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A Longitudinal Study of the e-Market for Software Components

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Abstract

Component Based Software Development (CBD) holds high promises, but develops its full potential only when software components are traded in a component market. The Internet seems ideal for this purpose and various sources have predicted a bright future for the Internet Software Component Market (SCM). However, very little is known about the current status, structure and trends within the SCM. This study develops a model of the SCM and a classification of components traded in the SCM. Using these, a number of propositions are developed and tested using a longitudinal dataset. The results show that the SCM is still in its early stage although there are some trends towards a mature market. The research method deployed in this study provides insights into how the SCM develops and can also be deployed to study other e-markets.

Keywords: *E-market, software components, E-commerce, Digital markets, Intermediaries*

Introduction

CBD promises a large step forward in the quest to maximize reuse in software development. Although a variety of definitions of CBD exist, key to CBD is building systems through the assembly of pre-engineered and pre-tested software components. CBD can only deliver its promise if a variety of high quality software components are available for reuse at a reasonable price. “*Components develop their full potential only in a component market*” (Szyperski, 1998). Some large organizations may benefit from organizing a closed internal component market. However, for most components it seems that the most appropriate marketplace would be the Internet that is well suited for offering, promoting, searching, buying and distributing components. As Bakos (1998) observes: “Internet based electronic market places leverage information technology to match buyers and sellers with increased effectiveness and lower transaction costs, leading to more efficient, “friction-free” markets.

Little research has been done into the SCM. Within the area of electronic commerce research, most attention has been given to B2C markets including books, CD’s, cars, travel, financial products and services. More recently, researchers have addressed B2B markets for products such as computer hardware and office supplies (Turban et al. 1999). It is remarkable that the SCM gets little research attention. As Sprott (2000a) observes : “The SCM is one of the few genuinely electronic marketplaces. Everything from initial location through fulfilment to actual usage can be done on the Internet”. A flourishing SCM would allow organizations to reuse components against low costs, as multiple users share the high costs of quality design, documentation, testing and support.

Industry watchers have predicted huge growth figures for the software component market. Gartner group (1998) predicts the component market will grow to \$7 billion in 2001, of which \$2 billion directly comes from component sales. Giga information group predicts an *off-the-shelf* component market of \$3,3 billion in 2001 (Whiting, 1997). Ovum (1998) goes further by estimating the size of the software component market to be \$64 billion in 2002. These huge variations can be explained by the different definitions of components and SCM that are used (Sprott, 2000b). Furthermore, these studies provide little information of the actual structure of the market. Traas and van Hillegersberg (2000) provide an overview of the parties active in the SCM and the type of components they offer. From this overview it becomes clear that by 1999, the open-SCM was not yet a huge multi-billion dollar E-market. Otherwise, little is known of the actual structure and state of the SCM. What growth is actually achieved, what types of components are currently offered and what is the structure of the SCM? It is the objective of the research reported on in this paper to gain insight into these questions.

The paper will first present a classification of software components. Next, a market model of the SCM is introduced. Both are then used to develop a number of propositions on market structure and evolution. Next the paper introduces the longitudinal research method used to test the propositions and presents the results. Finally, conclusions and future research are presented.

The contribution of this research is twofold. First, more insight in the SCM and its development is obtained. Second, the results obtained can be compared to and potentially generalized for other e-commerce markets of intangible goods on the Internet.

The e-Market for Software Components

Software Components Classification

Several definitions of software components exist. The definition by Szyperski (1998) is used here as it includes the tradability of components in a market: “a software component is a unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be deployed independently and is subject to composition by third parties”.

