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Supply chain integration systems by small engineering to order companies

The challenge of implementation

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Abstract

Purpose – The purpose of this paper is to develop a model for overcoming the key barriers to the implementation of supply chain integration systems by small engineering to order (ETO) companies.

Design/methodology/approach – Qualitative data from three in-depth case studies are collected. The three case studies are small UK ETO companies, i.e. manufacturing companies that customise generic product types to meet specific customer requirements and only make these to order.

Findings – The paper identifies three key barriers: management awareness of the benefits and implementation challenges of these systems, perceived risk to the business and to information security and intensity of skills needed for their successful implementation. The paper proposes an iterative model that aims at overcoming these barriers.

Research limitations/implications – The authors apply the knowledge on technology adoption in the context of small ETO companies to explain the apparent lack of implementation of supply chain integration systems by small ETO organisations; and propose a model to overcome these barriers. The main limitation is the lack of full validation of our model. Although this model has been presented and discussed the with case study companies, it has not been fully implemented yet. A full implementation and subsequent review would provide unequivocal validation.

Practical implications – The paper presents a model for overcoming the key barriers of implementation of supply chain integration systems by small ETO companies. Managers and consultants that aim at implementing such systems can use this model prior to implementation to reduce the potential impact of these barriers on the implementation.

Originality/value – There are two contributions of this paper. The first is the explanation of the barriers that inhibit the implementations of supply chain integration systems by small ETO companies. The second is the development of the model for overcoming these.

Keywords Supply chain management, Small enterprises, Integration, United Kingdom

Paper type Case study

1. Introduction

Supply chain integration systems provide the means to integrate business processes across two or more companies. They aim at reducing costs and improving quality primarily through the accurate and speedy electronic sharing of information across two or more businesses (Davenport, 1998; Hendricks *et al.*, 2007). Such information sharing can lead to immediate operational improvements such as improved throughput, customer response times and delivery speeds (McAfee, 2002). Furthermore, integration systems can improve management decision making by providing real-time information (order changes, contracts, introduction of bespoke products in the manufacturing sequence, real time sales information on bidding and auctions), providing marketing

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information, and of course, expanding the geographical coverage of the products and services companies offer (control business from a central location as opposed to several locations) (Davenport, 2000; Damanpour and Damanpour, 2001). Finally, as such systems are often required by key customers, suppliers' business survival often depends on their successful implementation (Bingi *et al.*, 1999).

Empirical studies that have examined the link between implementation of these systems and organisational performance have found mixed results (Fu *et al.*, 2006a, b; Hendricks *et al.*, 2007). Two important reasons for the results for this inconsistency are the methodology and the choice of the metrics used to assess performance (Hendricks *et al.*, 2007). As it is not possible to isolate other factors that affect organisational behaviour, it is difficult to decisively conclude that the implementation of an integration system will improve performance. An additional reason that has led some studies to conclude that implementing such systems may not lead to improved performance is the high-implementation costs which may often exceed the operational savings achieved following their implementation (Chatterjee *et al.*, 2002).

Despite the lack of consistent evidence and the high costs, the potential benefits of information sharing have driven several manufacturing companies to include supply chain enterprise integration in their business strategy (Webster *et al.*, 2006). There is however little evidence of this being the case with engineering to order (ETO) companies which is the focus of our work. ETO companies are those manufacturing companies that customise generic product types to meet the specific requirements of each customer and only make these to order (Hill, 2000). Relatively few such companies have fully and successfully adopted such systems and even fewer have reported clear benefits. In spite of the importance of this issue for these companies, little work has been carried out to explore the barriers that inhibit the adoption of integration systems and how they can be overcome.

In this paper, we aim to cover this gap and provide guidance on overcoming the barriers that inhibit the implementation of such systems by small ETO organisations. To do so we first review the literature on technology adoption in general. We then relate the findings of the literature in the context of small ETOs. We do so following the collection of qualitative data from three such companies. Finally, we propose a model aiming at overcoming these barriers.

