Exploring B-to-B e-commerce adoption trajectories in manufacturing SMEs

Louis-A. Lefebvre, Élisabeth Lefebvre, Elie Elia, Harold Boeck

Abstract

The intent of this paper is to capture the gradual unfolding of business-to-business (B-to-B) e-commerce adoption in small and medium-sized enterprises (SMEs). Empirical evidence was gathered in three separate but complementary phases: first, a pilot study to identify and validate metrics for B-to-B e-commerce adoption; second, an e-survey to gain an in-depth understanding of B-to-B e-commerce adoption and its related benefits; and third, a multiple case study to further validate the e-commerce adoption trajectories we observed and their underlying dynamics. Findings suggest logical evolutionary paths to the penetration of B-to-B e-commerce in SMEs. The cumulative and self-reinforcing nature of both e-commerce initiatives and the benefits derived therefrom points to the existence of e-commerce adoption trajectories.

Keywords: B-to-B e-commerce; SMEs; Adoption trajectories; Cumulative benefits

1. Introduction

Electronic commerce (e-commerce) represents a highly pervasive innovation (Prananto et al., 2003) that is leading to significant changes in the traditional ways of doing business. The intent of this paper is to capture the gradual unfolding of business-to-business (B-to-B) e-commerce adoption in small and medium-sized enterprises (SMEs). More specifically, the objectives are as follows:

(i) to propose and validate a stage model of B-to-B e-commerce adoption in the specific context of manufacturing SMEs;
(ii) to assess whether B-to-B e-commerce initiatives are undertaken in a cumulative and path-dependent way and to explore whether SMEs follow e-commerce adoption trajectories;
(iii) to determine whether the benefits derived from e-commerce adoption are self-reinforcing as SMEs gain more experience with e-commerce initiatives.

This line of inquiry seems particularly relevant for several reasons. First, B-to-B e-commerce represents roughly 70–85% of total e-commerce activities (OECD, 2004; The Economist, 2004). Second, SMEs appear to be lagging behind their larger counterparts (Drew, 2003) despite the considerable efforts made by governmental agencies to accelerate e-commerce adoption among SMEs (e.g., eEurope Action Plan, 2002; OECD, 2002; OECD, 2004; US Department of Commerce, 2002a). Third, our collective knowledge of e-commerce issues in SMEs remains scarce (Jeffcoate et al., 2002; Kendall et al., 2001) and is even slimmer in the case of B-to-B e-commerce (Gebauer and Shaw, 2002).

The paper is structured as follows. In the next section, we briefly outline previous work on e-commerce penetration measures, build on the evolutionary theory to propose the concept of e-commerce adoption trajectories, and examine some of the relevant literature regarding benefits related to B-to-B e-commerce. This is followed by a discussion of the methodology (Section 3). The results are then presented...
2. Theoretical issues

2.1. Measuring B-to-B e-commerce penetration: an integrative and business process approach

E-commerce has been narrowly defined as buying and selling over the Internet but, 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). The latter definition is retained here. Since organizations first started to use EDI (Electronic Data Interchange) systems a few decades ago (Gebauer and Shaw, 2002), electronic integration between manufacturers and their business partners (subcontractors, suppliers, distributors, customers, etc.) has grown steadily. In fact, the advent of Internet and Web-based technologies has opened up new avenues for B-to-B e-commerce, in particular hybrid e-commerce solutions such as Internet-EDI (Chan and Swatman, 2004). B-to-B e-commerce also implies exchanging and sharing information within the firm itself or with external stakeholders (Daniel et al., 2002) and therefore supports both intra- and inter-organizational processes through public (e.g. on the Internet) and private networks (e.g. Extranet and Intranet).

Some indicators previously 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 Beveren and Thomson, 2002). Other studies provide monetary figures related to e-commerce transactions (OECD, 2002; Statistics Canada, 2001). These studies offer valuable indicators but are of little help in understanding how organizations rely on e-commerce to support their ongoing activities. Some pioneering work has been done on e-commerce activities as a whole (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 for measuring e-commerce penetration. In other words, we propose to identify, at the firm level, which business processes are carried out electronically in the manufacturing context.

2.2. E-commerce adoption from an evolutionary perspective: path dependency, trajectories and stage models in SMEs

In evolutionary theory, the focus is on the explanation of dynamic behavior over time (Burgelman, 1983; Nelson and Winter, 1982). We will draw heavily from the rich body of literature in this field to retain two crucial concepts: path dependency and trajectories. E-commerce adoption is considered here as ‘path-dependent’ in the sense that the outcome depends on how adoptions accumulate (Arthur, 1987). Prior experience and knowledge gained from that experience allow new knowledge to be assimilated and exploited (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) suggest the existence of sequences of innovations. Given that e-commerce is considered to consist of clusters of separate innovations (Daniel et al., 2002; Lertwongsatien and Wongpinunwatana, 2003) making up a technology system (Rosenberg, 1982), rather than a single technology, e-commerce adoption trajectories appear to be a concept that warrants further investigation.

