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The Business Model for the Functional Rapid Manufacturing Supply Chain

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Abstract

The use of the Rapid Manufacturing (RM) technologies to manufacture end used product has become a more viable proposition these days than it was in the past. However, the characteristics of the technology allow for unconventional usage and subsequent supply chain support requirements. Therefore, it can be argued that the RM supply chain concepts have the potential room for further evolution. This research focuses on the possibility and structure of a business model tailored for the unconventional RM supply chain requirements. In this regard, the paper proposes the Virtual Trading System or VTS, which is an e-business platform that could potentially provide an alternative to the RM industry, in terms of supply chain functionality. The research outlines the structure of such a business model in detail, based on the requirements of the RM industry.

Key words

Rapid Manufacturing, Rapid Prototyping, 3D Printing, Supply Chain, Business Model, e-Business, Virtual Trading System

JEL Classification: L6, M1

Introduction

Rapid Manufacturing (RM) has evolved from Rapid Prototyping (RP) technologies that have been successfully used to physically create designs and concepts. RM is concerned with the direct manufacture of parts and components using additive manufacturing techniques (Reeves, 2007; Hopkinson et al., 2006; Holmström et al., 2010). RM differs from the traditional production technology in that the *modus operandi* is not subtractive or formative (machining and moulding respectively), but rather, is additive in the way it layers up parts during manufacture. Internationally, RM is also referred to as: Layer Manufacturing Technologies (LMT), Generative Manufacturing and 3D Printing (3DP) amongst many others (Pham & Dimov, 2001; Levy et al., 2003; Hopkinson et al., 2006; Ariadi et al., 2008). This paper develops a business model to implement a functional supply chain for RM products.

RM technology lends itself to all types of customisation and is best suited to creating an infinite number of choices for one or more features. This perhaps is one of its

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biggest benefits. The consumers are becoming increasingly refined in their tastes and desires for new products. One method for tackling the requirements of the consumer is to provide a mass customisation service (Ruffo & Hague, 2007). However, RM is still thought by some people as a mere extension of RP (Reeves, 2007). In practice, the major difference between the two is in the supply chain where RM products are intended for end use, not just as a prototype. Hence, a functional supply chain required for RM products is still in an evolutionary stage and there remains scope for further research in this area.

The technology in the meantime continues to break new grounds. In particular, 3D printer, a less costly variation of RM technology has the potential to reach mass consumers. This variation of RM is very popular and has enjoyed impressive growth over the years (Wohler's Report, 2013). The market for 3D printing in 2012, consisting of all products and services worldwide, grew 28.6% to $2.204 billion. This is up from $1.714 billion in 2011 (Wohlers Report, 2013). In addition to 3D printers, there are other forms of the technology such as Sterolithography (SLA), Jetted Photopolymer (J-P), Selective Lase Sintering (SLS), Fused Deposition Modelling (FDM), Electron Beam Melting etc. (Additive3D, 2013; Tuck et al, 2006). Wohler's Associates conservatively forecasts industry-wide growth of the RM industry (including all forms of the technology) to be $3.1 billion by 2016 and $5.2 billion by 2020 (Wohlers Report, 2013).

RM is challenging the traditional way a manufacturing business can operate, since an individual can print 3D objects at home provided the computer aided design (CAD) is accessible (Lipson & Kurman, 2013). In addition, there is increasing scope of using the technology in the aerospace, automobile industries amongst others; albeit the cost of manufacture may be an issue is some applications of the technology (Campbell et al., 2012; Hasan & Rennie, 2008). In RM, not only the complexity is independent of cost; RM techniques are also able to produce virtually any geometry (Hopkinson et al., 2006, Holmström et al., 2010). In addition, higher volume does not need to be manufactured to offset the cost of the tooling, then the possibility of highly complex custom parts become apparent. One of the most important opportunities to arise from the ability to "manufacture for design" comes from the very real potential to consolidate many components into one. RM lends itself to all types of customisation and is best suited to creating an infinite number of choices for one or more features. The customisation of a product could be in terms of different functionality, different aesthetics, different user-fit, etc. Every product made using RM would be unique in some way. This effectively means manufacturing could be conducted into batch sizes of one (Hopkinson et al., 2006; Tuck & Hague, 2006; Holmström et al., 2010). However, at times the cost of RM can be a barrier in utilising the technology for manufacturing purposes. In spite of the cost issue there is scope for the use of RM technologies even in the case of medium size business as exemplified by Hasan and Rennie (2008), in their case study based research on spare parts requirement of vintage motorcycles. The key here is the use of the technology to break into new markets. According to a study (Hasan, 2008) involving senior industry consultants, the use of RM products can be increased if: 1) customers/ users operating RM machines or RM products stationed all over the world can be supported; 2) technical support services have to be modified as RM finds its way in non-conventional settings; 3) more efficient ability of the businesses to cater for individual customers. Therefore, in light of the vast potential of RM as technology to manufacture end used products and to support the subsequent unconventional sup-

ply chain requirements, this paper argues that there is a need for a new business model.

