

# E-COMMERCE ADOPTION TRAJECTORIES AMONG MANUFACTURING SMEs

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## ABSTRACT

The intent of this paper is to provide empirically tested and validated metrics to capture the gradual adoption of e-commerce among manufacturing SMEs. The results suggest that e-commerce adoption is purposely undertaken in a cumulative, and thus path-dependent, way. The findings also demonstrate that most SMEs follow e-commerce adoption trajectories. The proposed stage model for e-commerce adoption and the derived index of e-commerce penetration represent potentially valuable contributions.

## KEYWORDS

E-commerce adoption, e-commerce indicators, SMEs

## 1. INTRODUCTION

Although public policy makers encourage small and medium-sized enterprises (SMEs) to fully engage in the digital economy (OECD, 1998 and 2000), our empirically based understanding of electronic commerce (e-commerce) adoption among these firms is still limited (Kendall et al., 2001) and appears to be even more limited in a manufacturing context (Elia et al., 2003). A few studies point to the fact that SMEs are lagging behind their larger counterparts in terms of e-commerce adoption (for instance, Coppel, 2000; Kendall et al., 2001; Charles et al., 2002). But very little is known about the level of e-commerce penetration and diffusion among these firms.

This paper departs from previous studies by simultaneously pursuing three objectives: (i) to propose a stage model of e-commerce penetration; (ii) to develop an index of e-commerce penetration based on the above-mentioned model; (iii) to examine e-commerce adoption trajectories. The intent of this paper is to provide empirically tested and validated metrics to capture the gradual adoption of e-commerce among manufacturing SMEs.

## 2. THEORETICAL ISSUES

The measurement of e-commerce penetration and diffusion is plagued with difficulties. In this section, we will briefly outline previous work on e-commerce metrics. The specific context of e-commerce adoption among SMEs will then be discussed. Finally, we will build on the evolutionary theory to propose the concept of e-commerce adoption trajectories.

## **2.1 E-commerce metrics**

E-commerce has been narrowly defined as buying and selling over the Internet. From a broader perspective, “e-commerce is considered as the use of Internet and related technologies to support any activity that is necessary for an organization to function effectively” (Magal et al., 2001, p. 2). This definition is retained here.

Some previous indicators used to assess e-commerce penetration rely on connectivity measures, such as access to the Internet, and the types of information and telecommunications technologies used (see, for instance, Grandon and Pearson, 2003; Riquelme, 2002; US Department of Commerce, 2002a; Van Bevern and Thomson, 2002). Other studies provide monetary figures related to e-commerce transactions (OECD, 2002; Statistics Canada, 2001). These studies provide valuable indicators but offer little help in understanding how organizations rely on e-commerce to support their ongoing activities.

Some pioneering work has been done on broad e-commerce activities (Bertschek and Fryges, 2002; US Department of Commerce, 2002b) and on e-commerce business processes and capabilities (Zhu and Kraemer, 2002). More recently, authors such as Elia et al. (2003) have attempted to derive new e-commerce metrics based on business processes. Advocates for this latter approach believe that this “process view is a more dynamic description of how an organization acts” (Magal et al., 2001, p. 3). Furthermore, this process view provides a cross-functional perspective that is typical of the reality of e-commerce and allows one to focus on the value creation processes in firms. We will therefore retain business processes as the unit of analysis to measure e-commerce penetration. In other words, we propose to identify, at the firm level, which business processes are carried out electronically.

## **2.2 The specific context of e-commerce adoption in SMEs**

SMEs’ alleged vulnerability to problems during e-commerce adoption may be exaggerated. Without a doubt, SMEs lack the financial and non-financial resources to implement sophisticated technologies. However, they still seem to be able to capitalize on the potential of e-commerce. For instance, a survey of about 1,200 American and European firms showed that small firms may experience a greater proportional revenue increase per employee from e-commerce than their larger counterparts (CREC, 1999). Moreover, e-commerce has been shown to expand markets and to effectively target market segments (Conference Board, 2000).

