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DIGITAL SUPPLY CHAINS: TOWARDS A FRAMEWORK FOR SOFTWARE DISTRIBUTION

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Summary

This paper assesses the effect of non-physicality of a digital product - software - on SCM practice. A number of in-depth, one-on-one interviews were held in 8 software companies that predominantly supply to enterprise customers on a global scale. The aim was to explore distribution challenges within software supply chains and how companies are addressing these challenges. The research has identified three different classes of software distribution models: One, which tends to rely on traditional physical infrastructures and paradigms, and two others that better exploit the properties of the digital products.

Educator and Practitioner Summary

The Internet has an important impact on how software is distributed. By assessing the effect of such a non-physical good on SCM practice, this research elicited three major distribution concepts: One relying on traditional physical infrastructures, and two others that better exploit the properties of the digital products.

Keywords: Digital product, Supply Chain, Software distribution

Introduction

Research in operations management, marketing and supply chain management has predominantly studied the relationships between upstream manufacturers and downstream retailers in supply chains for physical goods (Chellappa and Shivendu, 2003 cite Padmanabhan and Png, 1997). Physical goods are so defined because they obey physical laws. They possess mass and occupy volume. Over time, they can break down and degrade. It is not possible to create products without first sourcing appropriate materials. Energy (which also needs to be sourced) is expended in transformation and transportation. It could be said, therefore, that a large proportion of SCM has to do with overcoming the constraints imposed by physics on the products under consideration.

However, with the rise of information and communication technology (ICT), many important products can no longer be considered physical in the traditional sense of word. An increasingly important class of products described variously as digital products, virtual goods

or information goods (Shapiro and Varian, 1999) has emerged that cannot be considered physical in the traditional sense of the word. Surprisingly, little is known about digital product supply chains, where products such as software, movies, music and newspapers are created, stored and delivered in a digital form over a network (Chellappa, 2000). This paper attempts to develop a conceptual supply chain framework by exploring online distribution of one such digital good: software.

The paper begins by outlining the research background and methodologies employed in this study. It will then describe the distinctive characteristics of digital goods and depict the changing landscape and challenges for software companies. An integral part of this paper represents how the Internet has transformed the supply chain for software and how the Internet has affected related software distribution models.

Research Design

The aim of this research is to discover and understand challenges of digital distribution and how organisations respond to them. A literature review evaluating traditional versus digital software supply chain models gives insights into digital distribution practices. To establish digital software supply chain designs, the exploratory research end of spectrum is perceived as the most appropriate method as it is open-ended in nature. It gathers preliminary information that will help define problems, may suggest hypotheses and areas for further investigation. Thus, semi-structured interviews with open-ended questions represent the most appropriate way to achieve this objective as they are looking for processes and patterns that explain "how and why" questions. In determining the nature of the transformation of (digital) music supply chains, Graham et al. (2004) utilised a model by Hardaker and Graham (2001) on the basis of four interrelated dimensions involved in the design of supply chains: (a) the structure of activities; (b) the choice of actors; (c) the governance mechanism; and (d) the co-ordination structure. This approach was found to be transferable to analysing (digital) software supply chain designs. Thus, a number of in-depth, one-on-one interviews were held with software distribution practitioners in 8 companies with a significant software business and that predominantly supply to enterprise customers on a global scale. Focusing on challenges in software distribution, the interviews were designed to elicit detailed, concrete stories about the subject's experiences based on common themes that emerged from the literature review. Bias and error during the interview was minimised through open questioning, assurances of confidentiality and sending the write-ups back to the respondents once completed for their review and approval. All except one respondent worked in a major global company with revenues exceeding $1bn.

Characteristics of Digital Products

Before outlining differences of physical and digital supply chains, the nature of digital products by itself need to be defined. Digital products don't have physical forms or structures and cannot be physically consumed (Choi et al., 1997). They are created, stored and delivered digitally and refer to any goods or services that can be digitised and converted into a binary format (Hui and Chao, 2002). They can be compressed without losing much information or quality and as such have a technical quality similar to the original (Peitz and Waelbroeck, 2003). Moreover, digital products can be described as experience goods as they have to be

used first before their value to the individual customer can be determined (Nezlek and Hidding, 2001).