The use of RM technology coincides with the rapid increase and use of ICT technologies. The several decades have shown rapid increases in growth in the field of computer peripherals and internet access. This trend, where non-technology compliant customers are increasingly faced with new technology, inevitably leads to consumers being brought closer to the process, or being involved in the creation of their desired product. The internet has provided a viable means for business-to-business and consumer communication (Hopkinson et al., 2006). Technological advancement has opened up new opportunities for integration and management of all aspects of the supply chain, including for example, procurement production, inventory control, communication and logistics (Wynarczyk, 2000). The key to enable such supply chain is integration (Grimm, 2004) and e-business has emerged as a key enabler to supply chain integration. It is interesting to note that a digital entity (CAD file) is a prerequisite to make any RM product (Fralix, 2008). Such characteristics of RM make it convenient to be supported by the rapid development in the ICT sector. Hence, it may well be the case that RM supply and demand can be fulfilled virtually.

In summary, it is evident there are vast benefits of RM; however, in order to take advantage of these benefits, a comprehensive business model needs to be in place. A business interested in utilising RM could choose to outsource the technology use, install their own RM facility or even could alternate between them. Whatever the scenario, it is certain a business model is needed where all components of the supply chain including the network of suppliers, original equipment manufacturers, designers, engineers or even customers who are all geographically apart, have to communicate. This research investigates the question- "What would be the structure of an efficient ICT enabled e-business model for RM technologies?" Accordingly, this paper will describe the structure of an ICT enabled e-business model which can help implement the requirements of functional a RM supply chain.

1 The Concept of the Business Model

The business model defines the steps that are needed in order to complete a transaction.

This research adopts the definition of the business model advocated by Timmers (1999), which is:

- an architecture for product, service and information flow, including a description of the various business actors and their roles;
- a description of the sources of revenues;
- a description of the potential benefits for the various business actors.

The definition of an e-business model according to the literature WP3-E-Business Model Roadmap Deliverable 3.1 is (WP3, 2003):

"*A model is an abstraction of a complex 'reality'. It defines a set of entities their roles and their relationships. It can even define some qualitative and quantitative values of those entities. More specifically, a business model implies a set of entities in a com-*

mercial venture and portrays them in the context of two distinct set of factors, endogenous, that embrace factors that lie in the control of individual enterprises such as organisational, technical and individual factors as well as factors beyond the control of individual enterprises such as industrial and societal factors that in some cases are defined by policy makers. An e-business model is, thus, defined as an Internet-enabled business model."

Tapscott (2000) defined a topology that is based on the business networks creating a new kind of collaborative e-business (Business Webs). The classification can be used to describe e-business formats that are strongly based on cooperative alliance (Tapscott et al., 2000):

- Agora – dynamic pricing (e.g., Yahoo; eBay)
- Aggregation – selection and convenience (e.g., Amazon; E*Trade)
- Value Chain – process integration (e.g., Cisco; Dell)
- Alliance – creativity (e.g., AOL; MP3)
- Distributive Network – allocation, distribution (e.g., Enron; UPS)

The definition of e-business adopted in this research is:

"E-business or electronic commerce can be defined as any electronic communication that facilitates the exchange of goods, services or other assets and information exchange between suppliers, buyers and relevant stake holders. It is also termed as Business-to-Business or B2B, Business-to-Customer or B2C which can be classified as including sell-side (e-catalogues), e-marketplaces, trading partner agreements and buy-side (e-procurement)."

2 The Input to the Design Process of the E-Business Model

In order to construct a structure of a proposed e-business model for the RM product industry, different e-business models and their concepts have been studied. The feasibility study has been conducted in this regard. The design of the e-business model has been constructed in line with different governmental, non-governmental policy literature and other literature surveys. The policy literature includes the Work Package3- E-Business Model Roadmap (WP3, 2003), a policy paper constructed for the European Commission etc. The feasibility study also included a selected literature review on different e-business literatures. The model has been constructed in line with the requirements of the RM industry. In this regard this research has taken input from different industry sectors including the RM industry stakeholders. This has been done through a series of interviews during the research period. This section will elaborate on some of the findings of the mentioned interactions.