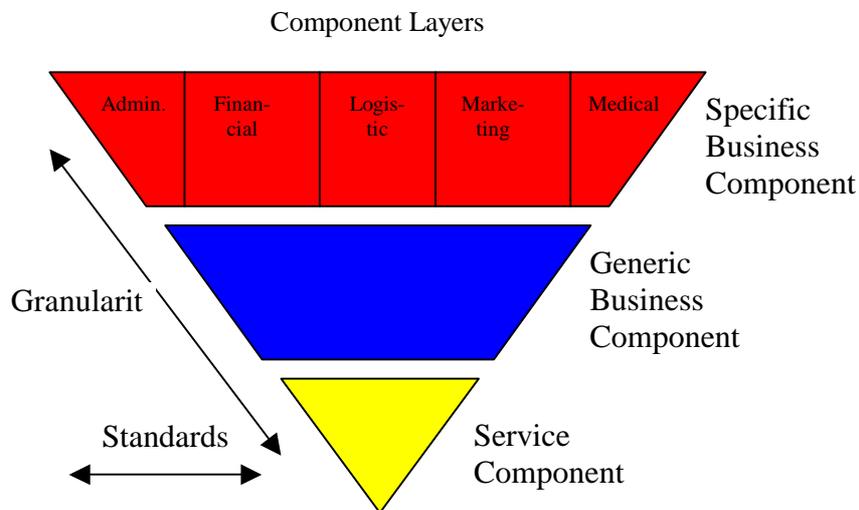


Figure 1: Software components (*Business Architects, 2000*)

Figure 1 presents a high-level classification of software components. Service components implement functionality in the technical infrastructure. Examples of service components include encryption components, database connectors, compression components etc. Generic business components offer horizontal functionality that is useful across business domains. Examples include a document viewer, an email client, an address entry component etc. Specific Business components offer vertical functionality. In this area interface standards are only beginning to emerge (e.g. see Sprott, 2000c). Therefore, the SCM is likely to focus on Service and Generic Business components. To get insight into these market segments, we require a further classification of these components. We use three

main properties of a component to further classify Service and Generic Business components: *type*, *documentation* and *technical standard*.

Pfister (1997) has developed a taxonomy of six different *types*. Controls (1) and containers (2) are both visual components, however a container can supply context (e.g. HTML browser) while a control cannot (e.g. simple editor). There are four non-visual components. A command package (3) interacts with visual objects (e.g. spelling checker), a library (4) is a collection of independent functions or classes, a framework (5) is expandable by plug-ins and, finally, a business component (6) implements domain specific program logic, and thus includes both the earlier discussed Generic and Domain business components.

We further argue that *documentation* is an essential part of a component. Documentation is important for making the decision to buy the component and essential to successfully assemble the component. Especially for medium and large grained components, documentation is required. To classify the documentation supplied with the component five different documentation methods are discerned: a simple description (1), technical details (2), demos (3), test reports (4), and component source code (5).

Finally the *technical standard* refers to the technical environment in which a component functions. Since it is expected that open (as opposed to proprietary) standards will be responsible for most of the sales of software components on the Internet, this study focuses on the three major open component standards that exist today: ActiveX, JavaBeans and CORBA (Kara, 1998).

Market Structure

Figure 2 present a model to study the market structure of the SCM. At the beginning of the chain is the software component producer (P). At the other end is the customer, who can vary from an individual end-user (for simple plug-and-play components) to the IT department or systems integrator. As in other e-markets, components can find their way from producer to customer in several ways.

Customers can try to find an appropriate component by searching for various producers on the market and evaluating their offerings. The producer may offer a search engine to help the SI/IT find the component in its assortment. The producer will handle pricing, licensing and the transaction which includes delivery and payment of the component. The SI/customer has to rely on the producer to assess the quality of the component and for services and support.

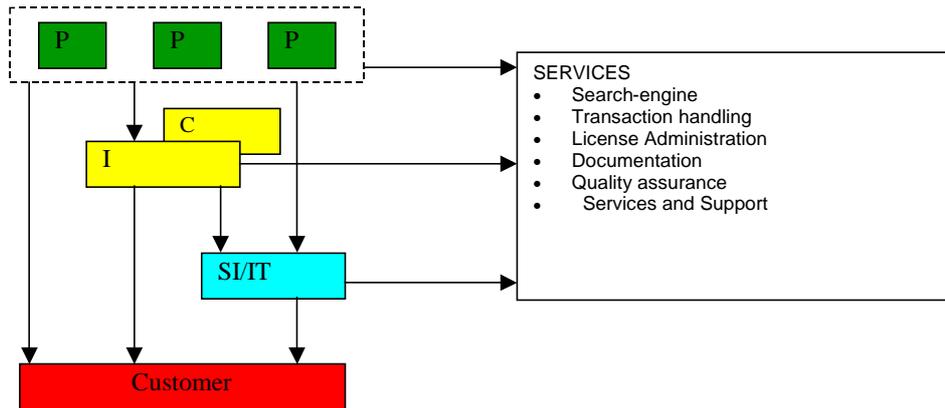


Figure 2: Structure of the software component market.