Previous work demonstrates that SMEs manage their internal and external information systems less formally (La Rovere, 1996) and do not adequately plan the use of ICT (Lees and Lees, 1987). But these smaller firms are becoming more “sophisticated” (Bergeron and Raymond, 1992). Furthermore, their CEOs appear to be becoming more aware of the importance of e-commerce (Grandon and Pearson, 2003); they are finding that they can achieve the same benefits associated with EDI through the Internet, and without making substantial investments (Boyer and Olson, 2002).

Based on the above discussion, e-commerce appears to be a viable solution even for smaller firms.

## **2.3 E-commerce adoption from an evolutionary perspective**

In evolutionary theory, the focus is on the explanation of dynamic behavior over time (Nelson and Winter, 1982; Burgelman, 1983). We will draw heavily from the rich body of literature in this field to retain two crucial concepts: path dependency and trajectories. Ecommerce adoption is considered here as “path-dependent” in the sense that the outcome depends on how adoptions build up (Arthur, 1987). Prior experience and knowledge gained from that experience allow the assimilation and exploitation of new knowledge (Cohen and Levinthal, 1990). Path dependency implies a dynamically self-reinforcing behavior, whether this behavior is triggered by historical accidents or by rational decisions.

Technological trajectories (Dosi, 1982) imply the existence of sequences of innovations. Given that e-commerce is considered as “clusters of separate innovations” (Daniel et al., 2002), e-commerce adoption trajectories appear to be a concept that warrants further investigation.

### 3. METHODOLOGICAL ISSUES

Several important issues are addressed in this section: issues related to measurement, to the target population and types of respondents and to the data collection method.

#### 3.1 Instrument development

The indicators of e-commerce adoption in manufacturing SMEs were first developed and validated in a four-step pilot study which relied on separate sources of information:

*Step 1: A thorough review of previous studies of e-commerce penetration.*

*Step 2: Simulations of simple and advanced e-commerce applications carried out with CEOs of SMEs.* These transfer activities reached some 1,503 organizations over the last four years and allowed us to obtain a first set of business processes that could be conducted electronically.

*Step 3: Five focus groups with CEOs of manufacturing SMEs.* The first set of business processes, classified during step 2 under five main value chain activities (product development, engineering and design; procurement/purchasing; production/operations; sales, marketing and after-sales services; and production logistics) were validated by the focus groups.

*Step 4: One panel of experts.* The business processes were further validated by a panel of twelve independent experts. Using the Delphi method, the experts also reached a consensus on the relative degree of complexity of each of the business processes retained in step 3. The pilot study, which is in line with the grounded theory approach (Strauss and Corbin, 1990), allows us to first propose a stage model for e-commerce adoption based on 36 business processes, and then classify SMEs according to stage.

All other research variables, namely the firms' characteristics (size, exports and imports) and the volume of e-commerce transactions, were derived from the literature review.

#### 3.2 Population and respondents

The targeted population represents manufacturing SMEs, which are defined here as firms with fewer than 500 employees, a definition similar to the one used by government agencies such as the US Small Business Administration. The focus on the manufacturing sector is justified for two main reasons. First, it offers the possibility of examining a wider range of business processes than would be the case in the retail industry or the service sector. Second, it minimizes the differences resulting from sectorial particularities with respect to e-commerce adoption (Zhu and Kraemer, 2002).

The chief executive officer (CEO) was selected as the single informant since he or she acts as the "principal architect of corporate strategy" (Harrison, 1992), including technological choices and investments (Lefebvre et al., 1997).

#### 3.3 Data collection method

A systematic sample was drawn from an up-to-date government list of all manufacturing SMEs operating in one Canadian province. The list included the name and electronic address of the CEO, as well as some key characteristics (such as the number of employees and the geographic location). CEOs of the selected firms were reached by e-mail and asked to participate in an on-line survey. Compared to traditional mail questionnaires, an electronic survey offers some advantages such as the creation of a more interactive and attractive instrument, the reduction in handling costs and response cycle time, as well as the elimination of errors due to data re-entry (Couper, 2000; Rogelberg et al., 2001; Dillman, 2000).