Hui and Chao (2002) propose a framework for classifying digital products based on two dimensions: product category and product characteristic. There are three digital product categories in the framework, namely tools and utilities[1], content-based digital products[2], and online services[3]. Each of these product categories possesses different product attributes and serves different purposes for buyers. The second dimension of Hui and Chao (2002) include intrinsic characteristics, which means the features that are "born" with the product and cannot be changed by the sellers. Those are delivery mode, granularity and trialability. Delivery mode refers to the delivery mechanism from sellers to buyers, which are either at one time through the Internet or interactively on a continual basis. Granularity means divisibility of digital products. Trialability is the ability to try a digital product before purchase.

Whinston et al. (1997) identifies three key properties of digital goods:

- Indestructibility (the tendency of a digital product to maintain its form ad-infinitum);
- Transmutability (the ease by which a digital product can be modified); and
- Reproducibility (the ease by which digital products can be reproduced, stored and transferred).

The property of reproducibility in particular makes digital products different from physical products. This property has huge consequences so long as there is sufficient storage and bandwidth available to copy, move and transport product – an increasingly valid assumption - (Eldering, 1999; Grochowski, 2003). No raw materials or energy need to be sourced or used up in the process. Replication is instantaneous and no manufacturing facility is required. Thus, economists refer to digital products as having an almost zero marginal cost (Shapiro 1999, Whinston 1997). However, Shivendu (2008) outlines that while digital products have negligible marginal costs of production, they usually have very large product development costs. However, due to the ease of reproducing digital products, piracy and the protection of embedded intellectual property represents a major challenge.

Competitive strategies for physical goods typically need to take into account factors such as production costs, distribution costs, and inventory costs. Digital products (particularly when distributed over the internet) consist of almost zero manufacturing, inventory and distribution costs. Thus the basis of competitive advantage among digital product producers is less dependent on what would be considered to be "traditional" supply chain approaches.

The Software Industry and Challenges for Digital Software Distribution

The software industry can be considered as a typical high technology industry, which is characterised by innovation-driven market growth, rapidly shrinking product and technology lifecycles, high knowledge intensity and global market reach. It is primarily comprised by two

[1] For ex. Software programmes, such as general, commercial software, shareware, freeware that are easily downloadable and that either help users to perform specific functions or act as a supplementary utility for other purposes.

[2] The value of these digital products are in their information content, for ex. newspapers, journals, research databases, online entertainment (music, magazines, videos).

[3] These are services that provide access to resources like server connections as well as utilities, for ex. Internet telephony, support services (such as consultant search services).

major groups of companies: a few top market shareholders and many smaller software firms. The industry is fairly labour intensive with regards to skilled employees that are competent in new technologies and programming languages. There are little barriers of entry to this sector. Software itself has the ability to be modified and upgraded continuously and as such companies are able to capture first-mover advantages by releasing software products (that may not be standardised as yet) before their competitors. Timely releases are very crucial in this industry as the quality of the product in itself is not a primary concern to customers since regular upgrades and patches are available. Furthermore, additional features can easily be added to an existing software product, which reduces barriers to product improvement (Chou and Ruchika, 2006).

In many ways, software supply chains can be compared to service supply chains. Online software models and traditional service models are often very similar from a customer viewpoint. Software however has the additional attribute of being downloadable, enabling customers to replicate the service locally or off-line. In this case, software begins to take on some of the characteristics of product supply chains.

Successful software distribution is highly dependent on bandwidth on the Internet (Hui and Chao, 2002). Thus, bandwidth constraints remain very significant when distributing digital products. Some software products are very large, occupying many gigabytes of disk space (Chaffey, 2007). Our interviews confirmed that bandwidth still requires large investment costs and particularly with software products in excess of 2-gigabyte technical problems rapidly increase.