2. Literature review

Factors that inhibit adoption of new technologies have been explored by researchers in various contexts. As a result, formal theories and individual factors have been proposed aiming at explaining and predicting the adoption of new technologies. The most prevailing formal theory is the technology acceptance model (TAM) (Davis *et al.*, 1989) and stems from decision theories and social psychology (Riemenschneider *et al.*, 2003). TAM argues that two particular beliefs, perceived usefulness (the subjective probability that using a specific application system will increase a user's job performance) and perceived ease of use (user's subjective probability that using a specific application system will increase his or her job performance) can explain and predict computer usage behaviour (Davis, 1986; Davis *et al.*, 1989). TAM has since been used to explain computer acceptance to various contexts, such as free content web sites (Castaneda *et al.*, 2007) and tax filling (Fu *et al.*, 2006a, b). Most of these studies have focused on the ability of TAM to explain the adoption of computer systems by

individual users or business executives (Riemenschneider *et al.*, 2003) while they have used quantitative techniques to validate their hypotheses. A few studies that have used the firm as the unit of study (Amoako-Gyampah and Salam, 2004) have explored the integration systems such as enterprise resource planning (ERP) and their potential impact on performance. They have found that training, project communication and closeness of fit with the ERP systems can increase the likelihood of success implementation (Hong and Kim, 2002; Park *et al.*, 2007).

Studies that examine technology implementation but do not explicitly consider the implementation of TAM, often try to identify how isolated factors can affect the adoption of a new system. The factors that are generally examined include management awareness (Bontis and Castro, 2000; McCarthy and Tsinopoulos, 2003), perceived risk (Attaran, 2000), required skill intensity (Rahim and Pennings, 1987; Mody and Dahlman, 1992), a firm's structural characteristics (Bayo-Moriones and Lera-Lopez, 2007) and the product complexity (Tan *et al.*, 1998; Christopher and Towill, 2000; Childerhouse and Towill, 2006). As we explain in the next section of the paper during our conversations with the managers of the ETOs we found that it was the first three (management awareness, required skill intensity and perceived risk) that have specifically affected the implementation of integration systems. In the next paragraphs, we briefly elaborate on how these factors may affect adoption of new technologies.

Management awareness of the benefits of the new systems may result to higher commitment to their implementation (Bontis and Castro, 2000; Tovstiga and Fantner, 2000; Froome, 2001). As management commitment is often cited as a key success factor to change projects (Bingi *et al.*, 1999) higher management awareness can increase the likelihood of implementation. In TAM terms, higher management awareness would increase the perceived usefulness of the new systems and therefore increase its chances of successful implementation.

Perceived risk is often found to have a profound effect on the implementation of new technologies. With a few exceptions (Fu *et al.*, 2006a, b) most research studies have concluded that risk of failed implementation or risk of the loss of data often stops both companies and individuals (Choudhury *et al.*, 2008) from the implementation of a new technology. It may for instance result in risk of unsuccessful implementation and therefore potential loss of investment. Similarly, integration systems often manage information such as intellectual property which is perceived as providing organisations with competitive advantage. Therefore, the risk of a security breach to these will reduce the likelihood of implementation of the new system.

The skill intensity required to implement new integration systems is usually relatively high (Rahim and Pennings, 1987; Bingi *et al.*, 1999). This is so because a new set of skills is often needed to both implement and operate a new system. To overcome this difficulty companies often outsource part or all of the implementation and train their staff to use it post implementation. Despite the apparent simplicity of this process it has often led to dissatisfaction in its implementation and use (Kumar *et al.*, 2003; Yusuf *et al.*, 2006). In terms of TAM, the required skill intensity would decrease the perceived ease of use and would therefore reduce the likelihood of successful implementation.

3. Method

The aim of this study is to explore the barriers that inhibit the implementation of integration systems by small ETO companies and to provide guidance on

overcoming them. To address this aim we carried out three in depth case studies. We did so to understand the operation and uniqueness of ETO companies. Case studies help placing research results in an organisational context (Eisenhardt, 1989; Boiral, 2007) and thus they can help us examine in detail the barriers to the implementation of new technologies. This is especially important for ETO organisations, the output of which makes the implementation of off the shelf software packages difficult. Such companies typically develop unique solutions for integrating their processes across the supply chain. Therefore, to examine the process of implementation of the software packages we had to understand in detail these unique solutions and the potential barriers to their implementation.