In a complex market with many producers and a huge variety of products specialized Intermediaries usually play an important role (Bakos,1998). Intermediaries may assist the customer in searching a suitable product and in comparing its price and quality. The most basic form of an Intermediary is a Catalogue (C). A catalogue is simply a collection of links to the websites of producers. More advanced intermediaries offer a larger set of services. An advanced search engine can assist the user in locating a suitable component by comparing the offerings of many producers. Intermediaries may handle the full transaction. Each producer may have its own way of specifying the functionality of a component. An intermediary may help understandability and comparability of components by offering a single documentation standard. The intermediary could document its components using this standard or request the producer to deliver appropriate documentation. By defining and performing independent tests, Intermediaries can help users to assess the quality of a component. Furthermore, it can be helpful to a customer to have a single helpdesk for support.

Propositions

Using the classifications regarding the type of components and the SCM structure, we will now develop four groups of propositions to assess the state and evolution of the SCM. The four groups deal with the generic structure of the SCM, the technical component standards, the types of components offered and the component documentation respectively.

Structure of the SCM

The first set of propositions addresses the high level structure of the market. We do not yet segment based on the various component types and standards. In a growing market new producers are expected to enter the market (P1.1). The growth of the market will increase its complexity, which creates demand for intermediaries that

organize available components (P1.2). Catalogues offer little added value as intermediaries expand their services. Catalogues are useful in a new market, but as an electronic market matures, we expect that only a small number of extensive catalogues will remain (P1.3).

A growing component market will attract many new component producers. Producers that sell their components directly in a growing market are likely to enlarge their assortment. Therefore we expect the total number of components offered by producers to grow (P1.4). Smaller producers and new entrants with a limited assortment are more likely to sell their components through an intermediary only. Therefore we expect the average number of components a producer sells to increase (P1.5).

In addition to attempts to include components from existing producers, intermediaries will seek for new producers to enrich their assortment. Intermediaries may even play an active role in facilitating new component producers, for example with development funds and knowledge. Therefore the sum of all components offered by intermediaries is expected to grow (P1.6). Occasionally new intermediaries will enter the market. These probably will try to focus on a specific segment instead of competing with the large intermediaries that moved early into the market. The limited number of components offered by new specialized intermediaries can thus compensate the growth of the number of components sold by the large intermediaries. We therefore expect the average number of components offered by intermediaries to remain stable, while the standard deviation is likely to increase (P1.7).

The established catalogues will continue to include components that appear on the market, and thus enlarge their offering (P1.8). As few new catalogues enter the market, the average number of components sold by catalogues also increases (P1.9). However, as a result of the lower entry barriers much of the growth of the total number of different components available on the market is expected to come from small new producers. These producers are likely to make use of the delivery channels of the large intermediaries, rather than setting-up their own web-shops. As component vendors that do not sell directly are only offered through intermediaries, it is likely that the large intermediaries have a larger collection of components than the large catalogues (P1.10).

In summary:

- P1.1 #direct selling producers is growing rapidly
- P1.2 #intermediaries is growing
- P1.3 #catalogues is stable
- P1.4 #components sold by producers is increasing
- P1.5 Average #components sold by a producer is increasing
- P1.6 Total #components sold by intermediaries is increasing
- P1.7 Average #components sold by intermediaries stable with an increasing standard deviation
- P1.8 Total #components in catalogues is increasing

- P1.9 Average #components in catalogues is increasing
- P1.10 Large intermediaries have a larger collection of components than large catalogues

Technical Component Standards Offered

Of the three technical standards that exist today, ActiveX and JavaBeans are compatible with the widely adopted Microsoft and Sun Java platforms, while CORBA components are compatible with the OMG component architecture (see www.omg.org). The latter has only been defined recently and has not been implemented in all common platforms yet. ActiveX builds upon the MS-windows platform that dominates the market. Most producers are thus likely to sell ActiveX, followed by JavaBeans and CORBA (P2.1). The same ranking is likely to apply to the total number of components that are offered (P2.2). Given the increasing attention for JavaBeans, we expect the difference between ActiveX and JavaBeans to become smaller both in number of producers (P2.3) as in the total number of components available (P2.4). Furthermore, we anticipate that technical standards become less important, and producers will focus on component functionality and then develop various technical versions of a component. As a result, the number of producers that offer multiple technical standards is likely to increase (P2.5). Established catalogues and intermediaries are expected to offer all three technical standards (P2.6). In summary:

- P2.1 Most producers sell ActiveX, followed by JavaBeans and CORBA
- P2.2 The highest #components available on the market are ActiveX, followed by JavaBeans and CORBA
- P2.3 The difference between the #producers selling ActiveX and #producers selling JavaBeans is decreasing
- P2.4 The difference between #ActiveX components and #JavaBeans components on the market is decreasing
- P2.5 The #producers that offer multiple technical standards is increasing
- P2.6 Established catalogues and intermediaries offer all three technical standards

Type of Components Offered

Regarding the type of components, visual controls and fine-grained components are well-understood, and we therefore expect a large market supply that is still growing (P3.1). Most new entrants will offer controls, as the upfront investment is relatively low (P3.2).