2.1 Interviews

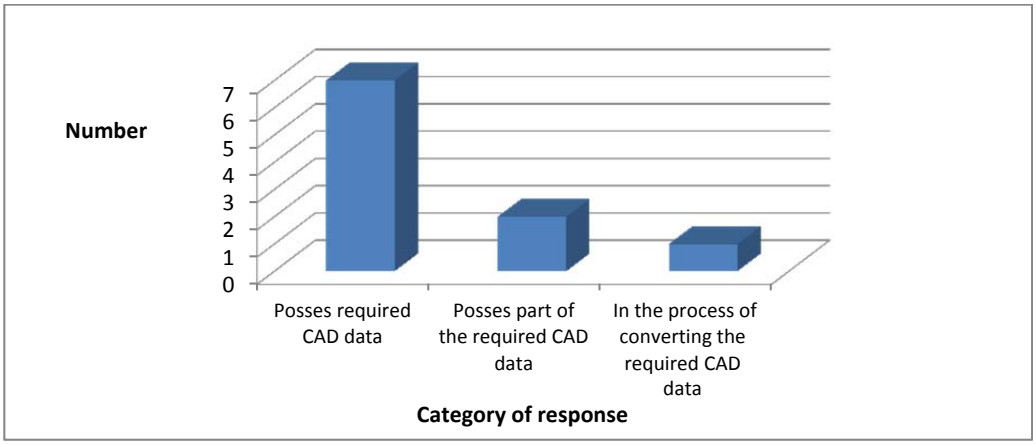
The participants to the interviews were chosen from a range of industry sectors; including part or product suppliers to the aerospace and automotive industries. The interviewees were chosen on the basis of their businesses prior experience with RM and/or the potential to use RM systems. All of the interviewees are part of the decision

making team of their respective businesses. Among the interviews, a couple of them took place at business offices of the interviewees whereas; the rest took place in the side-line of the Aerospace Procurement-2008 Manchester, Medtec Exhibition-2008 Birmingham and the SFF symposium 2008 Austin, USA. The interviews and data collected are important since the interviewees (companies) are potential stakeholders in the proposed business model. One of the questions asked in the interviews was:

"Whether they possess digital CAD data for their manufactured products?"

The number of people who answered this question is 10 and their responses are illustrated in the bar chart in Figure 1.

Figure 1 Response of the interviewees regarding availability of CAD data



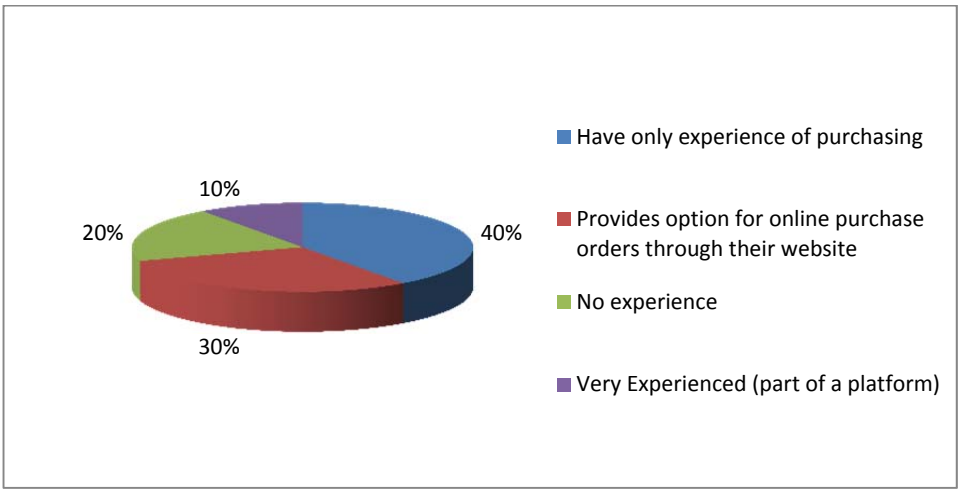
It should be mentioned that none of the interviewees replied that they don't have CAD or don't have any intention of acquiring CAD data for their manufactured products. Amongst the two interviewees who responded that they possess part of the required CAD data. One of them, a Managing Director of a company supplying parts to the aerospace industry responded that his company still has some old drawings in 2D sketch format. The other business which is involved in the automotive industry responded that his company is in the process to acquire the required 3D CAD data.