A few years ago, generalized access to the Internet was considered a potential shortcoming for on-line surveys, but it no longer represents an important issue since the majority of Canadian SMEs were connected to the Internet in 2001 (68% of small firms and 91% of medium-sized firms according to Chambers et al. (2002)). It is, however, acknowledged that the use of an electronic survey minimizes the number of non-adopters of e-commerce.

No significant differences (goodness of fit tests) were found between respondents and non-respondents with respect to firm size. However, the response rate was slightly higher for urban areas. The overall

response rate reached 7.67%, which is quite acceptable for an electronic survey. A total of 230 manufacturing SMEs participated in the survey. Subsequent data analyses were performed on these 230 firms.

## 4. RESULTS AND DISCUSSION

Data obtained from the electronic survey will be analyzed in three consecutive steps. First, we will present the proposed stage model for e-commerce adoption (section 4.1). Second, indicators of e-commerce adoption will be proposed and the profiles of the 230 manufacturing SMEs at each stage of the model discussed (section 4.2). Third, we will examine e-commerce adoption trajectories (section 4.3).

### 4.1 Stage model of e-commerce adoption

The 36 business processes which can be executed in an electronically mediated environment were thoroughly validated during the pilot study. These business processes allow us to propose a stage model for e-commerce adoption among manufacturing SMEs. As indicated in figure 1, SMEs can be positioned at four different stages, with stage 1 being the least complex and stage 4 the most complex.

#### **Stage 1: Electronic information search and content creation**

- Seek out new suppliers
- Seek out products/services
- Advertise the company and/or its products/services
- Seek out new customers
- Convert information on products/services into digital form

#### **Stage 2: Electronic transactions**

- Buy products/services using electronic catalogs
- Place and manage orders with suppliers
- Access suppliers' product/service databases
- Sell products/services using electronic catalogs
- Receive and manage customer orders
- Access customers' product/service databases
- Offer customers after-sales services

#### **Stage 3: Complex electronic transactions**

- Buy products/services by electronic auction
- Buy products/services by issuing electronic calls for tenders
- Negotiate contracts (price, volume, etc.) with suppliers
- Make electronic payments to suppliers
- Sell products/services by electronic auction
- Sell products/services by responding to electronic calls for tenders
- Negotiate contracts (price, volume, etc.) with customers
- Receive electronic payments from customers
- Allow customers to access the company's inventories
- Access customers' inventories
- Allow suppliers to access the company's inventories
- Access suppliers' inventories

#### **Stage 4: Electronic collaboration**

- Transfer documents and technical drawings to customers
- Transfer documents and technical drawings to suppliers
- Integrate software supporting product design (e.g. CAD/CAM, VPDM, PDM)
- Do collaborative on-line engineering with suppliers
- Do collaborative on-line engineering with customers
- Automate the production floor using a manufacturing execution system (MES)
- Integrate the MES into the management information system
- Ensure the management of quality assurance using the management information system
- Automate distribution/logistics using a logistics execution system (LES)
- Allow distribution/transportation partners to access the information they need (SKU, quantity, delivery turnaround, etc.) in order to reduce time and costs related to distribution
- Optimize returns management ("reverse logistics")
- Track products (purchased and sold) during transportation

Figure 1. Proposed stage model for e-commerce adoption among manufacturing SMEs

At stage 1, SMEs start to capitalize on the possibilities provided by the Web and perform activities such as searching for new suppliers or products/services or ensuring a presence on the Internet with an informational Web site. At stage 2, SMEs can move on to electronic transactions, from transaction preparation to transaction settlement, but excluding electronic payments. These electronic transactions are, however, easier to realize than those that characterize the next stage. At stage 3, the level of complexity increases due to (i) the type of electronic transactions (auctions, calls for tenders), (ii) the fact that the transactions are finalized electronically and now include electronic payments, and (iii) business partners' level of involvement in the exchange of strategic information. The fourth and last stage requires continuous electronic collaboration between business partners: It includes activities related to collaborative engineering, e-distribution and e-logistics. SMEs positioned at stage 4 could usually belong to networks and supply chains driven by electronically sophisticated large firms.