While zero marginal cost of digital products is an advantage from the direct cost standpoint, it also means that market forces will continually act to reduce the price to zero, thus putting pressure on profit margins (Messerschmitt and Szyperski, 2003). Our research substantiates that significant costs are incurred in the production of the first software product, however competition from low cost producers have served to reduce these costs greatly. Open source software, the most prominent of these models, employs free software expertise in the production of very competitive products[4]. This serves to push commercial software prices down, challenging incumbents to experiment with new means of generating revenue (Young, 1999).

[4] For example Mozilla Firefox, Apache Tomcat, Java.

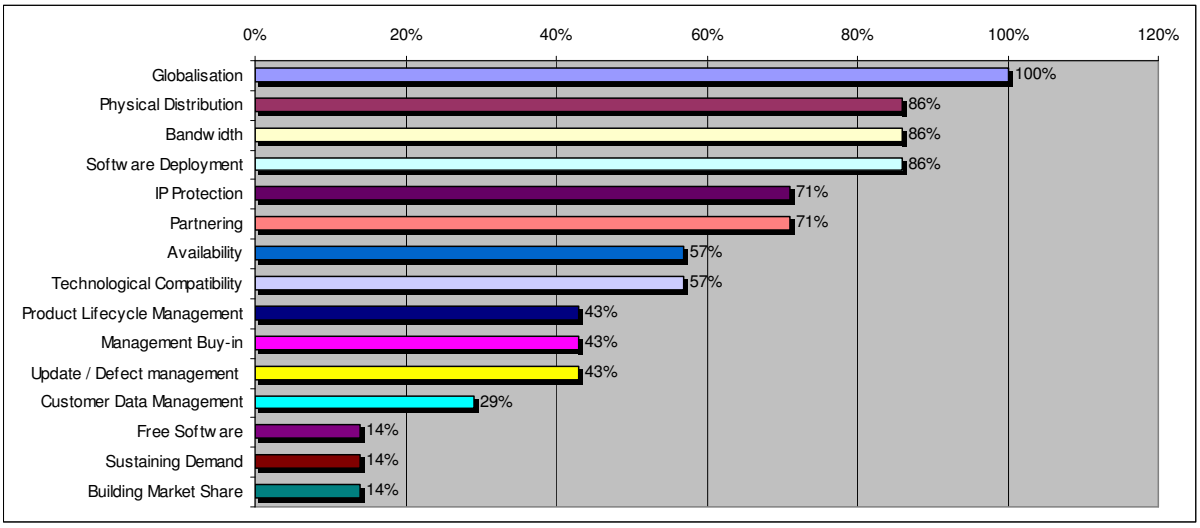

Figure 1: Challenges for Software Distribution

Copyright protection and software piracy is another major challenge that was identified in the interviews. Software piracy is defined as the unauthorized use, duplication, and distribution or sale of commercially available software (Moores and Dhillon, 2000). What emerged from the interviews however was that a significant number of respondents had relatively relaxed approaches to limiting piracy, and that some had no technological anti-piracy mechanisms whatsoever.

Other challenges affecting software supply chains are outlined in Figure 1. Many of these are not specifically digital distribution challenges however. Globalisation was named by all of the interviewed companies as a significant obstacle to overcome. Some globalisation challenges represent legal issues and national considerations, such as embargos and licensing in various countries, as well as issues concerning version and configuration issues. With regards to software deployment a strong preference towards the use of engineers and consultants could be found in enterprise-focused software companies while installations for consumers tend to be automatic. Technological compatibility has further been identified as a critical challenge. There is a key difference between digital and physical goods in that goods such as software cannot exist without a physical support infrastructure (i.e. hardware) or other software products to be present before it can work properly (Messerschmitt, 2003). Normally, technological compatibility is worked out by software developers, and not by the distribution personnel. Partnering was evident in many of the interviewed companies, emphasising on long-term relationships. However, channel conflict and commission management represented significant issues. Further challenges that were mentioned was website availability, product lifecycle management, management buy-in, update and defect management, while customer data management, free software, sustaining demand and building market share have been cited less frequently as major challenges.

