although comparable with some previous studies and although we have considered non-response bias, the survey response rate was only 10.96%. This is likely to have been caused by a combination of factors, including survey length, the quality of the database of contacts, and the high number of surveys executives receive. There is, however, a trade-off here: a shorter survey may have increased our response rate but it would also have reduced the depth of our data.
2. Although we focused on statistically significant results, closely related to the above is the issue of the number of responses, which was only 111 for the explanatory part. This limited the number of hypotheses we were able to test decisively.

3. Only one survey response per organisation was obtained; as a result, it is possible that the data reflects the opinions, biases and areas of expertise of the individual respondents. It is argued here that this effect is minimised because most firms were small or medium sized, but multiple responses per organisation would add reliability to the results through triangulation. Again, increasing the number of respondents per organisation would involve a trade-off, e.g. with the response rate and number of responses.

Future research can build on this study, including by addressing the above limitations. For example, the study could be replicated in the UK or in other countries using an abridged version of the questionnaire. This may allow sufficient data for the order release and dispatching stages to also be investigated. The theoretical framework tested in this paper could also be revised or extended. Two options for this are suggested here. First, the decision support requirements in our framework were taken from the MTO literature; the framework could be revised to also reflect the MTS literature. And second, we constructed the framework to investigate the links between ERP functionality and performance at a given planning stage, but we did not look at knock-on effects between stages. Hence, the theoretical framework could be extended to allow this to be tested. For example, it may be interesting to look at whether using CEM functionality for setting lead times not only improves performance at the CEM stage but also makes post-order acceptance decisions, such as order release, easier or more effective. Finally, future research could involve conducting research into how more MTO-specific planning concepts could be embedded within ERP systems to improve the alignment between ERP systems and the needs of MTO companies.

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Figure 5: Results for the Theoretical Framework – CEM Functionality at the CEM Stage

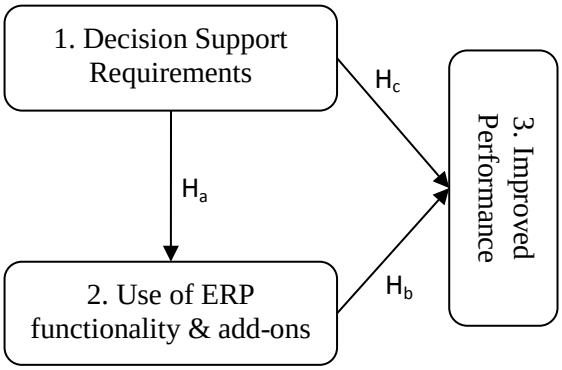
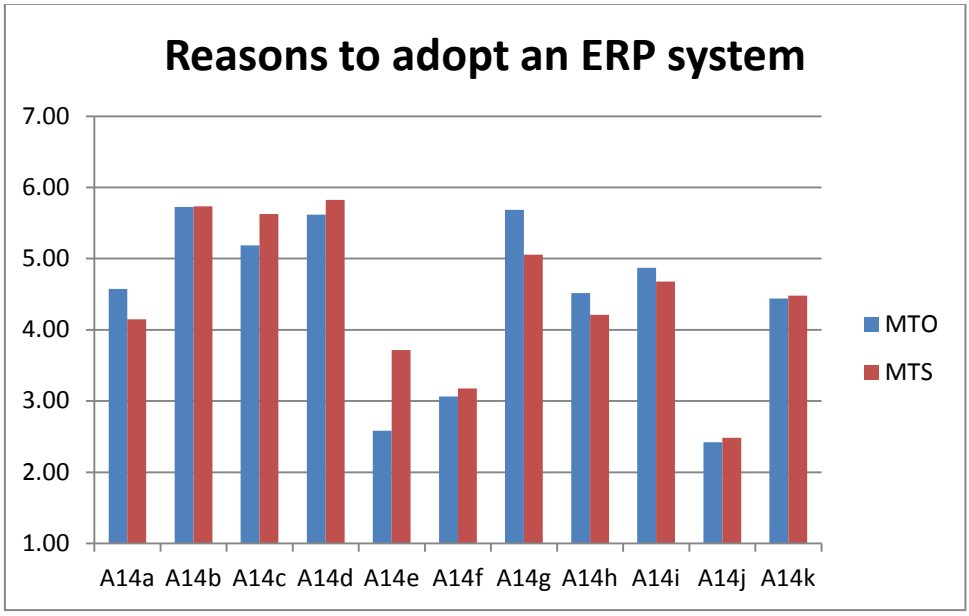


Figure 1: General Theoretical Framework



A14a: to lower costs; **A14b**: to simplify & standardise business processes; **A14c**: to integrate operations, systems or data; **A14d**: replace legacy systems; **A14e**: adoption linked to global activities; **A14f**: to improve e-commerce activities; **A14g**: to improve production planning effectiveness; **A14h**: to support change/innovation; **A14i**: to keep up with the competition; **A14j**: adoption encouraged (or enforced) by key customers; **A14k**: other.