### 4.2 Indicators of e-commerce adoption and profile of manufacturing SMEs

The four stages described in section 4.1 imply that at least one business process is conducted electronically by the SMEs that have adopted e-commerce. But what about non-adopters? We suggest dividing the non-adopters into two groups: those with no interest and those with some interest in e-commerce (stages 00 and 0 respectively). The proposed index of e-commerce penetration among SMEs would therefore present six stages (Figure 2), allowing us to position each of the 230 responding firms at one of the six stages.

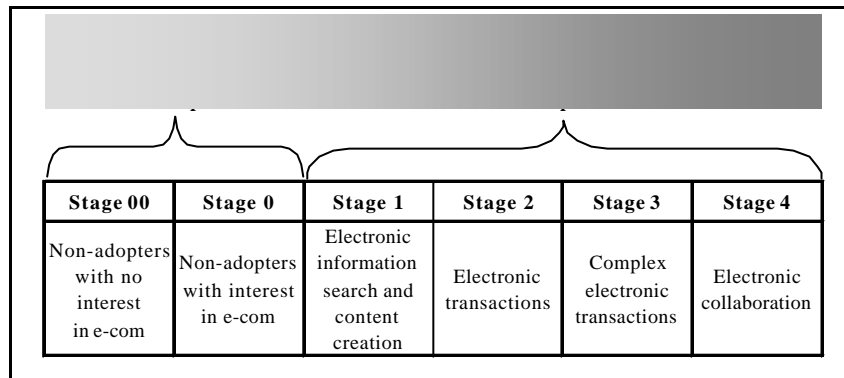


Figure 2. Proposed index of e-commerce penetration among SMEs

From the information displayed in Figure 2, a number of interesting observations can be made:

- (i) The group of non-adopters represents 47% of the responding firms ( $n_1 = 76 + n_2 = 32$ ), which is comparable with the data provided by Canadian national agencies. Surprisingly, most of the non-adopters ( $n_1 = 76$ ) show no interest in e-commerce.
- (ii) Firms size does seem to play a major significant role: there is a net progression between stages 1 and 4, where average annual sales increase from stage to stage (from CAN \$18.13 million to CAN \$139.19 million).
- (iii) SMEs at stages 3 and 4 are significantly more active with regard to exports and imports.

Figure 3 also displays the relative volume of electronic transactions – i.e. e-sales and e-procurement. The results validate to a large extent the proposed index of e-commerce penetration, at least in the context of manufacturing SMEs, since the relative volume of electronic transactions increases significantly from stage to stage. Finally, the results clearly indicate a path dependency among SMEs that have adopted e-commerce (bottom part of figure 3). The vast majority of firms have attained stage 1 (103 out of 122 SMEs or 84.43% of all e-commerce adopters) while most passed through the stages in order, rather than, say, leaping from stage 1 to stage 3 (although see section 4.3).

SMEs characteristics	Non-adopters		Adopters				p <sup>(1)</sup>
	Stage 00	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	
		Non-adopters with no interest in e-com (n <sub>1</sub> = 76)	Non-adopters with interest in e-com (n <sub>2</sub> = 32)	Electronic information search and content creation (n <sub>3</sub> = 8)	Electronic transactions (n <sub>4</sub> = 17)	Complex electronic transactions (n <sub>5</sub> = 47)	
Size (annual sales in \$CAN)	53.82 M	31.53 M	18.13 M	23.34 M	84.46 M	139.19 M	NS
Level of exports	9.32%	8.08%	11.95%	8.78%	17.12%	16.97%	**
Level of imports	17.23%	11.69%	12.14%	8.12%	20.61%	32.45%	***
Volume of e-transactions % of sales <sup>(2)</sup>	N/A	N/A	0.00%	1.43%	9.29%	12.58%	****
% of e-procurement <sup>(2)</sup>	N/A	N/A	0.00%	0.98%	16.59%	21.27%	****
Cumulative number of SMEs that have reached							
	Stage 4					50	
	Stage 3				81		
	Stage 2			102			
	Stage 1		103				

(1) Level of significance of the Kruskal Wallis test (non-parametric ANOVA)