3.1 Case study description

We included three UK ETO companies that manufacture complex products following the receipt of customer orders. The smaller company employed 120 and the larger 230 people. Examples of these products include special purpose machinery, insulation for use at nuclear plants, large-scale safety equipment, etc. Please note that due to the sensitivity of the information shared with us during the data collection we cannot report the names of the companies.

3.2 Data collection process

Data was collected by:

- observing the usage of the systems over a period of two to three days;
- interviewing three key informants within each case study business unit; and
- reviewing any available records, e.g. minutes of meetings, which could have provided further insight into the implementation of supply chain integration systems.

During the observations we were given access to, and demonstration of the usage of, the systems in question. We then noted how the systems were actually being used by the companies' employees for the fulfilment of the orders. Familiarisation with the systems allowed us to put them and the people we interviewed into context.

To ensure that we examined all the angles of the implementation process, we would typically interview the business unit director, the operations manager and an IT manager from each case. The director would provide a broader view of the needs, benefits, and aspiration of the new systems and how they support the business strategy. The IT manager would provide a technical view of the implementation challenges and how the system is designed to work. Finally, the operations manager would provide an insight on how such systems have changed the running of the day-to-day operations.

During the interviews and observations we focused mainly on how the systems should work and how they actually worked. Furthermore, during this process we familiarised ourselves with one order, which we then used in the interview section. This step was added to ensure that the interview was focused on specific examples and thus identified specific problems on the usage of such systems.

The semi-directed interviews lasted about 45 minutes-1 hour. The interview structure consisted of two parts. During the first part we asked for some general information about the company, the business unit, and their role within it. We also

asked them to describe the technology used to manage information across the supply chain. More specifically, we asked them to name and describe the systems used and the reason for implementing them in the first place. One of the companies had implemented a customisable off the shelf system while the other two had developed their own. During the second part of the interview we asked them to describe what they thought the key barriers were in the implementation of these systems.

After we developed our implementation model (explained in a later section of the paper), we asked the directors to review and comment on it. The model presented in this paper is the one following the revisions.

4. Results and discussion

Predictably, the three companies analysed provided evidence of some integration of supply chain systems within their operations. The level of adoption however varied significantly. At the basic level all three companies had developed web sites to advertise their services, while only one had to adapt their systems to communicate with those of their customers. One had implemented an affordable ERP system in the mid cost range and the other two had developed in house bespoke systems for their specific requirements. Finally, all companies had participated to e-auctions for winning new business but considered the process to be inappropriate for ETO companies.

From our observations and conversations with the three informants there were three common barriers to the complete implementation of fully integrated systems: senior management awareness, risk (business and information security) and skill intensity.

The level of awareness of the senior management team was raised as a key issue in the implementation of business integration systems by all our interviewees. Even the three directors we interviewed argued that they did not know enough about the systems to embark on an investment. There were two areas that were affected by this apparent lack of knowledge. The first related to the benefits of the implementation. In line with the arguments found in the literature, our interviewees argued that the perceived usefulness of these systems needs to be clearly articulated. As it was argued by one of the directors:

> I know the general benefits of using these systems. However, I need to know what they mean for us. By the very nature of our operation [. . .] we have challenges which suggest that we cannot simply implement off the shelf solutions. So we need to know how these general benefits of information sharing will apply on our case. A technical brochure is not enough to convince me [. . .]

The second area related to the difficulties and disruption a company would face during the implementation process. Similar to the previous arguments our director interviewees explained that they felt there was little experience on the implementation of such systems by ETOs. This view is supported by our review of the literature during which we could not find any study focusing specifically on this sector.

It is important to note though, that despite the scepticism expressed, most of our interviewees understood the benefits that such systems have brought to other industrial sectors. Yet, it is lack of awareness on the applicability to the ETO sector and more specifically to their business that created the greater doubts.