Figure 2: Comparison of Reasons to Adopt an ERP System – MTO vs. MTS Companies

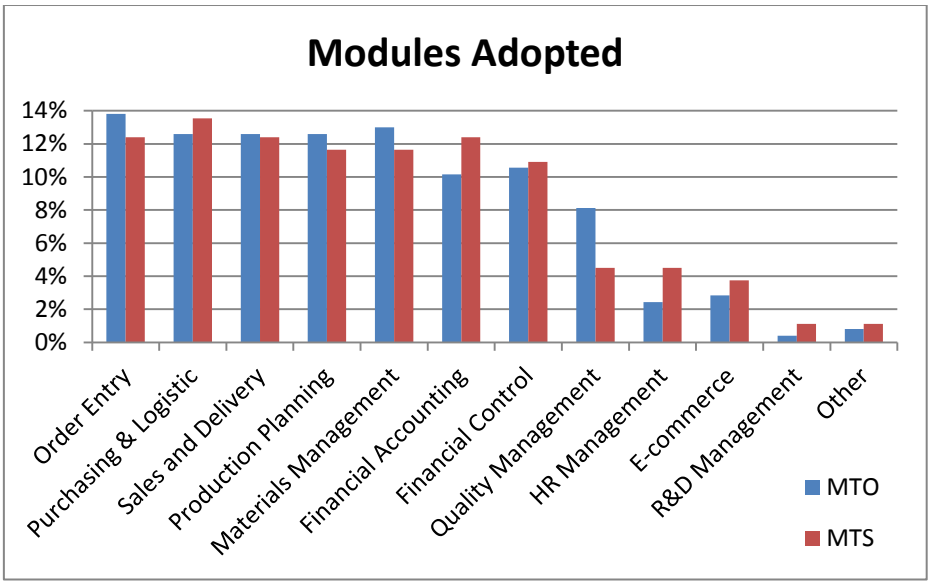


Figure 3: Comparison of Adopted ERP Modules – MTO vs. MTS Companies

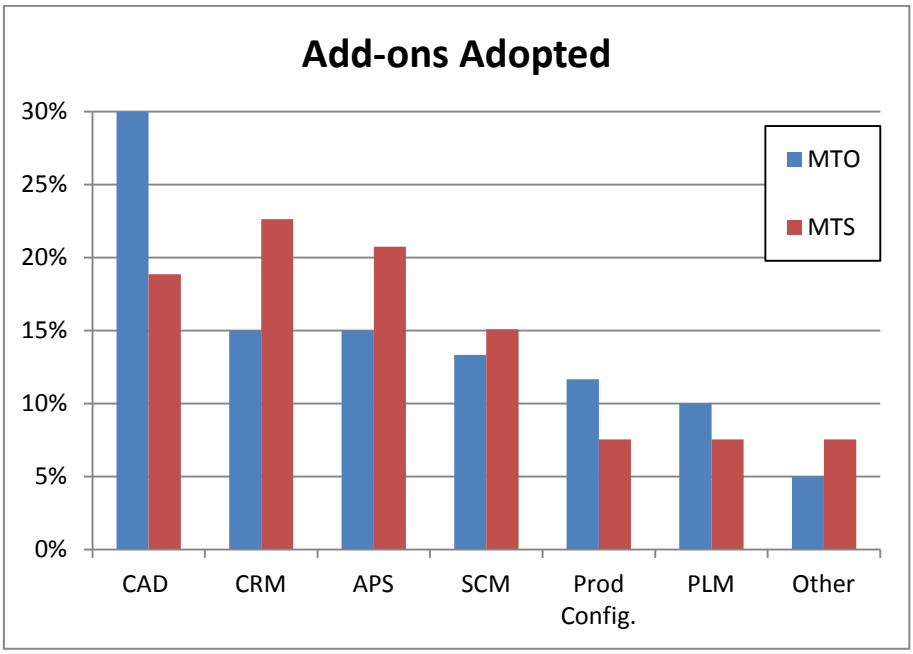


Figure 4: Comparison of Adopted ERP Add-ons – MTO vs. MTS Companies

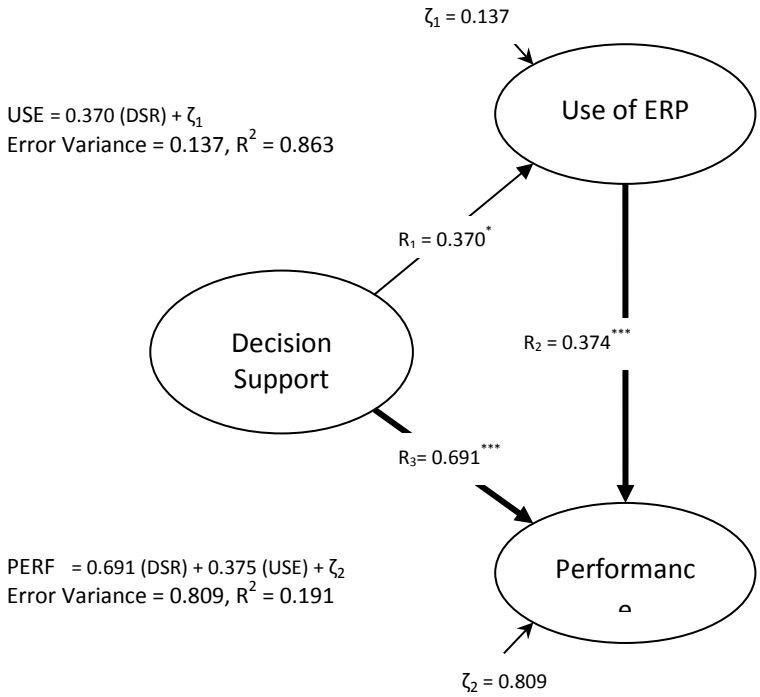


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Table 1: Summary of Requirements and Applicable ERP Functionalities and Add-ons

Requirements	ERP Functionality
Customer Enquiry Management (CEM, e.g. mechanisms for generating alternative due dates and prices)	Customer Enquiry Management (CEM) functionality of core ERP system Available-to-Promise (ATP) functionality of core ERP system Capable-to-Promise (CTP) functionality of core ERP system Product Lifecycle Management (PLM) add-on
Design and Engineering (D&E, e.g. to document the design and specification of products during the order processing cycle)	Product Configurator (PC) add-on Product Lifecycle Management (PLM) add-on
Order Entry (OE, e.g. for detailed capacity planning and possible due date renegotiations of confirmed orders)	Material Requirements Planning (MRP) functionality of core ERP system Advanced Planning and Scheduling (APS) add-on
Order Release (OR, e.g. to decide when to start production)	Order Release functionality of core ERP system, where available
Shop Floor Dispatching (e.g. for shop floor scheduling and sequencing in job shops)	Material Requirements Planning (MRP) functionality of core ERP system Advanced Planning and Scheduling (APS) add-on
Customer Relationship Management (CRM, e.g. to retain and develop customer relationships or cope with a changing customer base)	Customer Relationship Management (CRM) add-on
Supply Chain Management (SCM, e.g. for responsive rush order handling)	Supply Chain Management (SCM) add-on

Table 2: Key Attributes of a Rigorous Survey (from Forza, 2009) vs. Our Approach

'Ideal' Survey Attributes (Forza, 2009)		Responses (Our Approach)
Prior	Unit of analysis (UoA) clearly defined	Company as the UoA when only one plant; where there are multiple plants, UoA refers to the plant at which the respondent is based.
	Operational definitions clearly stated	The constructs (decision support requirements, use of ERP functionality, and performance) and their dimensions were structured following a theoretical assessment. The variables were all defined and operationalized.
Defining sample	Sample frame defined and justified	Sample composed of all UK manufacturers; no particular industry targeted.
	Random sampling used from the sample frame	Stratified random sampling was performed for industry, company size and respondent profile; ERP adoption and production strategy could not be assessed prior to survey response.
	Minimum required sample size estimated	Study suffices the number required (>52) for exploratory analysis for a sufficient power (>0.8). Number of responses large enough to allow first order structural modelling in the explanatory analysis.
Instrument	Existing validated measures adapted	Exploratory analysis comprised of existing pre-validated items, but the items in the explanatory part are particular to this research.
	Need for objective & perceptual questions	All variables have been perceptually measured. To reduce subjectivity, multi-item measurement was used where possible.
	Instrumentation consistently reflects UoA	The instrument items are prepared for answering by high level managers to reflect the unit of analysis.
	Compatibility of scales for measuring	Exploratory part has open-ended, rank, multiple-choice & Likert scales; explanatory part has only 7-point Likert scales.
	Respondents chosen are appropriate	High level managers are chosen to improve the likelihood of getting meaningful information and to decrease random or even bias error.
	Multi-item variables used	Multi-item variables were created in the questionnaire where appropriate due to the use of perceptual questions.
Data	Satisfactory response rate	Techniques for better response rates resulted in an adjusted response rate of over 10%.
	Non-response bias estimated	No significant difference observed on comparing the characteristics of the respondents in the first and subsequent waves.
	Inconsistent and uncertain data cleaned	Missing/uncertain/inconsistent responses were cleaned and marked accordingly.
	Necessity of any treatments of data	Missing data (<3%) has been coded using SPSS in the exploratory, and using AMOS, in the exploratory parts.
Metrics quality	Content (or face) validity assessed	Assessed by academics and practitioners using the manual sort method in 3 rounds which resulted in a high estimate.
	Field-based pretesting of measures	A pilot study was conducted in advance of the full-scale survey to improve measurement capability and wording.
	Reliability assessed	Reliability estimated by measures, including Cronbach's alpha; all measures indicated the instrument's adequacy.
	Construct validity assessed	Discriminant, convergent and criterion-related validities assessed; models refined and simplified accordingly.
	Confirmatory methods (e.g. Structural Equation Modelling & Principal FA) used	Structured Equation Modelling (SEM) technique applied in the explanatory part of the study. Principal Factor Analysis (PFA) also applied to help assess reliability and construct validity.
Analysis	Appropriateness of tests for hypothesis testing	The suitability of univariate & bivariate tests (descriptive & group-wise comparisons), and multivariate tests found to be adequate.
	Adequacy of tests for the available data	Goodness of fit tests for explanatory part and t-test and one-way ANOVA for the exploratory part were found to be adequate.
	Test assumptions satisfied	Non-parametric tests applied when parametric test assumptions violated (e.g. normality).
Interp.	Internal validity of findings	The significance of causal links amongst the constructs has been interpreted for internal validity.
	Acceptability of inferences	While the acceptability of inferences is high in the exploratory findings, SEM of particular stages may need further evidence.
	Applicability to other populations	Theoretical framework may be applicable to different realities, e.g. the manufacturing sector in countries other than the UK.