Containers are usually more complex and they are only successful when they follow a recognized standard so that others can create controls that fit into the container. Therefore probably only small minority of producers offers containers (P3.3) and most new producers do not offer containers given the high upfront investments

(P3.4). Both command packages and libraries are a somewhat traditional approach to component reuse. We therefore think that a small and stable number of producers offer command packages and libraries (P3.5). Frameworks have received much attention recently. However, given their complexity and high upfront investments we only expect a limited and slightly growing number of producers (P3.6). Business components should bring benefits to both horizontal and vertical business domains. However, as few domain standards have been established, we foresee that only a slightly growing minority of the producers offer business components (P3.7). Furthermore, we expect ActiveX to be strong in the area of controls and containers given the long tradition of ActiveX components in graphical user interface, and anticipate that the focus of JavaBeans is more on business components and frameworks (P3.8).

In the early stages of maturity of the SCM, it is likely that intermediaries will offer all six types, while later, as the market matures, specialized intermediaries will focus on some of the types only (e.g. business components). Thus, the average number different component types that intermediaries sell will decrease (P3.9). In summary:

- P3.1 The majority #producers sells controls
- P3.2 Most new entrants offer controls
- P3.3 A small minority #producers offers containers
- P3.4 Most new producers will not offer containers
- P3.5 A small and stable #producers offer command packages and libraries
- P3.6 A limited and growing #producers sells frameworks
- P3.7 A growing minority #producers offers business components
- P3.8 ActiveX focuses on controls and containers, JavaBeans is strong in frameworks and business-components
- P3.9 The average #component types that intermediaries sell is decreasing

Component Documentation

In a mature SCM our proposition is that the customer should be able to easily assess the value of a component through extensive documentation. A simple description of the component is a minimal requirement and we expect that all producers, catalogues and intermediaries present this (P4.1). Given their business model of only redirecting customers to the producers' website, it seems that catalogues will not offer more sophisticated documentation (P4.2). Technical details are essential for a customer and will be provided by a growing majority of producers and intermediaries (P4.3). A demo version of a component increases its trialability, and we assume that a growing percentage of producers and intermediaries allow customers to download demo versions (P4.4). Test reports provide trust into the component, especially when intermediaries provide an independent test facility. We therefore expect that a growing number of intermediaries delivers test reports

(P4.5). Producers will continue to bring test reports (P4.6) although these are not objective and thus less valuable. Source code is an inexpensive method to provide extensive technical details. However, in a mature SCM we expect that components will only be specified by their interfaces, and thus delivering source code will be less common (P4.7). In summary:

- P4.1 All producers, catalogues and intermediaries present a basic description of the component
- P4.2 Catalogues do not offer documentation other than a basic description
- P4.3 A growing majority of producers and intermediaries provide technical details
- P4.4 A growing percentage of producers and intermediaries allow customers to download demo versions
- P4.5 A growing percentage of intermediaries delivers test reports
- P4.6 A stable percentage of producers delivers test reports
- P4.7 A decreasing percentage of producers and intermediaries deliver source code with a component

Research Method

To test the propositions stated above, a longitudinal research method was deployed. Data on the SCM was collected from November 1998 to March 1999 to create a 1999 market overview, and from December 1999 to February 2000 to create a 2000 market overview.

Data collection aimed at identifying all websites where software components can be found and/or bought. To locate the websites a selection of well-known search engines was used, including Yahoo, AltaVista, Lycos, Infoseek, Metacrawler, Excite and Hotbot. The following terms were used as keywords to locate the websites: software component, component, CBD, componentware, ActiveX, JavaBeans and CORBA. The website addresses that resulted from the search queries were visited and the relevant websites and the components offered were classified by the authors using the classification schemes described above. Using the search method and classification schemes described an overview of the component market was compiled. Given the extensive Internet search method used, it seems safe to assume that the data collected represent the vast majority of parties active on the Internet component market as of early 1999 and early 2000. It seems unlikely that any of the major online component suppliers did not register their website at any of the search engines used. In the next section the research database of the SCM market is used to test the propositions.