The second barrier that emerged during the interviews was the perceived high risk of implementation. We identified two types of risk, business and security. The first relates to changes of the way the business is run and the potential risks that

these entail. The second relates to the potential of security breaches and thus loss of intellectual property. We elaborate on both types of risk in the next paragraphs.

Older companies have gained experience in certain organizational routines. As a result the efficiency of the execution of these routines is increased (Sorensen and Stuart, 2000; Cefis and Marsili, 2006; McCarthy *et al.*, 2006). However, the implementation of integration systems requires significant change in the routines as has been reported in previous studies (Sherry and Martin, 2007). Therefore, the implementation of large new systems requires an entrepreneurial spirit, which is not always compatible with traditional organizational structures (Lal, 1999; Hamel, 2000; Muggeridge, 2001). Therefore, the perceived business risk of failure is increased. Furthermore, given the size of these companies, the impact of the risk is high and could lead to complete business failure. The size impact on attitude to risk on the implementation of new technologies could explain some of the conflicting results found in the literature on the importance of risk (Fu *et al.*, 2006a, b).

As was explained to us by the company that had implemented the more sophisticated system, prior to implementation such systems were perceived as risky to the business. This was so because the routines needed to run these systems did not constitute elements of the core products and processes, which members of staff were familiar with. Their adoption required significant changes which led staff to act outside the range of the routines they were used to. Moreover, the new routines were often perceived as non value adding.

The second type of risk was security. Each of the companies we interviewed held a market niche (e.g. fire protection, specialist insulation). The knowledge to develop their products was created through an incremental process that may have taken years and often decades to complete. Such knowledge is protected by two means; patents and secrecy. Patenting new processes offers sufficient protection but due to high depreciation of the patented knowledge (Schankerman, 1998) and difficulties in patenting complex technologies (Kingston, 2001) secrecy is a more feasible option for the ETO sector. As a result, ETO companies' information systems often store sensitive data, which if accessed by competition may have significant impact on their competitive advantage. Fear of such a breach thus acts as a barrier to the enthusiastic adoption of supply chain integration systems.

Despite having appropriate firewalls to protect their systems from external threats, our interviewees expressed concerns about the overall security. As was explained by our interviewees there are two specific means through which supply chain integration systems can lead to loss or disclosure of valuable knowledge. The first is related to the bidding process. To win new contracts ETO companies would often have to go through a process of competitive bidding. This bidding process often requires them to disclose some information in the public domain. An online supply chain integration system which makes this information easily available to anyone that has access to the bidding information, can lead to loss of valuable data and therefore limit the willingness of participating companies to fully integrate with such systems. The second is related to the daily development of new core processes. As knowledge on the processes of ETO companies is increasingly becoming more complex, more and more technical information is stored on the computer systems. A potential breach of the system could lead to disclosure of the knowledge needed to carry out these core processes as illustrated in the following quote:

> There is a lot of concern about the information we put in there and we tend to be very conservative about what information we put into the public domain and how we ensure only the appropriate eyes can see it.

Given the sensitive nature and the amount of knowledge stored in the computer systems of ETO companies, high-perceived risk of a security breach inhibits the adoption of supply chain integration systems.

The final issue that emerged as inhibiting the adoption of supply chain integration systems is skill intensity. Adopting supply chain integration systems and IT systems in general within a business requires skills different to the ones needed to run the core processes of the business (i.e. technical skills focused on the core competences of a business) (Lal, 1999). Such skills are needed first to implement these systems in production processes, and second to use them effectively during normal operations (Reason, 1998). Therefore, lack of them may reduce the ease of use of supply chain integration systems and consequently act as a barrier to their implementation.

ETO companies' technical knowledge is relatively high. ETO companies' manufacturing and supply chain processes are unique and the level of customization is high. Therefore, a lot of tacit knowledge is accumulated by the workforce and makes it difficult to replace. Thus, when needs for new skills arise, say, due to the acquisition of a new technology, training existing staff is a more feasible option than employing new ones. Consequently, all three companies had a policy for re-training existing employees. The policies for retraining employees focused primarily on the skills needed to run the core operations. Nevertheless, acquisitions of new technologies for integrating supply chain integration systems also received significant emphasis in terms of training.