The Supply Chain and Distribution of Digital Software Products

A number of different definitions of supply chains and their effective management exist in literature. Supply Chain Management in a traditional sense is concerned with the strategic management of a firm's activities, which together provide customers with the appropriate level of service at optimum cost (Christopher, 2005; Lambert et al., 1998; Sweeney et al., 2005). Chou and Ruchika (2006) note that in short, the aim of all entities in a supply chain is

to ensure that a product moves down the chain in the most effective manner, so as to maximise profits earned by the whole chain as well as minimise wastage of raw materials, labour and time. A supply chain is *"a connected series of (networked) organisations (suppliers, original equipment manufacturer, distributors, transporters, etc.), resources, and activities involved in the creation and delivery of value, in the form of both finished products and services to end customers"* (Pant, Sethia and Bhandari, 2003). It traditionally focuses on the hardware (material or goods) flow and the related information flow (Chou and Ruchika, 2006) that can be both upstream and downstream. Within a supply chain, upstream suppliers provide input; the company then adds value to these inputs, before passing them downstream to the next actor, which can be either another company or the end user (Porter, 1985). The effective management of a supply chain transforms it into a value chain, where organisations tied in it derive a number of benefits (Baltacioglu et al., 2007). Traditionally, a value chain is the combination of nine generic value-added activities that provide (product and service) value within an organisation to be passed on to a customer. However, Ramsay (2005) notes that value is a perceived quality that is associated with the benefits that can occur at various points along a supply chain. Thus, value chains can operate in both directions.

Managing the supply chain in traditional markets mainly provides challenges related to cost-effectiveness and physical barriers. By contrast, in a digital marketplace supply chain management encounters barriers that are not physical but rather strategic in nature (Nath, Saha and Salehi-Sangari, 2007). Chou and Ruchika (2006) argue that a digital software-focused supply chain is a supply chain where the digital product (software) constitutes a significant part of the total value of the product and where goods are not physically flowing through the supply chain. In a software supply chain, for example, a significant proportion of the supply chain is comprised by only one entity, which is usually one single company handling the design, development and production of a software product. It is usually at the distribution stage that a software company might engage the services of another company to market its product. Moreover, channel coordination policies such as returns are not applicable in the digital world.

In order to outline the differences of a traditional and digital software supply chain and to describe a distinctive distribution framework for software, certain characteristics that determine a supply chain need to be contrasted. Hardaker and Graham (2001) have identified four interrelated dimensions that are involved in designing a supply chain, which are: (1) activities within a SC; (2) actors within a SC; (3) SC governance and (4) SC co-ordination. These four dimensions will be used in the following to establish idiosyncratic features of software supply chains and describe unique digital distribution patterns apparent in the software industry.

Supply chain activities and software distribution

The structure of activities is related to the natural sequence of processes inherent in a supply chain. In many industries, activities can be serially interdependent (Hardaker and Graham, 2001). The traditional software product supplied by physical means, such as a CD represents such a structure. Chou and Ruchika (2006) have identified several stages of a software planning and production process. A cycle time up to three years could be required. The first three stages of the process involve design and development and testing of the software. The next three stages involve preparing the support infrastructure that accompanies the main software product. This might include a user-guide or documentation, media production and

other add-on features, as well as the final product rollout. Finally, marketing and distribution, as well as retailing efforts to sell the software ensue.