Results

High-Level Internet Market Structure

Propositions P1.1 to P1.11 can be assessed using Table 1. The data shows that the number of component producers grew 56% and the number of intermediaries increased 60% from 1999 to 2000. Four new intermediaries appeared in 2000, one intermediary present in 1999 disappeared from the market. Three new intermediaries started with offering hundreds of components, but one new entrant chose to offer a small set specialized on software engineering. The number of catalogues remained relatively stable, with only one new entrant in 2000 (P1.1 to P1.3 are supported).

The total number of components offered by producers increased considerably by 131% and the average number of components per producer grew by 45%. The total number of components offered through intermediaries grew 79% (P1.4 to P1.6 supported). However, do note that several intermediaries may sell the same component, so the total number of unique components available on the market is probably lower than 4832. It is nearly undoable to remove all double counts. Nevertheless, the data show that there is not yet a trend towards a small number of very large intermediaries plus a number of small and specialized intermediaries (P1.7 not supported).

The catalogues have increased their offering both in absolute numbers (+ 53%) as on average (+32%). The two largest intermediaries each offer around 1500 different components, which is considerably more than the largest catalogue. Note that a large number of probably small producers chooses only to sell their components through intermediaries (P1.8 to P1.10 supported).

	1999						2000					
nr of components	nr sites	tot	avg	std	min	max	nr sites	sum	avg	std	min	max
producers	27	375	13,9	6,7	10	25	43	865	20,1	14,0	5	84
catalogues	6	1037	172,8	127,5	30	329	7	1591	227,3	212,7	40	626
Intermediaries	5	2697	539,4	662,8	10	1326	8	4832	604,0	606,4	30	1516

Table 1: Number of components sold by sites

Technical Component Standards Offered

Table 2 shows that most producers sell ActiveX followed by JavaBeans while no CORBA components are currently sold on the Internet. Also, the majority of components directly available from producers are ActiveX (P2.1 and P2.2 supported). Also, most new producers that entered the market in 2000 sell ActiveX only. The total of ActiveX components has rapidly increased in 2000. Thus, JavaBeans are not yet catching up, at least not in the quantitative sense. Surprisingly, a vast majority of producers specializes (83%). Knowledge of the

technical standard still seems more important than the functional or domain knowledge needed to develop a component (P2.3 to P2.5 rejected).

Although in 1999 most intermediaries (80%) offered only a single standard, in 2000, the majority (75%) offers multiple technical standards. Catalogues have not developed in this manner and have kept their focus. P2.6 is thus only partly supported.

components technology offered by market parties:	1999						2000					
	nr sites	tot	avg	std	min	max	nr sites	sum	avg	std	min	max
producers												
activex only	13	190	14,6	7,2	10	25	26	538	20,7	15,8	10	84
beans only	7	100	14,3	7,3	10	25	8	114	14,3	7,7	5	25
corba only	0	0	0,0	0,0	0	0	0	0	0,0	0,0	0	0
activex and beans	7	85	12,1	5,7	10	25	7	136	19,4	9,1	10	31
activex,beans,corba	0						0					
intermediaries												
activex only	2	1386	693,0	895,2	60	1326	1	277	277,0		277	277
beans only	2	1301	650,5	777,1	101	1200	1	1516	1516,0		1516	1516
corba only												
activex and beans	1	10	10,0		10	10	5	2293	458,6	614,4	30	1500
activex,beans,corba	0						1	746	746,0		746	746
catalog												
activex only	4	707	176,8	164,0	30	329	4	884	221,0	277,4	40	626
beans only	2	330	165,0	21,2	150	180	2	405	202,5	183,1	73	332
corba only	0						1	302	302,0		302	302
activex and beans	0						0					
activex,beans,corba	0						0					

Table 2: Various technical component standards offering per market party

Type of Components Offered

Table 3 shows the data related to the types of components offered on the market. The data show that most producers offer containers and controls (P3.1 supported), although in 2000, there is no further shift towards controls (P3.2 not supported). Other than expected, many producers offer containers, and the percentage of producers that offer this type is slightly increasing (P3.3 and P3.4 rejected). Perhaps, an explanation is that most producers offer some kind of proprietary container for their controls to work in. Command packages and libraries are offered by a relatively stable percentage of producers (P3.5 supported). There is a small decrease in the percentage of producers selling frameworks and a small increase in

the number of producers selling business components. Interestingly, when these figures are examined for the two technical standards, the data show that most of the growth in controls and containers comes from new ActiveX components, and most new frameworks and business components use JavaBeans technology. (P3.6 rejected, P3.7 and P3.8 supported). In 1999, an intermediary offers an average of 4.2 different types, versus 4.1 in 2000. There is thus no strong trend towards specialization (P3.9 not supported).