Another question asked in the interview was:

"Are you (Business you represent) familiar (users) with any form of internet commerce?"

The pie chart in Figure 2 shows the responses of the interviewees to this question. As in the case of the first question, 10 people representing their business were asked for their responses. Amongst them 40% have experiences of purchasing online whereas 30% provides option for online purchase orders through their website. 20% responded that they do not have any experience of internet commerce. One of the interviewees responded that his business is part of an e-business platform named Exostar.

Figure 2 Responses of the interviewees regarding experience of internet commerce



The idea of these interviews was to identify whether the possible businesses that could be part of the business model that this research would elaborate are ready for such a model or not. The responses shows that there is satisfactory preparedness in terms of the CAD data and businesses are more or less familiar with the idea of internet commerce.

2.2 Input from RP/RM Service Bureaux

The current situation of RP/RM manufacturing is very much service bureau centric. The service bureaux provide their customers specialised manufacturing service for RP/RM products. Therefore, any business model for RM technologies has to take into account the RP/RM service bureaux and the role they will play in the changing situation. Therefore, it is very important to take input from the service bureaux as they will potentially be a very important part of the business model. In this quest e-mail interviews were sought from different service bureaux across the UK and overseas. Table 1 lists the location of the RP/RM service bureaux who have responded and their respective locations. The name of the company cannot be disclosed for confidentiality reasons.

Table 1 List of RP/RM service bureaux taken part in interviews

Name of the Service bureau	Location
Company A	Berkshire, UK
Company B	Belfast, UK
Company C	Hertfordshire, UK
Company D	Poole, UK
Company E	Birmingham, UK
Company F	Illinois, USA

One of the questions asked in the interviews was:

"Q1. Would you be interested to be part of an e-portal which will only conduct trade of RM products?"

The responses to this question are listed in Table 2

Table 2 Responses to Question 1

Response	List of individual responses from RP/RM service bureaux to Q1.
1	Possibly, we would have to assess what impact being a member would have on the existing customers
2	In principle we would be interested
3	In principle that sounds interesting
4	Not at the moment, depending on the amount of commission sharing
5	Yes we would be interested
6	We would not be interested unless it becomes a de-facto method that gains popularity

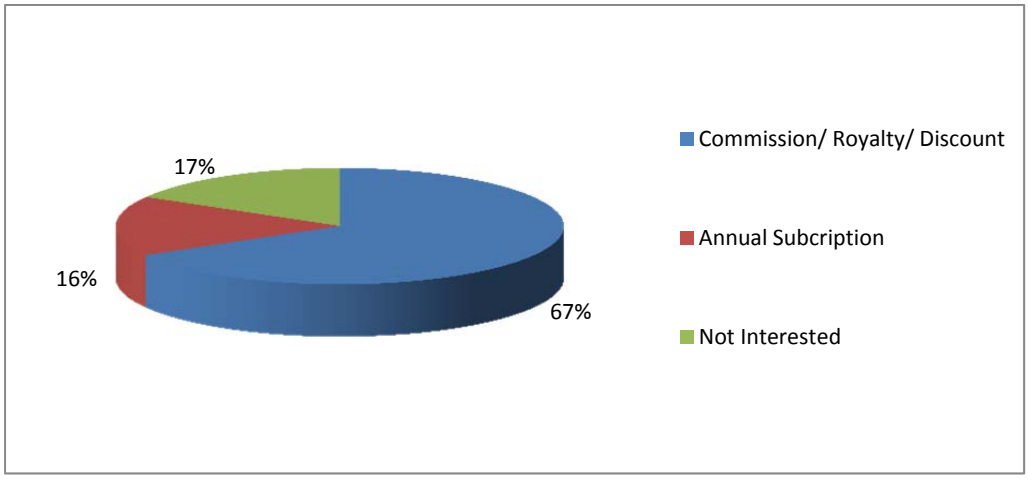
In general four out of six respondents have replied that in principle their business would be interested. However one respondent answered that they would be interested only if it is a popular practice. However, one respondent replied that they are not interested at the moment but would consider it depending on the financial agreement (commission sharing) with the portal.

The second question was "Q2. What kind of financial agreement your business would be interested in with the e-portal service provider?"

The responses received to this question are as follows:

- Royalty on sale, commission type payments;
- Commission based on the volume of transactions;
- Annual subscription fee with unlimited sales;
- Discount or commission on invoicing.

Figure 3 Responses to the question regarding financial arrangement



It is evident that most RP/RM service bureaux would prefer a commission based system whereas some would prefer an annual subscription. Figure 3 is a pie chart representing this data.