The above three barriers are of course interlinked. For instance, high-skill intensity implies relatively higher levels of training within an organization, which in turn may result to higher level of awareness and knowledge within an organization. When this is the case the management approach would be more entrepreneurial as managers may be more inclined to take calculated risks. Considering the three barriers could therefore help increase the implementation success. In the following section, we propose a model that aims at overcoming these barriers.

5. A proposed model of implementation

The overcome the barriers identified in the previous sections we propose a model that consists of an iterative process taking place prior to the commencement of the implementation process. The model aims at informing the decision-making process for the implementation. Processes for the technical part of the implementation, i.e. after the completion of our proposed model, depend on the system that is being implemented and have largely been explained in the literature. Furthermore, we suggest that this process should be owned by an implementation champion. As often found in both the project and change management bodies of literature, ownership of such processes increase the likelihood of success. The model is shown in Figure 1 and explained in the following paragraphs.

In the way of validation, we presented the barriers we identified and our proposed model with the most senior of our interviewees. They made several recommendations for the improvement of the model, particularly in relation to the operation of the

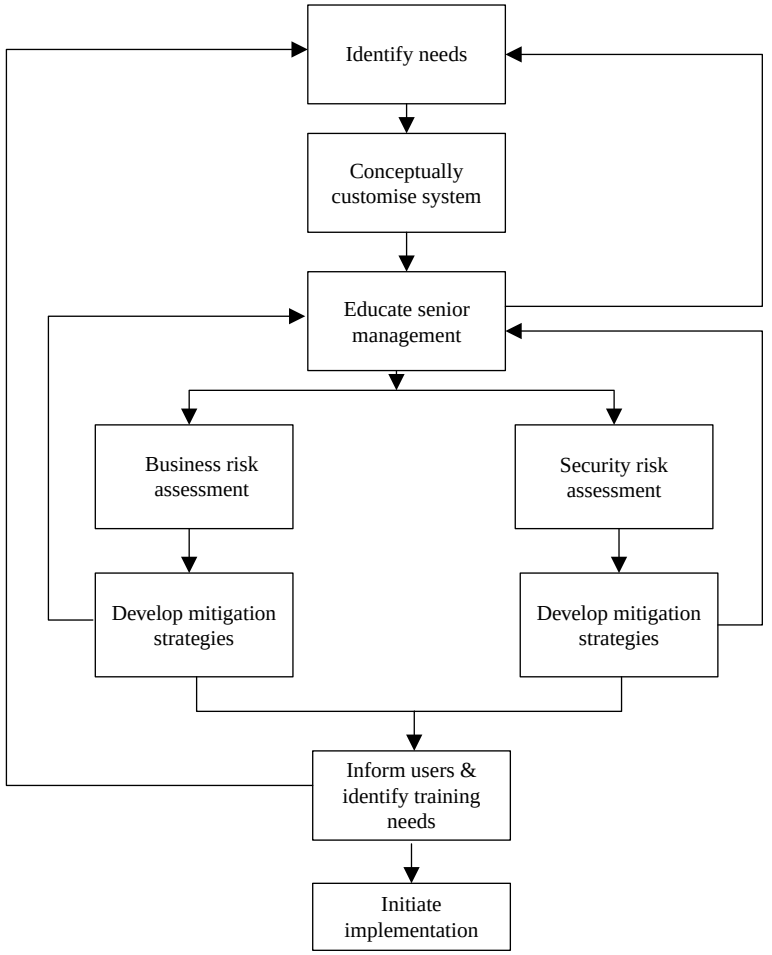

Figure 1.
Proposed model

feedback loops. The model we present in this paper and shown in Figure 1 is the one that includes all the recommendations.

The model starts with the identification of the need for the system. As was clearly indicated several times during our observations and conversations with the three companies ETOs' needs are unique and therefore off the shelf integration systems cannot easily be used. During the needs' identification stage the role of the implementation champion is to build a technical and financial case for the need of the model. In two of our case study companies the implementation of such systems was either the responsibility of an engineering director or simply the IT manager with no proactive approach for the development and implementation for the identification of needs. In the third case (the one with the more sophisticated system in place), the acquisition and implementation of the integration system was a response to changes in the market.