\* p<0.10, \*\* p<0.05, \*\*\* p<0.01, \*\*\*\* p<0.001

(2) Ratio of e-sales over total sales

Ratio of e-procurement over total procurement

NS = non-significant

N/A = not applicable

Figure 3. Profile of manufacturing SMEs and validation of proposed index of e-commerce penetration

### 4.3 E-commerce adoption trajectories among manufacturing SMEs

If we examine closely the intended e-commerce strategies (simply measured here as the business processes that will be conducted by electronic means within a 12-month period), the following comments arise from Figure 4:

- (i) All non-adopters with an interest in e-commerce (stage 0) will move towards stages 1, 2, 3 or 4. Their interest in e-commerce seems likely to translate into future action.
- (ii) Most SMEs follow a trajectory: they either stay at the same stage if they are positioned at stages 1, 2, 3 or (obviously) 4 or they go on to the next stage (stage 0 to 1: 6 SMEs; stage 1 to 2: 3 SMEs; stage 2 to 3: 8 SMEs; stage 3 to 4: 30 SMEs).
- (iii) Some SMEs leap over one or even several stages. The more inexperienced they are with e-commerce, the more they tend to follow this non-linear trajectory: this is particularly evident with SMEs currently positioned at stage 0. In addition to their inexperience, it is also possible that SMEs are “pushed” towards rapid e-commerce adoption by their business partners or that they are present on electronic marketplaces that offer advanced e-commerce functionalities (such as e-collaboration activities) in a rather user-friendly fashion.

The overall impression gained from figure 4 is that e-commerce adoption is purposely undertaken in a cumulative, and thus in a path-dependent way, and does not seem to be the result of stochastic decisions. Results strongly suggest that SMEs follow e-commerce adoption trajectories.

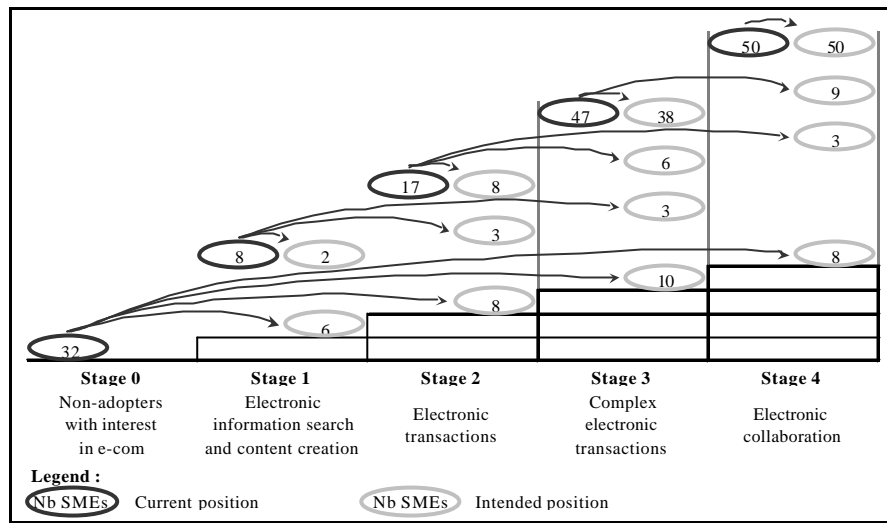


Figure 4. E-commerce adoption trajectories

## 5. CONCLUSION

The findings of this study should be interpreted in the light of certain limitations. The sample size (n = 230) is rather small, especially considering that it is divided into six clusters (i.e. firms belonging to each of six stages).

This may preclude making comprehensive generalizations. However, considerable efforts were made to identify, test and validate the 36 business processes from multiple sources of information. Triangulation increases internal validity.

Two major contributions emerge from the study. First, we have attempted to derive improved metrics for e-commerce penetration, and metrics are essential if research is to progress (Straub et al., 2002). Both the stage model for e-commerce adoption and the index of e-commerce penetration may represent valuable first efforts to capture one crucial dimension of the digital economy. Second, our findings suggest logical evolutionary paths and deepen our understanding of e-commerce adoption among manufacturing SMEs. With this increased understanding, researchers and policy makers may better target their efforts at monitoring and fostering e-commerce among smaller firms.

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