The third question asked in this regard was "Q3. What kind of service would you expect from the e-portal?"

The responses to this question were varied. One of the interviewees answered that he would expect the e-portal to introduce paid subscribers to the vendors. Another interviewee responded that he would expect the e-portal to have a mechanism where more customers for the bureaux could be sourced. Whereas, one service bureau expects the e-portal to provide the service of sending out quotes and having a mechanism for collecting proceeds. The important fact to note is that the RP/RM bureaux would prefer a system where sourcing opportunity for their products is increased.

2.3 The Purpose of the Model

The design of the model has been constructed considering how it could influence a future increase in the production and use of RM products. The key objective of the model has been set to:

- Settle the supply and demand of RM products over a virtual trading system;
- Devise a business model which would result in an increase in RM production;
- Devise a functional RM supply chain.

3 The Structure of the Virtual Trading System (VTS)

It is important to identify the entities that would constitute the VTS. The components are outlined below:

- RM product procurer (The business or individual interested to buy RM product);
- RM product seller (The business interested to sell RM product);
- Commerce service and infrastructure provider (enabling the flow of business including transaction);
- Individual Customer.

The VTS is proposed by the author to be financed by a consortium of the major stakeholders in the RM industry including the RM machine manufacturers, material producers and major RM technology applicants. This is because the purpose of the VTS is to have a positive effect on RM production. Therefore, it is in the interest of all the stakeholders that the VTS is developed as a collaborating platform for the RM industry. This would help ensure trust and greater knowledge assimilation. At present there are examples of many consortium led e-business models in the world like Covisint (specialising automobile industry), Exostar (aerospace industry) etc. (Covisint, 2013; Exostar, 2013). However, it is proposed that the operational responsibility is entrusted to a third party. A professional ICT firm could/should be entrusted with the operational responsibility of the VTS. It is however very important that any business

model is financially profitable. It is proposed that any business being part of the platform has to pay an annual membership fee. The proposed VTS should only allow business firms not individuals to be members. However, an individual client should be able to access designated sections of the platform through a simple registration process and execute trade without paying any membership fees. In this case, a part of the sale value would belong to the platform. The proposed VTS should allow a global cross-catalogue search service or facilitate uploading of the member's catalogues. The members would also be allowed to conduct reverse auctions which would be discussed later in the paper. The VTS should also provide value chain integration facilities such as an RM information exchange and other guideline tools. The sale of products using some of the mentioned tools provided by the VTS would incur a royalty fee, payable to the platform. A part of the information exchange would remain free of charge providing an incentive to the members for being a part of the platform.

3.1 The Requirement of the RM Industry

In designing the trading structure of the VTS it is necessary to keep in mind the key features of RM production. It is established from literature findings that the ability to manage key data, such as the CAD files necessary for manufacture will be a key driver in the implementation of RM technologies (Hopkinson et al., 2006). This fact has also been verified through different interactions with the RM industry. It is for most products that manufacturers have CAD data for different inventories. Therefore, it is important for any business model concerning manufacturing products such as RM to organise this CAD data in an organised library. This important feature about RM technologies was taken into consideration while designing this model. Another important criterion that was taken into account was the need for RM intelligence gathering and brokering. In addition, how to source RM suppliers efficiently and effectively was also considered.

4 The Trade Engine

The trade engine is the mechanism through which the VTS is expected to support the trading of RM products. The trade engine can offer platform members with two separate processes to communicate with potential suppliers. The processes are 1) reverse auction and 2) e-catalogue.

4.1 The Reverse Auction

Reverse auction is a proposed method for settling the demand of RM products online. At the heart of any auction model is the concept of personal price elasticity. That is, customers will determine the price depending upon the price/value trade-off (Friedman & Barbara, 1999). The reverse auction can be defined as a process where buyers set up an auction to receive bids from suppliers. The suppliers bid down the price for fulfilling that order (Wyld, 2000). One leading online commerce company, Freemarkets, claims that customers buying through it should be able to save around

20% on their supplies (Pritchard, 2002). It suggests that there is a significant justification for utilising online auctions to conduct purchases.

The concept of a reverse auction is to source suppliers. The emphasis is to make the market for RM products more competitive and cooperative. The word cooperation is used here because the suppliers, while competing with each other, are cooperating to establish a better market dynamic for the RM supply chain. This section will explain the reverse auction process in more details.