Table 3. Overall content validity measures evaluated for each round.

	Round 1 (3 judges, 127 items)	**Round 2 (4 judges, 102 items)**	**Round 3 (3 judges, 89 items)**
The Percentage of agreement	75.3%	65.5%	76.0%
Cohen's Kappa (κ)	0.74	0.64	0.75
Perreault & Leigh's reliability index (I_r)	0.86	0.78	0.86
Proportional Reduction in Loss (PRL)	~0.97 ($\hat{p}$ = 0.74)	~0.91 $\hat{p}$ = 0.66)	~0.98 ($\hat{p}$ = 0.76)

Table 4: Profile of Companies Surveyed

Number of Employees	**%**	**Annual Turnover**	**%**	**Production Strategy**	**%**	**Supply Chain Position**	**%**
1-10	1	Turnover<£2m	14	MTO	47.6	OEM	44
11-50	37	£2m≤Turnover<£10m	41			Tier 1	19
51-250	40	£10m≤Turnover<£50m	22	MTS	52.4	Tier 2	25
251-500	17	£50m≤Turnover<£100m	18			Raw Mat. Supplier	7
501-1000	2	£100m≤Turnover<£250m	2	Total	100	Other	5
>1000	3	£250m≤Turnover	3			Total	100
Total	100	Total	100				

Table 5: Chi-Squared Test Results for Non-Response Bias (Sample of 8 Questions)

Exploratory Survey Question	Chi-Square	Degrees of Freedom	Asymptotic Significance
Number of Employees	5.48	5	.360
Sales Turnover	7.38	5	.194
Production Strategy	2.27	5	.811
Shop Floor Routing	4.85	4	.303
Supply Chain Position	4.32	4	.364
ERP Efforts	4.17	4	.383
Industrial Sector	8.25	10	.604
Adopted ERP Modules	7.32	10	.695

Table 6: Case Study Company Characteristics

Company	Interviewees	Description	No. of Employees	Turnover	Product Range	Notes on ERP Adoption
MTO ERP Adopter 1: MA1	Managing Director; Manufacturing Manager; IT Coordinator & Purchasing Manager	Textile manufacturer, e.g. laundry and filtration products for woven and non-woven fabrics	24	£1.8m	Approx. 1,000 different products per year; 500 new products per year	Implemented a single commercial ERP system in 2007; previously using an in-house built legacy system that could no longer be maintained.
MTO ERP Adopter 2: MA2	Operations & IT Director	Lighting specialist, e.g. LED and retail store lighting solutions	96	£13.5m	Approx. 30 product families; builds around 1,000 product variants; some repeat business	Longstanding user of an ERP solution, but the company has recently been bought out and is now implementing the single ERP solution used by the parent company.
MTO ERP Non-Adopter: MNA	Managing Director	Capital goods firm, e.g. providing condition monitoring equipment to assess steel produced in casting machines	40	£17m	Largely one-off products; little repeatability; low-volume production	Uses a variety of software packages across the business; no integrated ERP solution is in use.

Table 7: Reasons behind ERP Adoption (All Respondents)

Reasons	n	Mean	Std. Dev.	Median	Mode
To simplify and standardise business processes	70	5.77	1.12	6	6
To replace legacy systems (old hardware/software)	71	5.75	1.51	6	7
To integrate enterprise operations. systems, or data	70	5.44	1.33	6	6
To improve production planning effectiveness	70	5.41	1.6	6	7
To keep up with competitive forces in the industry	68	4.85	1.55	5	5
To cope with increased workload/business	52	4.62	1.71	5	5
To lower costs	70	4.46	1.63	4	4
To support change/innovation in the company	67	4.34	1.74	4	4
Linked to global activities (support glob.strategy)	69	*3.23*	2.03	3	1
To improve e-commerce activities	68	*3.16*	1.75	3	1
Adoption encouraged (or enforced) by key customers	67	*2.43*	1.49	2	1

Table 8: Reasons behind ERP Non-Adoption (All Respondents)

Reasons	n	Mean	Std. Dev.	Median	Mode
ERP would not suit the needs of the company	37	5.84	1.66	7	7
Cost of the consultancy for selection, implementation, etc	33	4.76	2.05	5	7
Cost of the software solution itself	33	4.58	1.97	5	5
Risk of implementation failure	34	4.47	1.94	4	4
Current economic climate	34	4.38	2.2	5	7
Cost of the training for employees	33	4.27	1.86	5	5
Cost of the hardware upgrades required	33	4.24	1.94	4	4

Table 9: Comparison of Model Fit & Causal Path Significance – All Respondents

	χ^2 (df)	*p*	CFI	RMSEA	(1) DSR → Use			(2) Use → Perf.			(3) DSR → Perf.		
					Est.	S.E.[a]	C.R.[b]	Est.	S.E.[a]	C.R.[b]	Est.	S.E.[a]	C.R.[b]
CEM	14.41 (12)	0.28	0.98	0.07	0.37*	0.17	2.42	0.37***	0.10	3.66	0.69***	0.14	5.33
CEM-ATP	12.64 (12)	0.40	0.99	0.03	0.02	0.27	0.10	0.26**	0.06	2.58	0.83***	-0.14	6.28
CEM-CTP	11.42 (12)	0.49	1.00	0.00	0.14	0.26	0.89	0.18	0.07	1.72	0.82***	-0.15	5.74
CEM-PLM	20.43 (12)	0.06	0.94	0.12	-0.02	0.21	-0.01	0.05	0.09	0.48	0.83***	-0.15	5.91
D&E-PC	13.29 (12)	0.35	0.99	0.05	0.15	0.26	0.92	-0.03	0.11	-0.21	0.42*	-0.19	2.40
D&E-PLM	26.86 (12)	0.01	0.86	0.16	0.24	0.24	1.37	-0.11	0.14	-0.57	0.44*	-0.21	2.21
OE-MRP	14.52 (11)	0.21	0.98	0.08	0.19	0.15	1.13	0.69***	0.33	4.21	-0.16	-0.21	-1.38
OE-APS	11.81 (7)	0.11	0.96	0.14	0.07	0.42	0.37	0.62***	0.12	4.94	-0.11	-0.30	0.77
CRM	3.87 (7)	0.80	1.00	0.00	0.55***	0.19	3.31	0.34*	0.14	2.38	0.50**	-0.19	2.78
SCM	24.06 (11)	0.01	0.87	0.17	0.63	1.46	1.33	0.47	0.33	1.62	-0.42	-1.20	-1.22

[a] S.E. is an estimate of the standard error of the covariance.
[b] C.R. is the critical ratio obtained by dividing the covariance estimate by its standard error.
* Significant at 0.05 level (critical value = 1.96); ** significant at 0.01 level (critical value = 2.58); *** significant at 0.001 level (critical value = 3.29).