% of sites that offer a component type	1999							2000						
	nr sites	t1	t2	t3	t4	t5	t6	nr sites	t1	t2	t3	t4	t5	t6
Producer	27	59,3	81,5	48,1	22,2	14,8	3,7	43	60,5	72,1	44,2	27,9	11,6	4,7
Catalog	6	100,0	100,0	83,3	50,0	16,7	16,7	7	100,0	100,0	85,7	71,4	57,1	28,6
Intermediary	5	80,0	100,0	100,0	80,0	40,0	20,0	8	100,0	100,0	100,0	100,0	87,5	50,0
Tech standard vs types*														
activex only	13	53,8	84,6	38,5	7,7	23,1	0,0	26	65,4	76,9	46,2	26,9	11,5	0,0
beans only	7	42,9	71,4	71,4	28,6	14,3	14,3	8	25,0	50,0	37,5	37,5	25,0	25,0

*t1= Controls, t2= containers (2), t3= command package, t4=library, t5= framework, t6=business component. * data could only be generated for producers that sell a single technological standard.*

Table 3: Type of components offering per market party and per technical standard

Component Documentation

Table 4 shows that virtually all producers and intermediaries offer component descriptions. Although in 1999, most catalogues only provided a reference to the component, in 2000 most catalogues have improved their service and offer a description of the component. (P4.1 supported). Catalogues generally offer little help, except for one that offers test reports and one that started to offer technical descriptions in 2000 (some support for P4.2). Technical details are offered by a small and slightly growing majority of the producers. The percentage of intermediaries that offers this grew from 40% to 50% in 2000 (P4.3 supported). Demo versions are very popular among producers, but less common among intermediaries (some support for P4.4). The percentage of intermediaries that offer test reports has decreased (P4.5 rejected. Only few producers provide test reports but their percentage has doubled from 1999 to 2000. Source code as a means of documentation is stable with producers and growing in popularity with intermediaries. (P4.6 and P4.7 rejected).

% of sites that offer this doc.type	1999						2000					
	nr sites	d1	d2	d3	d4	d5	nr sites	d1	d2	d3	d4	d5
Producer	27	96,3	51,9	88,9	7,4	22,2	43	97,7	55,8	81,4	16,3	20,9
Catalog	6	16,7	0,0	0,0	16,7	0,0	7	71,4	14,3	0,0	14,3	0,0
Intermediary	5	100,0	40,0	40,0	60,0	0,0	8	100,0	50,0	50,0	37,5	25,0

d1= simple description, d2= technical details, d3= demos, d4= test reports, d5= component source code

Table 4: Percentages of market parties that offer various component documentation types

Conclusions

This study has provided insight into the nature of the SCM on the Internet. Based on the results we can conclude that the SCM is still in its early stages. The number of parties active on the global market can still be printed on a single sheet of paper and the total number of components in the market can still be counted. Furthermore the market is still dominated by small “graphical” controls and there is not yet a trend towards business components. Also, different technical standards rather than functional and domain knowledge are important segmentation factors. On the other hand, signs of a more mature market can be seen. For example, this study showed that both intermediaries and catalogues are expanding their services and components are better documented. Also the offerings within some categories of components have grown dramatically.

This study has also provided a way to get more insight into the role of catalogues and intermediaries in a complex and growing e-market. There are several conflicting views on the role intermediaries play in an e-market and on how they can deploy successful business models and avoid dis-intermediation. For example, should intermediaries specialize or aim to be present in all areas? Is there a continuing role for catalogues? By regularly classifying and counting the offerings of the various parties within an e-market as was done in this study, we can increase our understanding of how e-markets evolve. Future research plans include continuing the periodic scan of the SCM to observe and analyse the structure and trends. Furthermore, we plan to compare the SCM to other E-markets of intangible and complex goods.

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