The output of this process is then used to develop a new customised system. This customised system does not have to be an entirely new system but, as was demonstrated by the one company that had one in place, an adaptation of one which is used in the market. At this stage the senior management needs to be involved. We call this stage "educate senior management" because they will need to learn how the benefits of the new customised system will be applied, and what the challenges and potential benefits will be. As a consequence of this stage, it is very likely that there will be recommendations for modifications which will be fed back at the beginning of this process. These three initial stages will ensure the new system is customised to the unique needs of each ETO and more importantly that there is management commitment which is seen as a success factor in many projects (Holland *et al.*, 2000; Hong and Kim, 2002).

The next key step in our proposed model relates to the second barrier we identified, risk. As shown in Figure 1 we propose two parallel processes of risk assessment. The first explicitly examines the business risk and the second the security risk. Naturally, there will be overlaps between the two risk management processes. However, following our discussions with the IT managers, it was apparent that the assessment of the security risk involves technical detail which often goes beyond the knowledge of the non IT specialist. Therefore, during the security risk assessment IT staff will identify potential risks and develop mitigation strategies for those. The aim of the business risk management assessment is to identify how changes in the current processes will affect the business performance. Again this process should result in the development of mitigation strategies. The resulting mitigation strategies of both the security and the risk assessment processes will then need to be fed back to the "educate senior management" process, and, if needed, modify the system to reduce likelihood of occurrence of the most important risks.

The final stage relates to the final barrier we identified, skill intensity. Studies examining IT return on investment have found that training influences user attitudes and behaviour towards IT (Davis and Bostrom, 1993; Yi and Davis, 2001; Amoako-Gyampah and Salam, 2004), and return on investment (Rahim and Pennings, 1987; Mody and Dahlman, 1992). As a result employees are more likely to be open to new technologies when there is a clear policy that encourages continued training. As a result during the final stage of our proposed model the potential users of the new system are informed of the need of the new systems. Also, the implementation champion assesses any preliminary training needs. The outcome of this process will be fed back to the beginning of the model when there are significant gaps in the knowledge needed to run the new system.

As shown in Figure 1 and explained above, the process consists of several feedback loops which mainly aim at increasing the information available to the management, consequently, ensuring their continuous commitment. As a result of this process the supply chain integration system will be customised to the unique needs of an ETO and therefore it will strengthen the case for its implementation and increase the likelihood of its success.

6. Conclusions and future work

In this paper, we set out to examine the barriers to the adoption of supply chain integration systems by small ETO companies and propose a model for

overcoming them. Following a review of the literature and analysis of qualitative data collected from three small UK ETO companies we identified three barriers, namely, management awareness, perceived risk and required skill intensity. We also developed a model, which aims to reduce the impact of these barriers. The proposed model should take place prior to the initiation of the implementation of a new system.

The above findings and proposed model have implications for two types of practitioners; individuals within organisations that are trying to implement business systems, and those that are developing them for ETO organisations. For the former, the important advice is that "educating" the senior management for the systems' benefits and reducing the perception of any business risk would increase the likelihood of success. Indeed, during our conversations and observations we observed that in companies where the level of implementation was more advanced, the senior management we interviewed was significantly more aware of the potential benefits. For the latter, our advice would be that the key to the success of both the development and selling of supply chain integration systems to small ETOs is to overcome the perception that these systems are risky by ensuring information security is compromised.

The main limitation of our work is the lack of explicit validation of our model. This model has been developed using information collected from managers and users of small ETOs, i.e. those who are likely to use such a model. Furthermore, we discussed this model with those managers and further modifications were made (particularly in relation to the need for feedback loops). Although we have confidence on its practicality and usefulness, as the model has not been fully implemented yet, we cannot claim that it has been fully validated. Therefore, future work could further validate this model by applying it prior to implementation of a new integration system in a small ETO company.

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