Table 10: Comparison of Model Fit & Causal Path Significance – MTO vs. MTS Companies

		χ^2 (df)	*p*	CFI	RMSEA	(1) DSR → Use			(2) Use → Perf.			(3) DSR → Perf.		
						Est.	S.E.[a]	C.R.[b]	Est.	S.E.[a]	C.R.[b]	Est.	S.E.[a]	C.R.[b]
CEM	MTO	15.433 (12)	0.22	0.96	0.11	0.54*	0.33	2.55	0.44**	0.16	3.08	0.59***	0.31	3.31
	MTS	28.964 (12)	0.00	0.76	0.27	0.24	0.19	1.06	0.08	0.21	0.27	0.85*	0.22	2.48
CEM-ATP	MTO	13.702 (12)	0.32	0.97	0.74	0.56*	0.49	2.35	-0.07	0.17	-0.32	0.96**	0.47	3.19
	MTS	34.375 (12)	0.00	0.72	0.31	-0.24	0.44	-0.90	0.28	0.08	1.68	0.92**	0.22	3.22
CEM-CTP	MTO	11.799 (12)	0.46	1.00	0.00	0.57**	0.40	2.70	-0.11	0.17	-0.52	0.98***	0.42	3.52
	MTS	25.325 (12)	0.01	0.80	0.24	-0.07	0.41	-0.28	0.14	0.06	0.88	0.88***	0.16	3.85
CEM-PLM	MTO	17.657 (12)	0.13	0.91	0.14	0.29	0.47	1.17	-0.31	0.16	-1.75	0.99***	0.45	3.67
	MTS	21.666 (12)	0.04	0.86	0.20	-0.19	0.26	-0.80	0.34*	0.09	2.55	0.91***	0.13	4.96
D&E-PC	MTO	19.801 (12)	0.07	0.91	0.16	-0.28	0.38	-1.26	-0.18	0.14	-0.95	-0.46	0.33	-1.73
	MTS	7.548 (12)	0.82	1.00	0.00	0.15	0.69	0.82	0.07	0.09	0.81	0.30	0.70	1.67
D&E-PLM	MTO	17.002 (12)	0.15	0.94	0.13	0.31	0.37	1.40	-0.24	0.19	-0.77	0.23	0.34	0.64
	MTS	17.102 (12)	0.15	0.86	0.14	0.29	0.57	1.43	-0.07	0.13	-0.66	0.37*	0.58	1.99
OE- MRP	MTO	12.529 (11)	0.33	0.99	0.07	0.38	0.18	1.61	0.69***	0.36	3.52	-0.50***	0.19	-3.63
	MTS	-	-	-	-	-	-	-	-	-	-	-	-	-
OE- APS	MTO	5.514 (7)	0.60	1.00	0.00	0.07	0.45	0.24	0.55**	0.20	2.98	-0.17	0.36	-0.78
	MTS	10.304 (7)	0.17	0.93	0.17	0.18	0.99	0.63	0.82***	0.14	4.73	-0.12	0.62	-0.56
CRM	MTO	8.297 (7)	0.31	0.98	0.10	0.65*	0.39	2.43	0.30	0.25	1.20	0.61	0.47	1.85
	MTS	29.261 (7)	0.00	0.76	0.41	0.59	0.23	2.49	0.12	0.23	0.48	0.59*	0.25	2.22

[a] S.E. is an estimate of the standard error of the covariance.
[b] C.R. is the critical ratio obtained by dividing the covariance estimate by its standard error.
* Significant at the 0.05 level (critical value = 1.96); ** significant at the 0.01 level (c.v. = 2.58); *** significant at the 0.001 level (c.v. = 3.29).

Table 11: Summary of Hypotheses Tested & Degree of Support from the Data

Model	Hypotheses	All Data	MTO Data	MTS Data
CEM	H1a: The level of decision support requirements has a positive impact on the intensity of use of ERP's CEM functionality.	Supported	Supported	*Data misfit*
	H1b: The intensity of use of ERP's CEM functionality has a positive impact on performance at the CEM stage.	Supported	Supported	*Data misfit*
	H1c: The level of decision support requirements has a positive impact on performance at the CEM stage.	Supported	Supported	*Data misfit*
CEM-ATP	H1d: The level of decision support requirements has a positive impact on the intensity of use of ERP's ATP functionality.	Not Supported	Supported	*Data misfit*
	H1e: The intensity of use of ERP's ATP functionality has a positive impact on performance at the CEM stage.	Supported	Not Supported	*Data misfit*
	H1f: The level of decision support requirements has a positive impact on performance at the CEM stage.	Supported	Supported	*Data misfit*
CEM-CTP	H1g: The level of decision support requirements has a positive impact on the intensity of use of ERP's CTP functionality.	Not Supported	Supported	*Data misfit*
	H1h: The intensity of use of ERP's CTP functionality has a positive impact on performance at the CEM stage.	Not Supported	Not Supported	*Data misfit*
	H1i: The level of decision support requirements has a positive impact on performance at the CEM stage.	Supported	Supported	*Data misfit*
CEM-PLM	H1j: The level of decision support requirements has a positive impact on the intensity of use of ERP's PLM functionality.	Not Supported	Not Supported	*Data misfit*
	H1k: The intensity of use of ERP's PLM functionality has a positive impact on performance at the CEM stage.	Not Supported	Supported	*Data misfit*
	H1l: The level of decision support requirements has a positive impact on performance at the CEM stage.	Supported	Supported	*Data misfit*
D&E-PC	H2a: The level of decision support requirements has a positive impact on the intensity of use of the product configurator add-on.	Not Supported	Not Supported	Not Supported
	H2b: The intensity of use of the product configurator add-on has a positive impact on performance at the design & engineering stage.	Not Supported	Not Supported	Not Supported
	H2c: The level of decision support requirements has a positive impact on performance at the design & engineering stage.	Supported	Not Supported	Not Supported
D&E-PLM	H2d: The level of decision support requirements has a positive impact on the intensity of use of the PLM add-on.	*Data misfit*	Not Supported	Not Supported
	H2e: The intensity of use of the PLM add-on has a positive impact on performance at the design & engineering stage.	*Data misfit*	Not Supported	Not Supported
	H2f: The level of decision support requirements has a positive impact on performance at the design &	*Data misfit*	Not	Supported

	engineering stage.		Supported	
OE-MRP	H3a: The level of decision support requirements has a positive impact on the intensity of use of ERP's MRP functionality.	Not Supported	Not Supported	*Data misfit*
	H3b: The intensity of use of ERP's MRP functionality has a positive impact on performance at the order entry stage.	Supported	Supported	*Data misfit*
	H3c: The level of decision support requirements has a positive impact on performance at the order entry stage.	Not Supported	Supported(-)	*Data misfit*
OE-APS	H3d: The level of decision support requirements has a positive impact on the intensity of use of the APS add-on.	Not Supported	Not Supported	Not Supported
	H3e: The intensity of use of the APS add-on has a positive impact on performance at the order entry stage.	Supported	Supported	Supported
	H3f: The level of decision support requirements has a positive impact on performance at the order entry stage.	Not Supported	Not Supported	Not Supported
CRM	H4a: The level of decision support requirements has a positive impact on the intensity of use of the CRM add-on.	Supported	Supported	*Data misfit*
	H4b: The intensity of use of the CRM add-on has a positive impact on customer relationship management performance.	Supported	Not Supported	*Data misfit*
	H4c: The level of decision support requirements has a positive impact on managing customer relationships.	Supported	Not Supported	*Data misfit*
SCM	H5a: The level of decision support requirements has a positive impact on the intensity of use of the SCM add-on.	*Data misfit*	*Data misfit*	Not Supported
	H5b: The intensity of use of the SCM add-on has a positive impact on supply chain performance.	*Data misfit*	*Data misfit*	Supported
	H5c: The level of decision support requirements has a positive impact on supply chain performance.	*Data misfit*	*Data misfit*	Not Supported

Appendix A
Survey of the Effectiveness of ERP Systems for UK Manufacturing

This survey is part of an ongoing research project being conducted by the Supply Chain Management and Modelling research group at **Lancaster University Management School**. The research seeks to understand how effectively Enterprise Resource Planning (ERP) systems are able to meet the decision support requirements of manufacturing companies in the UK. We are interested in learning from the opinions of **adopters and non-adopters** of ERP systems.