The process starts when a procuring member of the platform decides to conduct a reverse auction for a purchase of some product. After this decision is made, next classification is made on the availability of the digital CAD data. It is important to understand the present scenario of RM bureau services. At present, if a business wants to ask for a quote from an RM/RP bureau it is more likely that the business will provide a digital CAD file of the intended product. The RM/RP bureau will analyse the CAD file and other requirements with their specialised software and provide a quotation for the product. An analysis has been conducted on identifying the kind of information that RP/RM service bureaux require in providing a quote for manufacturing. Table 3 lists the requirements for an online quotation sought by some of the RP/RM service bureaux (Laser Prototypes Europe Ltd., 2013; 3D Systems Pro Parts Marketplace, 2013); Xpress Product Development Group, 2013; and Advanced Prototyping Inc., 2013).

Table 3 Quotation requirement table

Name of the RP/RM service bureau	Standard requirement for quotation
3D Systems Pro Parts, USA	3D Data file (*.STL), Technology, Material, Quantity, Colour, Other Instructions
Laser Prototypes Europe Ltd., UK	3D Data file (*.STL), Quantity, Colour, Instructions
Xpress Product Development Group, UK	3D Data file (*.STL), Specification of the requirement
Advanced Prototyping Inc., USA	3D Data file (*.STL), Technology, Quantity, Material, Finish option, Special Instruction

In light of the present practice of the RP/RM bureaux and in consultation with designers and potential RM product procurers, a standard set of requirements to be provided by the platform member instigating the reverse auction process have been set for the VTS. These standards are tabulated in Table 4.

Table 4 Standard data set for the reverse auction process

Standard data for Reverse Auction	Description
3D data file	A CAD file in *.STL format
Material	Requirement of any specific material or a range of materials
Technology	Requirement of any specific RM technology platform
Quantity	Batch size

Miscellaneous instructions	This includes a wide range of instructions the manufacturer should consider. This may include the type of surface finish, application of the product, other facts such as post processing or the need of sub-assembly. In general it is any information the procurer presumes the potential manufacturer should consider before manufacturing and quoting.

The next step is that the procurer sets a time frame for the reverse auction. All the relevant information is posted as a bulletin in the designated information board for the potential suppliers to extract the data. However, it should be mentioned that this part of the information has to be available in a secure zone where only members can access. The procurer can in theory specify suppliers who can access this information. This feature would enable the procurer to ensure streamlining the bids it receives. Once the bidding is over the procurer can analyse the bids and proceeds with awarding a contract if it feels appropriate. The figure 4 illustrates the communication mechanism in the reverse auction process where as Table 5 tabulates the sequential procedures of a reverse auction process. Revenue source from this process would be a service charge applicable on each successful reverse auction. The fee would be applicable to the procuring member.