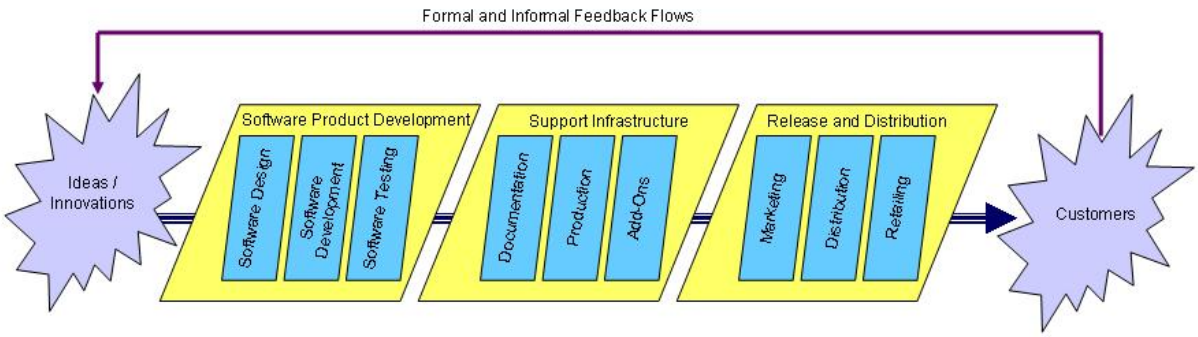

Figure 2: Software Supply Chain Activities and Processes

In the increasingly digitised software industry supply chain, the flow of material is declining in importance, due to the availability of the Internet as a free distribution medium. Our research has elicited that a digital product can be characterised as a movement of value instead. Thus, key flows represent information, ideas and innovation, from requirements into development, from release through to distribution and finally to the end-consumer. As such, information is shared mainly through electronic means within and outside of an organisation. Moreover, network technologies have the potential to transform the supply chains of many industries because of the abolition of the trade-off between richness and reach of information, which means that everybody can communicate with everybody at almost zero cost, without constraints on the richness of information. (Graham et al., 2004 cite Evans and Wurster, 1997). Richness of information includes characteristics such as bandwidth, customisation, and interactivity. Reach is defined as the connectivity, and is the number of agents involved in exchanging information. Before the Internet, to reach large numbers of people with rich information was a costly and time-consuming process. Traditionally, information could only be transferred in the form of a physical carrier such as a document, book, CD, etc; it could not travel by itself. Therefore, costs and physical constraints limited the size of the audience to which the information could be sent and the nature of the information itself (Graham et al., 2004).

The Internet has an important impact on how software is distributed. Through the interviews three major distribution characteristics could be identified: (1) Physical and pseudo-physical distribution; (2) free distribution; (3) no distribution.

(1) Pseudo-physical distribution

37.5% of the interviewed companies have chosen to pursue the first approach: born out of supply chains, legacy infrastructures and a competitive landscape that was designed to deal with physical product manufacture. Companies pursuing this strategy act to limit supply through technological copy protection measures backed up by legal enforcement. The customer's use of the software is impaired from the outset by highly restrictive licenses that need to be agreed to before the product can be used at all. Then, copy protection measures such as activation keys are included in the software to prevent duplicate copies being made. Complex supply chains need to be developed to support many of these initiatives. For instance, an infrastructure may be required to distribute activation keys in a secure fashion to the correct customers. These processes are complicated where third parties (distributors or

resellers) need to be involved. Billing mechanisms may need to be integrated with the distribution mechanisms. Such processes require significant customer support overhead.

(2) Free distribution

In the second approach, few or no controls are imposed on the distribution of software. Some or all versions of the software are distributed to users with few control mechanisms in place. Although, 50% of respondents offered free distribution of some sort, a number of different approaches were used:

a) *The total-service based model*. In this model, the software is free to distribute and install. However, associated services such as consultancy, bug fixing, hardware, training, technical support and customer support (all limited in supply) are available to the customer for a fee.
b) *The customised model*. In this case, the software is freely distributed. However, the nature of the software is that without extensive customisation, it has little value except to the customer for which it is intended. The companies involved deliver large-scale system installations, where the software requires extensive modification before it can be useful to the customer.
c) *The complementary model*. In this case the software is provided to enhance the value of a physical product such as computer hardware.
d) *The premium enticement model*. While basic or limited copies of a version of software are made available at no cost, an incentive is provided enticing users to upgrade their software to a premium version that is charged at a cost. This premium version may contain limited supply features (e.g. a 24x7 support hotline).

(3) No distribution

The third approach avoids the need to involve product replication at all. In this case the "infinite availability" of software is comparable to a resource such as electricity or water and is made accessible whenever and wherever the user desires it. In the Software-as-a-Service (SaaS) type model, a single instance of software is shared amongst multiple users. Replication is therefore not required. This model is gaining currency over the past few years as bandwidth (speed and market penetration) has increased and concerns over data security are addressed. However, just one company among the interviewed firms was using this approach.