Please answer all relevant questions. If you wish to comment on any question or qualify a response in any way, please use the comment box at the end of this questionnaire. Your comments may help us to better understand your responses. **We guarantee that your individual responses will be kept strictly confidential.** Only aggregated data will be reported. No names, identifiable company data or comments will appear in any reports that result from this study. If you would find it more convenient to complete this survey online, please go to **http://erpuk.questionpro.com/**.

This survey is divided into four sections (A to D) and should take 30 to 40 minutes to complete. **All respondents who provide contact details will be entered into a PRIZE DRAW and receive a copy of the study's executive summary of results** which you can use to evaluate your company's decision making practices and use of information systems relative to others in your industry.

Thank you very much for participating in this research project.

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SECTION A: Background Information (& ERP Environment)

This section focuses on background information about your company. For those companies that have implemented, are implementing or intend to implement an ERP system, there are also some questions about the implementation process in your company.

1. **Your position in the company: _____**
2. **Number of employees:**
   a. 1 - 10 people
   b. 11- 50 people
   c. 51 - 250 people
   d. More than 250 people
3. **Sales turnover last year:**
   a. Less than £2m
   b. At least £2m but less than £10m
   c. At least £10m but less than £50m
   d. At least £50m

4. **Which of the following statements best describes the company's products? Please select one response.**
   a. Each order is for a different product, made to the specific requirements of the customer
   b. All (or the majority of) products are bespoke but a few are made on a repeat basis
   c. All (or the majority of) products are bespoke but a large proportion are made on a repeat basis
   d. We have some bespoke products and some standard products
   e. Most products are standard; there is little difference between customer requirements
   f. All products are standard; orders are fulfilled from inventory
5. **How long is the 'typical' product lifecycle of your products? Please select one response.**
   a. Less than 30 days
   b. At least 30 days but less than 6 months
   c. At least 6 months but less than 1 year
   d. At least 1 year but less than 5 years
   e. least 5 years
6. **Whi industrial sector is your company involved in? Please select all relevant responses.**

   ☐ P wer ☐ Aerospace ☐ Chemicals
   ☐ E tronics ☐ Automotive ☐ Fast moving consumer goods
   ☐ M lea ☐ Food ☐ Other: _____
7. **Whi of e following statements best describes the 'typical' routing of a job through the hop flo in your company? Please select one response.** *[If your company does not ar act e b e.g., distributes products instead, please select option "e".]*
   a. out s v a lot; a job could start and finish at any point on the shop floor
   b. out s v but there is a dominant flow direction on the shop floor
   c. ere lit routing variation; most jobs go through a similar sequence of operations
   d. ere n outing variation; all jobs go through the same sequence of operations
   e. ot a lic e
8. **Whi of e f owing statements best describes your 'typical' supply chain position? Please ele one esp e.**
   a. rigi eq ment manufacturer (OEM), close to the end-customer for the product
   b. er su er: a direct supplier to the OEM
   c. er t su er: a supplier to tier one
   d. aw teri pplier
   e. the ___ _____

The following questions about ERP systems and the (potential) use of ERP in your company. Please start by answering question 9 and proceed to the relevant questions (dependant on your response to Question 9). Once you have completed Section A, please continue to Section B.

9. **ch of t ollow tements best describes your company's ERP efforts? Please select respon**
   The co ny has an ERP system
   └→ *Please answer* Q10 to Q16*, then continue to Section B*
   b. The co y is cur lling an ERP system
   └→ *Please answer* Q10 to Q16*, then continue to Section B*
   c. The com plans to system
   → *Please answer* Q15 & Q16*, then continue to Section B*
   d. The comp s no curre to install an ERP system
   └→ *Please answer* Q17 only*, then continue to Section B*
   e. The compa sed and ab doned an ERP system
   └→ *Please answer* Q18 & Q19*, then continue to Section B*
10. **How long did it t plement your ERP system (from software selection to 'going live')? If your company is ... ...plementing, please give the anticipated time period.**
    a. Less than 6 months

b. At least 6 months but less than 1 year
c. At least 1 year but less than 2 years
d. At least 2 years but less than 4 years
e. At least 4 years

11. Which of the following statements best describes your ERP installation? Please select one response.

a. Installation of a single ERP package (i.e., from a single ERP vendor)
b. Single ERP package but with other bespoke software added on (e.g., built in-house)
c. Best-of-breed installation using elements of several ERP packages (from several vendors)
d. Several ERP packages but with other bespoke software added on (e.g., built in-house)
e. In-house developed ERP system (bespoke, totally developed in-house)
f. Other: _____

12. Which of the following strategies best describes your approach to ERP implementation? Please put one tick in each column, indicating your initial plan and the approach actually taken.

	Initial plan	Actual approach
a. *Big bang* (single 'go live' date for all modules)	[ ]	[ ]
b. *Mini big bang* (single 'go live' date for a subset of modules)	[ ]	[ ]
c. *Phased-in by module* (modules with different 'go live' dates)	[ ]	[ ]
d. *Phased-in by location* (locations with different 'go live' dates)	[ ]	[ ]
e. *Phased-in by* (other, please specify):_____	[ ]	[ ]

13. Which of the following business processes are currently supported by tools within your ERP system? *Answering this question is a three stage process: first, select the processes supported by your ERP modules; second, rank the modules selected in terms of their importance to your company; finally, indicate the required degree of module customisation, i.e., changes that had to be made to the code of the package.*

Please tick the processes supported by your ERP system	2) Please rank the importance of the modules selected to your company	3) Please indicate the degree of customisation. None Minor Significant Major
☐ Financial Accounting	_____	
☐ Financial Control	_____	
☐ Treasury	_____	
☐ E-commerce	_____	
☐ Production Planning	_____	
☐ Purchasing and Logistics	_____	
☐ Materials Management	_____	
☐ Quality Management	_____	
☐ Sales and Delivery	_____	
☐ HR Management	_____	
☐ R&D Management	_____	
☐ Other: _____	_____	

14. Which of the following add-ons are currently used alongside your ERP system? *Answering this question is a three stage process: first, select the software added on to your ERP system; second, rank the software selected in terms of their importance to your company; finally, indicate the required degree of software customisation, i.e., changes that had to be made to the code of the package.*

Please tick the software added to your ERP system	2) Please rank the importance of the add-ons selected to your company	3) Please indicate the degree of customisation. None Minor Significant Major

☐ Advanced Planning and Scheduling	_____	
☐ Customer Relationship Management	_____	
☐ Supply Chain Management	_____	
☐ Product Lifecycle (or Data) Management	_____	
☐ Product Configurator	_____	
☐ CAD System	_____	
☐ Other: _____	_____	
☐ Other: _____	_____	
☐ Other: _____	_____	
☐ Other: _____	_____	

15. Which vendor provided, or will provide, the ERP software for your company? Please select all relevant responses.

☐ SAP ☐ Oracle ☐ SSA Global
☐ QAD Mfg/Pro ☐ Exel EFACS ☐ Intentia Movex
☐ Avanté (Epicor) ☐ MTMS (Made2Manage Systems) ☐ Other: _____