Figure 4 The communication mechanism of the reverse auction

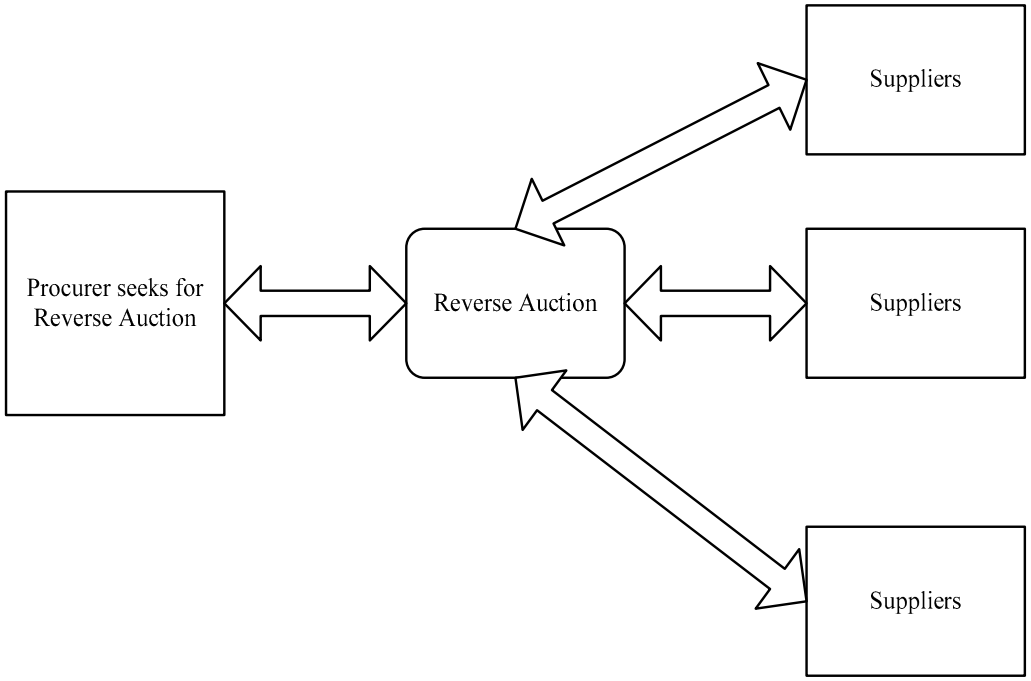


Table 5 Sequential procedures of the reverse auction process

1. The preparation of the detailed electronic product specification. This includes the digital CAD data of the intended product.
2. It is important to produce a clear requirements specification as it will help suppliers in bidding and also make post-auction evaluation more straightforward.
3. The platform is notified of the potential bid sought.
4. The suppliers express their primary interest to participate in the bidding process.
5. The buyer can potentially restrict suppliers, who could participate in the auction.
6. The start of the reverse auction event. The buyer and suppliers access the event through the internet. They can log in and out of the event to view and place bids. Suppliers bid anonymously against each other. There is no limit to the number of individual bids and the event can last any timescale as determined by the buyer.
7. The reverse auction closes. The bids are analysed according to present criteria available. The buyer can use bid evaluation tools and assessment engines in this regard.
8. The buyer decides on awarding contracts.

4.2 The E-Catalogue

The E-catalogue is another proposed method to buy and sell RM products through the VTS. The online catalogues, as a means of selling products, are firmly established in the market (Sweets, AEC info, Barbour Index) (Amor & Kloep, 2004). 3D Content Central (3D Content Central, 2013) is another example of a web based catalogue, where designers can host their 3D data. The catalogue proposed in this research is a digital database or pool of parts that can be manufactured using RM. The product in the catalogue will have the supplier's information sheet as well as the 3D CAD data, if the supplier consents to do so. However the author understands that there may be issues related to intellectual property and some suppliers may not wish to contribute their 3D CAD data to the e-catalogue. In the above circumstances, a 2D diagram of the product with sufficient description could be accepted for the e-catalogue. The VTS would offer support to bring suppliers catalogues online and electronically cross reference it with other e-catalogues. The supplier would also be able to advertise their brand name through the e-catalogue. The revenue source of this process would be a royalty fee applicable to the sale of products that is a portion of the sale value would belong to the platform.

5 The Information Exchange

The information exchange would work as an information brokering house. The information may include the following: 1) Consultancy services; 2) RM Intelligence; and 3) Knowledge tools.

The consultancy services are various knowledge or technical services a business may require in order to integrate RM production in their business. This may include: from specialised advice on RM implementation to more technical help including logistical, supply chain and other resource rendering services. The consultancy service providers are platform members registered with the platform to provide such services.

The RM intelligence can be segmented in to two parts: that is business knowledge and technology knowledge. The detailed databank of the information regarding material, technology and market trends is necessary. This basically includes any knowledge regarding RM that may possess a value to the others. At this moment a lot of the information on RM is disjointed. This may include different tutorials on RM production that other platform members and individuals may find interesting. There can also be educational tutorials on potential new RM applications etc. Transfer and sharing of knowledge regarding RM technology is very important for the technology to flourish. The transfer of knowledge regarding RM may to some extent reduce the effect of ignorance people have regarding the technology. At present, research is conducted regarding RM in a lot of places in the world including the UK. This includes research conducted in the academic community, in the research and development departments of businesses, RP/RM service providers and individual researchers. In this regard, it should be mentioned that there exists web based information sharing system such as the (RP Mailing List, 2013). But, the VTS aims to refine the concept and integrate it with other features. The idea of intelligence brokering is to share this knowledge amongst the industry. The knowledge should be provided by the platform members for the platform members. Therefore, the information exchange should be in theory like a library where new information is added on by the members. The contents may be both pay per access and free in nature depending on the value and the decision of the information supplier. In the case where the information is pay per usage a portion of the information access charge would belong to the platform.

6 The VTS Services

This section will elaborate how the VTS aims to fulfil the objectives of the business model. There are potentially five services that the VTS can offer to fulfil the objectives of the model. The services are discussed in this section.

Sourcing or Discovery: This service should be provided through the e-catalogue, reverse auction process and the information exchange. The potential procurer of RM products can access the e-catalogue and source new suppliers from a pool of suppliers. This is applicable to the individual clients as well. On the other hand reverse auction could provide procurers access to a vast pool of suppliers. This could result in a better market competition. The information exchange can be used by the platform members and interested segments of the society to learn and exchange information on RM and in the process discovering new business opportunities for themselves. It is expected that the sourcing or discovery services could impact the volume of RM production because of a more potentially efficient sourcing of suppliers and availability of relevant information. The concept of RM stake stakeholders being brought under a common platform will have a positive effect on the RM market.