Supply chain actors

This dimension means the level of dynamism in the choice of actors in a supply chain (Hardaker and Graham, 2001). The chain is seen as very static when actors are relatively established. On the other hand it is very dynamic, when actors vary from one market opportunity to another. There are various levels of flexibility in the choice of partners in-between. (Graham, Burnes, Lewis, Langer, 2004). Traditionally, the software industry has been dominated by a few well-established major players and thus has been very static in character. Chou and Ruchika (2006) argue that most stages of the traditional software supply chain framework is taking place in-house and decisions to outsource are only made when production and distribution is infeasible in-house due to investment constraints. Thus, a small supply chain is less complex than having a variety of different actors. Therefore, it can be seen that little effort is being made in liaising with a wide array of partners with regards to inventory management throughout the supply chain. This also ensures that profits stay in-house rather than being shared with additional actors within the chain.

As outlined above, the Internet is eliminating the need for physical distribution and the retail of software products and has let to the invention of new forms of distribution for software products. All interviewees highlighted that it facilitates communications between the different actors. Moreover, new online portals have entered the online market providing download capabilities for a wide range of software products. As such, the traditional software supply chain is developing into a more dynamic marketplace, allowing new start-ups to market and distribute their products at a low cost point. However, our interviews revealed that poor management of internal and external relationships within a software network could have a detrimental effect on supply chain performance. Relationship management becomes ever important, especially in the software distribution process. Many software companies collaborate together to produce customer deliverables and a much stronger customer interaction is advocated, than it has been with physical supply chains.

Supply Chain governance

This relates to the ownership and the control of various actors in the supply chain. Dyer (2000) argues that in line with transaction cost theory (Williamson, 1979), three alternatives for governing a transaction or supply chain relationship exist: (1) vertical integration; (2) arm's length relationship; and (3) partnerships. In a vertically-integrated supply chain the organisation that commissions other organisations to help create the final software product is the main force in the supply chain and controls as such key channels and value steps; at the extreme, a company would produce all inputs itself. This is opposed to independent parties that operate at arm's length relationships (Graham, Burnes, Lewis, Langer, 2004), which mean that a company buys inputs from outside through short-term suppliers for the best conditions each time an input is required. The concept of partnership, by contrast, means that a company sources from a small number of suppliers by building co-operative and long-term relationships (Dyer, 2000). If transaction costs are high, it is more favourable to own suppliers and distributors and as such produce in-house. On the other hand, if transaction costs are low, it is more favourable to outsource and procure materials and services.

Traditionally, the software supply chain has been characterised by a small number of very powerful companies that control all aspects of the software supply chain, from creation to test to distribution and installation. Companies such as Microsoft and SAP have made use of supply side economies of scale (availability of trained developers and IP), plus demand side economies of scale (customer lock-in and network effects) to achieve disproportional market shares, effectively pushing out the competition. To a large extent, such effects are still in play, although our interviews elicited that incumbents have to increasingly deal with new development models and revenue models that are resulting in a shift in the power dynamics of the industry. The rise of Open Source development (Hars, 2002) has enabled communities of programmers, motivated by non-financial incentives, to challenge commercial incumbents (e.g. Mozilla Firefox, Linux, Apache Tomcat). The movement of revenue from pay-per-unit business models to advertising business models has seen companies such as Google begin to challenge powerful companies such as Microsoft, particularly on the consumer side of the business.

Supply Chain co-ordination

Sweeney (2007) depicts that managing information flows in the supply chain is one of the most crucial activities in supply chain management as the flow of materials and money is

usually initiated by information movements. Hardaker and Graham (2001) reinforce this by outlining that co-ordination in a supply chain occurs through the communication of orders, stock level and demand feedback. Poor information flows essentially leads to the so-called bullwhip-effect that requires holding excessive levels of inventory. As such, high demand visibility plays a strategic role in reducing inventory levels (Sweeney, 2007). Thus, network-based communication structures in a supply chain might offset these effects.

The new co-ordination scenario surrounding Internet distribution is much different. Our interviews highlighted that in some respects co-ordination is less of an issue as the latest product can always be picked up by just clicking on a web-link, and because there is an abundance of copies to pick up, there are no critical inventory or purchasing issues to contend with. Companies that wish to retain control over their software through restrictions to copying have to contend with more complex co-ordination challenges, e.g. the supply of activation keys and the monitoring of software assets remotely to ensure that copyright is not being breached. Most companies we interviewed are not interested in the extra overhead associated with such oversight.