16. What are the reasons why ERP was, or will be, adopted in the company? *Please indicate your level of agreement from 1 (strongly disagree) to 7 (strongly agree) with each of the following reasons.*

	Strongly Disagree						Strongly Agree
a. To lower costs	1	2	3	4	5	6	7
b. To simplify and standardise business processes	1	2	3	4	5	6	7
c. To integrate enterprise operations. systems, or data	1	2	3	4	5	6	7
d. To replace legacy systems (old hardware/software)	1	2	3	4	5	6	7
e. Linked to global activities (support globalisation strategy)	1	2	3	4	5	6	7
f. To improve e-commerce (e-procurement & marketing) activities	1	2	3	4	5	6	7
g. To improve production planning effectiveness	1	2	3	4	5	6	7
h. To support change/innovation in the company	1	2	3	4	5	6	7
i. To keep up with competitive forces in the industry	1	2	3	4	5	6	7
j. Adoption encouraged (or enforced) by key customers	1	2	3	4	5	6	7
k. Other: _____	1	2	3	4	5	6	7

17. What are the reasons behind NOT adopting ERP in the near future?
Please indicate your level of agreement from 1 (strongly disagree) to 7 (strongly agree) with each of the following reasons.

	Strongly Disagree						Strongly Agree
a. Cost of the software solution itself	1	2	3	4	5	6	7
b. Cost of the consultancy for selection, implementation, etc	1	2	3	4	5	6	7
c. Cost of the training for employees	1	2	3	4	5	6	7
d. Cost of the hardware upgrades required	1	2	3	4	5	6	7
e. Risk of implementation failure	1	2	3	4	5	6	7
f. ERP would not suit the needs of the company	1	2	3	4	5	6	7
g. Current economic climate	1	2	3	4	5	6	7
h. Other: _____	1	2	3	4	5	6	7

18. Approximately how long did your company use an ERP system before abandoning it?

a. Less than 6 months
b. At least 6 months, less than 1 year
c. At least 1 year, less than 2 years
d. At least 2 years, less than 4 years
e. At least 4 years

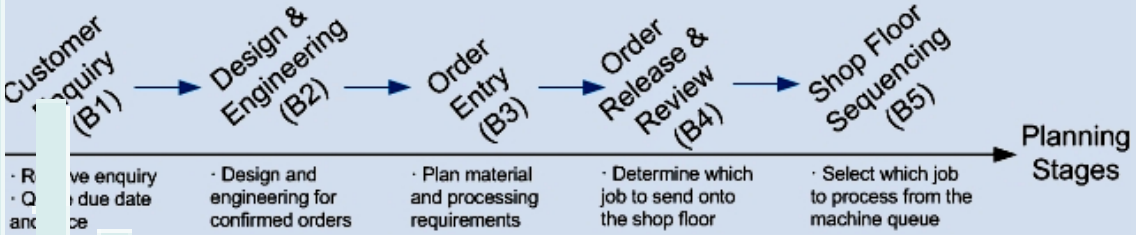
19. What were the reasons why the ERP system was abandoned? *Please indicate your level of agreement from 1 (strongly disagree) to 7 (strongly agree) with each of the following reasons.*

	Strongly Disagree						Strongly Agree
a. Significant financial loss due to underestimating implementation costs	1	2	3	4	5	6	7
b. Insufficient payback after adoption	1	2	3	4	5	6	7
c. The system was unable to meet the needs of our business	1	2	3	4	5	6	7
d. High cost of maintenance and training	1	2	3	4	5	6	7
e. Lack of personnel capable of using the system	1	2	3	4	5	6	7
f. The system was gradually neglected over time	1	2	3	4	5	6	7
g. The system was too complex for our company's organisational structure	1	2	3	4	5	6	7
h. The system failed to improve the effectiveness of our planning processes	1	2	3	4	5	6	7
i. The system failed to improve the efficiency of our transactions	1	2	3	4	5	6	7
j. Other: _____	1	2	3	4	5	6	7

<End of Section A, Please continue to Section B>

SECTION B: Decision Support Requirements

This section focuses on the decision support requirements of manufacturing companies. The first five groups of statements presented (B1 to B5) focus on the decision support requirements at critical planning stages in a manufacturing company, as illustrated in the figure below. The last two groups of statements (B6 and B7) focus on your company's decision support requirements for customer relationship management and supply chain management respectively.



Please indicate your level of agreement with the statements by circling the relevant number from 1 (strongly disagree) to 7 (strongly agree). If a statement is not applicable to your company, please circle the "n/a" option.

B1. Customer Enquiry Stage Decision Support Requirements

	Strongly Disagree						Strongly Agree	
We need to be aware of capacity and our use of manufacturing resources in order to set realistic due dates	1	2	3	4	5	6	7	n/a
We need to assess historical data on similar previous orders when setting due dates	1	2	3	4	5	6	7	n/a
We need to consider alternative due dates when negotiating with customers	1	2	3	4	5	6	7	n/a
We need to be aware of the availability of subcontractors and suppliers when promising due dates to customers	1	2	3	4	5	6	7	n/a
We need to perform a detailed analysis of costs when responding to a request for quotation	1	2	3	4	5	6	7	n/a
We need to assess data on previous similar orders when estimating costs and setting profit margins	1	2	3	4	5	6	7	n/a
Determining the price to quote is influenced by a wide range of factors, from our company's desire to increase profitability to the status of our relationship with a customer	1	2	3	4	5	6	7	n/a
We require a high degree of coordination among departments when responding to customer enquiries	1	2	3	4	5	6	7	n/a
The sales and manufacturing departments have to communicate with each other when we are responding to a quotation	1	2	3	4	5	6	7	n/a

There has to be a high degree of coordination between our company and our suppliers when we are responding to quotations	1 2 3 4 5 6 7 n/a

B2. Design and Engineering Decision Support Requirements

We require access to an archive of product information on previous similar orders to support the design and engineering task for confirmed orders	1 2 3 4 5 6 7 n/a
Maintaining a record of historical product data is essential if our design and engineering department is to handle our most complicated products and components	1 2 3 4 5 6 7 n/a
We need a high level of coordination between departments to support design and engineering tasks	1 2 3 4 5 6 7 n/a
The design and engineering department must be coordinated with the sales and manufacturing departments, especially for customised or bespoke products	1 2 3 4 5 6 7 n/a
Design and engineering tasks require a high level of coordination between our company and our customers	1 2 3 4 5 6 7 n/a
To support the design and engineering process efficiently, we need systems that are compatible with those used by our customers and/or suppliers	1 2 3 4 5 6 7 n/a
We need systems that are able to accommodate frequent product design changes at any stage of the process	1 2 3 4 5 6 7 n/a

B3. Order Entry Stage Decision Support Requirements

	Strongly Disagree						Strongly Agree	
If there is a long delay between making a quotation and it being confirmed by the custom[illegible] we must reconsider cost estimates and capacity availability	1	2	3	4	5	6	7	n/a
We rec[illegible]e a planning system which does not rely on us entering complete product inform[illegible]on (for planning or any other purposes)	1	2	3	4	5	6	7	n/a
When w[illegible] are planning capacity for confirmed orders, we need to consider the potential ef[illegible]t c[illegible]urr[illegible]t unconfirmed tenders on capacity availability	1	2	3	4	5	6	7	n/a
W[illegible]n w[illegible] ar[illegible]erforming detailed planning, we require software support to enable us to er[illegible]loy[illegible]nite[illegible]ading (i.e., so that we only allocate work to a work centre that is below or eq[illegible]l t[illegible] se[illegible]apacity limit)	1	2	3	4	5	6	7	n/a
Sh[illegible]t-t[illegible]n c[illegible]aci[illegible] planning is important to us because our main capacity constraint (or bo[illegible]en[illegible]k) c[illegible]ng[illegible] over time	1	2	3	4	5	6	7	n/a