Demand Identification: The suppliers can identify the demand of RM products through the reverse auction process where the VTS members would be notified of the intended purchase. This would in theory help the suppliers formulate strategies and provide them with indication and information about the demand for RM products. It is expected that the e-catalogue process would also help suppliers identify the true demand of their products. An approximate way of demand identification is necessary for devising a functional RM supply chain.

Content: It is important to have products and information available. The e-catalogue would in theory provide the buyer with a wide range of contents. The information exchange could act as the information brokering house which would provide the RM community with knowledge support, consultancy and support tools on all aspects of RM. This could ensure proper transfer of knowledge to different levels of the RM supply chain.

Transaction: The reverse auction and the e-catalogue processes are expected to facilitate actual trading of RM products once the procurer identifies the appropriate supplier. The VTS in theory can facilitate actual exchange of procurement information, such as purchase orders, between the buyer and supplier. This would provide a way to settle the supply and demand of RM products.

Promotion: The agreement for its members to be part of the VTS would serve as a promotion or advertisement for their respective businesses and their products. This could be done through the e-catalogue and the information exchange. Promotion or advertisement today is thought of as an integral part of any business model and therefore this would be an important feature of the VTS.

Feedback from the Platform Members: The VTS as a concept should be an ever evolving process. The platform has to be enriched and excelled in quality over time. Therefore, scope must be provided to the platform members to pass their comments on the services they received and on fellow platform members they conducted trade with. The data could work in favour of developing a supplier's profile over a length of time. This would be like the user feedback systems available in existing e-business platforms such as EBay or Amazon.

Conclusion

This paper has attempted to answer the research question- "What would be the structure of an efficient ICT enabled e-business model for RM technologies?" In this regard a reference definition for business and e-business models has been established. The paper has proposed an e-business model for settling the supply and demand of RM products over a virtual trading system. The discussions provided in this paper are based on the outcome of a feasibility study that has been conducted during the research period. The model has been constructed in view of the different requirements of the RM industry. In this regard, as mentioned before in this paper, input has been collected from different stakeholders in different forms. The paper further elaborated on the structure of the proposed model. It has outlined the services the model should provide. It has also outlined the potential revenue sources of the model. The emphasis has been given on identifying what would be efficient in terms of the RM industry.

One of the objectives of the model is to devise a functional RM supply chain. Reeves (2007) mentioned that RM is still thought by some people as a mere extension of RP and the major difference between the two (RP and RM) is in the supply chain, where the RM products are intended for end use, not just as be prototypes. Therefore, it can be argued that a functional supply chain required for RM products is still in an evolutionary stage. The resultant supply chain through VTS (as proposed by this business model) could provide alternative supply chain functionality through the following services: Sourcing or discovery; Demand identification; Content; Transaction; and Promotion.

Another objective of the business model is to settle the demand and supply of RM products virtually. Research indicates that the use of RM technology is spreading into newer applications (Wohler, 2012) and unconventional settings in geographically distant locations (Hasan, 2008). Concurrently there is an apparent advancement and use of ICT technologies (Wynarczyk, 2000). In light of the situation the model proposes the following two services 1) Reverse Auction and 2) E-catalogue, to settle the demand of RM products virtually.

The last but not the least objective of the proposed business model is to result in an increase in production and use of RM products. Cambel et al. (2012) pointed that the cost of RM applications in some cases is considered high and it will potentially reduce if the use the technology increases. In addition, Ariadi et al. (2008) discussed that there is a need for knowledge and information exchange. This paper argues that the increase in RM production can be achieved through the below mentioned Sourcing or Discovery and demand identification services in the VTS: 1) Reverse Auction; 2) E-catalogue; and 3) Information Exchange.

However, it is understood that the model would require an extensive user review. There is scope for the business model to be implemented in case based scenario in real life situation. Such, initiatives can be taken after securing appropriate funding for a prototype project. Real time financial, usability and trend related data can then be analysed prior to full launching of the business model. In this regard, it should be mentioned that a non-functional version of the business model was constructed and explained to audiences in different forums including conferences, symposiums and general discussions, to take into account their responses to the model. It should be mentioned that the audience in general were appreciative of such initiative and showed considerable interest in the concept.

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