Discussion and recommendations for further research

The research has identified three different classes of software distribution models: one, which tends to rely on traditional physical infrastructures and paradigms, and two others that better exploit the properties of the digital products. Approaches, which are comparable to physical distribution, tend to require significant management overhead (forecasting, inventories, copy-protection, license management, bandwidth management, etc.), whereas less traditional management processes are required for free and uncontrolled distribution over the Internet. In other words, from a traditional SCM standpoint, there is a variation in complexity according to the degree to which digital product distribution is made to resemble physical product distribution.

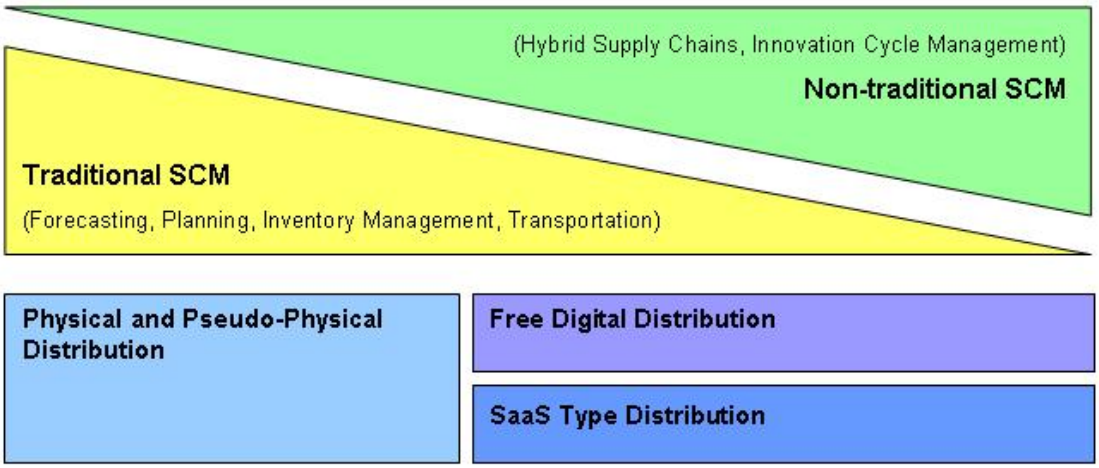

Figure 3: Changes in SCM requirements over the spectrum of digital distribution approaches

While this research reveals that physical and pseudo-physical distribution approaches remain important in the software distribution process, two new supply chain scenarios are emerging. Both scenarios assume that manufacturing and distribution are of minor importance in the world of digital products, and that the right software is instantly available whenever it is required. Both are areas worthy of significant further research.

1) Hybrid physical / digital / service supply chains. In this scenario, the supply or availability of digital product becomes integrated into a more comprehensive supply chain strategy involving physical supply and service-based elements. Hybrid distribution leverages the advantages of digital products to improve the performance of more traditional supply chains.
2) Innovation Cycle Management. In this scenario, the focus moves from the flow of product to the flow of innovation (e.g. ideas, software code, executables, feature suggestions) from first conception, to development, to release, and distribution into the hands of the customer. It is seen as a cycle because the flow of feedback back from customers (a kind of reverse logistics process in the digital world) is crucial to further innovation and new releases of product. The focus of SCM migrates from operational concerns to product development and lifecycle management considerations. This challenge is complex because development is increasingly fragmented amongst different groups (in-house developers, off-shore developers, contractors, specialists etc.), and customers can vary enormously in terms of their requirements, processes and feedback mechanisms.

Conclusion

Digital products such as software will affect the practice of SCM greatly over the coming years. While pseudo-physical distribution strategies, such as the use of copy-protection, are unlikely to disappear in the near term, it is likely that companies will leverage the free replication properties of digital products to enhance their current supply chains, and that they will put greater focus on the management of innovation cycles to drive the maximum amount of differentiation and value from their products.

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