B[illegible] O[illegible]er [illegible]ev[illegible]w and Release Decision Support Requirements

W[illegible] hav[illegible]a d[illegible]sic[illegible]oint after planning but before manufacturing commences at which w[illegible]let[illegible]min[illegible]whi[illegible] jobs to "release" (i.e., begin manufacturing)	1 2 3 4 5 6 7 n/a
W[illegible] rec[illegible]e s[illegible]twa[illegible] support to help us prioritise the release of planned orders onto the [illegible]p fl[illegible]r ap[illegible]opr[illegible]ely	1 2 3 4 5 6 7 n/a

[illegible]. S[illegible]p [illegible]por[illegible]equencing Decision Support Requirements

[illegible]op fl[illegible]r su[illegible]rvis[illegible] can easily cope with sequencing tasks on the shop floor without [illegible]ftwa[illegible] sup[illegible]rt	1 2 3 4 5 6 7 n/a
[illegible]e ge[illegible]rally [illegible]nplo[illegible]nple mechanisms for sequencing (e.g., first-in-first-out), either [illegible]erfo[illegible]d m[illegible]ually [illegible]ur shop floor supervisor or through our software system	1 2 3 4 5 6 7 n/a

B6. [illegible]M D[illegible]isio[illegible]pport Requirements

We [illegible]uire a [illegible]base[illegible] us manage our relationships with existing and potential cu[illegible]ers	1 2 3 4 5 6 7 n/a
To[illegible]ntain a [illegible]evelo[illegible]tionships with customers, we need to use several means c[illegible]mmunica[illegible](e.g., c[illegible]e-to-face contact, email, telephone, etc)	1 2 3 4 5 6 7 n/a
[illegible]im to ent[illegible]rst-time[illegible]ff) customers into longer and more robust [illegible]tionships	1 2 3 4 5 6 7 n/a
[illegible]e of our targ[illegible]to have[illegible]ustomers and to build prolonged customer	1 2 3 4 5 6 7 n/a

relationships based on trust

B7. SCM Decision Support Requirements

Information sharing is essential for coordination between our company and our customers	1	2	3	4	5	6	7	n/a
It is very important that we are able to respond quickly to urgent orders from our customers	1	2	3	4	5	6	7	n/a
We require an effective communication platform so that we are in close contact with our customers and are able to manage any urgent (rush) orders	1	2	3	4	5	6	7	n/a
Procurement costs are a major part of our total product costs and are of high importance to us	1	2	3	4	5	6	7	n/a
We require software support to reduce the time and cost of procurement and the time involved when negotiating with suppliers	1	2	3	4	5	6	7	n/a
A software system that is compatible with external systems and/or platforms (e.g., of our customers and/or suppliers) would provide a significant advantage to our company	1	2	3	4	5	6	7	n/a

<End of Section B>

SECTION C: ERP Features and Extensions

This section focuses on the functionality of ERP systems and extensions to ERP systems, e.g., for Advanced Planning and Scheduling (APS), and asks about the extent to which this functionality is used within your company.

If your company uses an ERP system: please answer this section and then continue to Section D.

If your company does not use an ERP system (including those that are currently installing ERP): the questionnaire finishes here - thank you once again for your valuable contribution to our research.

C1. Customer Enquiry Management via ERP

	Strongly Disagree						Strongly Agree	
ERP integrates and coordinates several departments in our company to support customer enquiry management tasks	1	2	3	4	5	6	7	n/a
We use our ERP to automate the entering of order details at the customer enquiry stage	1	2	3	4	5	6	7	n/a
We use our ERP system to store and retrieve historical data (e.g., on previous similar orders) to support due date and pricing estimations	1	2	3	4	5	6	7	n/a
We use the Available-to-Promise (ATP) functionality in our ERP system or in our Advanced Planning and Scheduling (APS) system when determining due dates	1	2	3	4	5	6	7	n/a
We use the Capable-to-Promise (CTP) functionality in our ERP system or in our APS system when determining due dates	1	2	3	4	5	6	7	n/a
We use Product Lifecycle Management (PLM) software (also known as “Product Data Management” (PDM) software) to support price estimations at the customer enquiry stage	1	2	3	4	5	6	7	n/a

C2. Design and Engineering via ERP

We use a product configurator application (or “variant generator”) within our ERP system to support design and engineering tasks	1	2	3	4	5	6	7	n/a
We use PLM software to support design and engineering tasks	1	2	3	4	5	6	7	n/a

C3. Planning for Order Entry via ERP

We use the MRP functionality of our ERP system during production planning	1	2	3	4	5	6	7	n/a
We use our ERP for mid-term and short-term planning tasks (e.g., to adapt capacity)	1	2	3	4	5	6	7	n/a
We use an APS for mid-term and short-term planning tasks (e.g., to adapt capacity)	1	2	3	4	5	6	7	n/a

4. P[illegible]nn[illegible]g a[illegible]e Order Review and Release Stage via ERP

We us[illegible]he f[illegible]tio[illegible] of our ERP system after planning but before manufacturing om[illegible]ces [illegible]lete[illegible] which jobs to "release" (i.e., begin manufacturing)	1 2 3 4 5 6 7 n/a
We u[illegible]he f[illegible]tion[illegible]f our APS system to determine which jobs to "release" (i.e., begi[illegible]anuf[illegible]ring)	1 2 3 4 5 6 7 n/a

C5[illegible]anni[illegible]at th[illegible]op Floor Sequencing Stage via ERP

We[illegible] the fur[illegible]nality [illegible]re ERP system to support sequencing decisions on the shop flo[illegible]	1 2 3 4 5 6 7 n/a
W[illegible]e the fun[illegible]ality of [illegible]ystem to support sequencing decisions on the shop floor	1 2 3 4 5 6 7 n/a

[illegible]Develop[illegible] Cust[illegible]elationships via CRM Software

[illegible] use our Cus[illegible]r Relat[illegible]nagement (CRM) software to help us improve [illegible]ationships wi[illegible]sting cu[illegible]	1 2 3 4 5 6 7 n/a
[illegible]e use our CRM[illegible]sess pot[illegible]sting customers, e.g., profitability loyalty	1 2 3 4 5 6 7 n/a
We use the analy[illegible]ls of our [illegible]m to support the development of strategies for improving our [illegible]nships wi[illegible]omers	1 2 3 4 5 6 7 n/a

C7. Supply Ch[illegible]nageme[illegible] via ERP and SCM Systems

Our ERP system pro[illegible]e foundations for Supply Chain Management (SCM) software applications	1 2 3 4 5 6 7 n/a
We use SCM software [illegible]ons to coordinate our supply chains	1 2 3 4 5 6 7 n/a

<End of Section C>

SECTION D: Performance Measurement

This final section focuses on performance measurement and asks you to describe the effect that the implementation of an ERP system has had on your company.

D1. Improved Customer Enquiry Management Performance

Since we began to use an ERP system:	Strongly Disagree						Strongly Agree	
More realistic (achievable) due dates have been quoted (promised) to customers	1	2	3	4	5	6	7	n/a
The time required to produce a quotation has been reduced	1	2	3	4	5	6	7	n/a
Our on-time delivery performance has improved	1	2	3	4	5	6	7	n/a
Our pr[illegible]dures at the customer enquiry stage have become more defined and standa[illegible]sed	1	2	3	4	5	6	7	n/a
The pr[illegible]ortion of quotations that become firm orders has been improved	1	2	3	4	5	6	7	n/a
The pr[illegible]ability of our products has increased (we have improved how we determine pr[illegible]s [illegible]ue[illegible]tes)	1	2	3	4	5	6	7	n/a

D[illegible] Ir[illegible]ro[illegible]ed Design and Engineering Performance

Th[illegible]ug[illegible]he[illegible]e of our ERP system:								
W[illegible]are[illegible]ette[illegible]abl[illegible]o meet customer order specifications	1	2	3	4	5	6	7	n/a
O[illegible]ab[illegible]y to[illegible]atis[illegible] customers when products are customised or bespoke has improved	1	2	3	4	5	6	7	n/a
P[illegible]duc[illegible]lev[illegible]pr[illegible]t activities are more efficiently performed (e.g., similarities between n[illegible]ar[illegible]pas[illegible]rd[illegible] is more easily detected, reducing duplicated effort)	1	2	3	4	5	6	7	n/a
W[illegible]car[illegible]uto[illegible]ate[illegible]eviously time consuming and manual documentation tasks	1	2	3	4	5	6	7	n/a

[illegible] Ir[illegible]ro[illegible]ed [illegible]anning Performance

[illegible]ug[illegible]he[illegible]e o								
[illegible] MR[illegible]mo[illegible]le w[illegible]in our ERP system, we have improved our adherence to due dates	1	2	3	4	5	6	7	n/a
[illegible]r ER[illegible]yst[illegible], le[illegible]times have been shortened	1	2	3	4	5	6	7	n/a
[illegible]r ER[illegible]yst[illegible], w[illegible]e able to be more proactive and anticipate unexpected scenarios	1	2	3	4	5	6	7	n/a

in planning		
Our ERP system, we are better able to control the release of orders, improving our adherence to daily schedules	1 2 3 4 5 6 7	n/a
Our ERP system, Work-in-Process (WIP) and congestion on the shop floor has been reduced	1 2 3 4 5 6 7	n/a
Our ERP system, we are better able to meet daily production schedules	1 2 3 4 5 6 7	n/a
Our APS system, production planning has improved	1 2 3 4 5 6 7	n/a
Our APS system, we are better able to meet daily production schedules	1 2 3 4 5 6 7	n/a

D4. Improved CRM Performance

Our CRM system helps us to:		
Improve customer satisfaction levels through close contact & coordination with customers	1 2 3 4 5 6 7	n/a
Convert one-off (or first time) customers into repeat purchasers	1 2 3 4 5 6 7	n/a
Explore new market opportunities (e.g., to find and evaluate potential new customers)	1 2 3 4 5 6 7	n/a
Increase the proportion of quotations that become firm orders	1 2 3 4 5 6 7	n/a
However:		
We have <u>not</u> observed any direct significant impact on profitability as a result of using CRM	1 2 3 4 5 6 7	n/a
The return on investment from our CRM system is <u>not</u> significant	1 2 3 4 5 6 7	n/a

D5. Improved Supply Chain Planning Performance

Through the use of SCM software:		
We have improved our ability to meet the due dates of urgent (or rush) orders	1 2 3 4 5 6 7	n/a
Coping with urgent (or rush) orders has become less of a challenge	1 2 3 4 5 6 7	n/a
Urgent (or rush) orders cause less disruption to our existing production schedule	1 2 3 4 5 6 7	n/a
However:		
We have <u>not</u> observed any direct significant impact on profitability as a result of using SCM	1 2 3 4 5 6 7	n/a
The return on investment from our SCM system is <u>not</u> significant	1 2 3 4 5 6 7	n/a

The questionnaire concludes here - Thank you very much for your time and contribution to our research. I ou would like to make any further comments on the effectiveness of ERP systems for UK manufacturing, please use the comment box below.

Comments:

Contact Details (optional)

Please provide your contact details below if you would like to be entered into a PRIZE DRAW and receive a copy of the study's executive study. Furthermore, after the survey, we plan to continue the project by studying individual cases - if you are interested in participating in the second stage of the work, please indicate this below.

☐ I would like to enter the prize draw and receive a copy of the study's executive summary.
☐ I would be interested in participating in the second stage of the research – the study of individual cases.

Name : _____

Company : _____

Address : _____

_____

_____

Appendix B: Interview Protocol for non-adopter

Section 1: Background Information

Basic Company Details

- Can you confirm how many people work for the company?
- What is the annual turnover of the company?
- What industries is the company involved in?
- Who are the company's major customers?
- Who are the company's main competitors?

Basic Job Information

- Can you give some examples of typical products the company makes?
- Are most products made from the same materials? Do you stock materials?
- Are there any common components?
- What proportion of orders are new, and what proportion are repeat jobs?
- How much of production is make-to-stock?

Section 2: "Why?" Questions on NON-ADOPTION

- Why do you think that ERP is not suitable to your needs?
    - What made you think that?
        - Evaluation analysis results?
        - Your insight?
        - Experience of managers/directors with other systems in other firms?
- Have you considered using packages other than ERP?
- If not using any software, how do you cope with managing the information flow, managing project-based jobs or planning production in your company?

Section 3: "How?" and "What?" Questions on DAY-to-DAY production

Customer Enquiries

- Please describe how you deal with requests for quotations (customer enquiries).
    - How do you determine prices & set due dates?

Due date:

- How do you generate alternative due dates when dealing with customer enquiries?
- To what extent are you aware of the availability of subcontractors and suppliers when promising due dates to customers?
- Why do you think access to historical data is not that important on quoting due dates?

Cost:

- How detailed is your analysis of costs when responding to a request for quotation? Which tools do you use for this?
- How do you maintain a good communication amongst departments when responding to customer enquiries?

- Have you considered using packages other than ERP for Customer Enquiry Management (CEM) planning?
    - If yes, how did this enable you to cope with CEM planning? & What effects have these had on performance?
    - If no, why not?

- Can you confirm what the strike rate (percentage of quotations converted into confirmed orders) of your company is?
- What functionality would help you improve your strike rate?

Design and Engineering
[Reported quite high decision support requirements in the survey for the design & engineering of your products.]
- Which software do you use for the design & engineering of your products?
- How flexible is your design and engineering software for handling your product diversity?
- How do you maintain the communication amongst departments to support design and engineering tasks?

Production Planning (for you or your associated manufacturing companies)
- How do you currently plan and schedule your production? [e.g., MS Excel, other]
    - At which particular production planning stage has your current planning method been most effective?
- Have you considered using packages other than ERP for production planning?
    - If yes, how did this enable you to cope with planning?
    - If no, why not?
- Do you have a decision point after planning but before manufacturing commences at which you determine which jobs to "release" (i.e., begin manufacturing)?
    - If yes, how do you deal with it? Do you get software support for this?
    - If no, do you think you may need such a decision point?
- Do you need complex tools to deal with shop floor sequencing?

Customer Relationship Management (CRM) & Supply Chain Management (SCM)

- Why do you not need a tool to help you manage your relationships with existing and potential customers? [CRM]
    - Do you think CRM software would help you
        - entice first-time or one-off customers into longer & more robust relationships?
        - have more loyal customers and to build prolonged customer relationships based on trust?
    - What do you currently do to ensure these kinds of relationships?
- How do you share information with your suppliers; and otherwise co-ordinate your activities with theirs? [SCM]