Such a line of inquiry falls within the realm of exploratory research for several reasons. First, the existence of common patterns of e-commerce adoption among SMEs remains unclear (Craighead and Laforge, 2003). Second, the sequential nature of e-commerce adoption by SMEs and, consequently, the existence of a stage model are not fully demonstrated (Fillis et al., 2004) except for a few exceptions (Chan and Swatman, 2004; Daniel et al., 2002; Rao et al., 2003). Third, there is a lack of research into the strategic plans for future use of e-commerce by SMEs (Drew, 2003), which represents a prime concern among SMEs’ managers (Damaskopoulos and Evgeniou, 2003). To our knowledge, no prior study has examined progression paths and e-commerce adoption trajectories.

2.3. Benefits derived from e-commerce in the specific context of 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. Previous work also demonstrates that SMEs manage their internal and external information systems less formally than large corporations (La Rovere, 1996) and do not adequately plan the use of ICTs (Lees and Lees, 1987). Still, these smaller firms have become 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, by using the Internet, they can achieve the same benefits associated with EDI without making substantial investments (Boyer and Olson,
Among the benefits, SMEs often rank the increased visibility offered by a Web presence as one of the most important motivations behind their e-commerce initiatives (OECD, 2004). E-commerce is also said to level the playing field for smaller firms (OECD, 2002) by expanding their market reach, reducing market entry barriers and targeting market segments more effectively. Consequently, an increase in revenues and market share can be expected. E-commerce also allows improved customer relations and communications (Sadowski et al., 2002; Santarelli and D’Altri, 2003) and improved customer service in general (Chan and Lee, 2003). With the more advanced B-to-B e-commerce initiatives, SMEs move from arm’s-length relationships to more cooperative relationships, especially in the context of supply chain management (Lefebvre et al., 2005). The result is a reduction in inventory cost and distribution costs (Gunasekaran et al., 2002; Lancioni et al., 2000) and improved customer relations and product development and design costs (Kothandaraman and Wilson, 2001).

E-commerce also allows improved customer relations and communications (Sadowski et al., 2002; Santarelli and D’Altri, 2003) and improved customer service in general (Chan and Lee, 2003). With the more advanced B-to-B e-commerce initiatives, SMEs move from arm’s-length relationships to more cooperative relationships, especially in the context of supply chain management (Lefebvre et al., 2003). The result is a reduction in inventory cost and delivery time (Frohlich and Westbrook, 2002; Turner, 2000), procurement (Chan and Lee, 2003), logistics and distribution costs (Gunasekaran et al., 2002; Lancioni et al., 2000) and engineering, product development and design costs (Kothandaraman and Wilson, 2001).

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

3. Research design and methodology

The empirical evidence was gathered in three separate but complementary phases: first, a pilot study to identify and validate metrics for B-to-B e-commerce adoption; second, an e-survey to gain an in-depth understanding of the gradual unfolding of the B-to-B e-commerce adoption and its related benefits among manufacturing SMEs; and third, a multiple case study to further validate the e-commerce adoption trajectories we observed and their underlying dynamics. This sequential qualitative-quantitative approach seems particularly appropriate for exploratory research (Creswell, 1994; Tashakkori and Teddlie, 1998).

3.1. Phase 1: the pilot study

As discussed in Section 2.1, we favored an integrative and process-based approach. The major difficulty encountered in this first phase resides in the identification and validation of a broad set of business processes, which can be conducted using electronic means. The three-step pilot study encompasses separate sources of information:

Step 1: Simulations of simple and advanced e-commerce applications carried out with the CEOs of SMEs. These transfer activities reached some 1503 organizations over the last four years and allowed us to obtain a first set of business processes that can be conducted electronically.

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

Step 3: 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 concerning the relative degree of complexity of each of the business processes retained in step 2.

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 which stage they are at.

3.2. Phase 2: the e-survey

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 of the firm (such as the number of employees and the geographic location). CEOs of the selected firms were contacted by e-mail and asked to participate in an online survey. Compared to traditional mail-in 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; Dillman, 2000; Rogelberg et al., 2001). A few years ago, the lack of generalized access to the Internet was considered a potential shortcoming for on-line surveys, but it no longer represents an important issue since the vast majority of Canadian SMEs are now connected to the Internet (OECD, 2004, p.12). It is, however, acknowledged that the use of an electronic survey minimizes the number of non-adopters of e-commerce who can take part.

No significant differences (goodness of fit tests) were found between respondents and non-respondents with respect to firm size. 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 192 manufacturing SMEs participated in the survey. Subsequent data analyses were performed on these 192 firms.

3.3. Phase 3: the multiple case study

Among the 192 SMEs which participated in the e-survey, we selected two firms per stage of the observed stage model, for a total of twelve firms. For each of these firms, multiple sources of evidence were used to allow triangulation (Miles and Huberman, 1994; Yin, 1994): (i) publicly available information; (ii) internal reports and other documents, and (iii) on-site semi-structured interviews with senior managers. All of the data from the multiple sources were
thoroughly examined, coded and analyzed. For interview data, within- and cross-case analysis was performed.

4. Findings

As the research design includes three phases and the results of each phase build upon the findings of the preceding one, we will present the results in a consecutive fashion.

4.1. Findings of the pilot study

4.1.1. E-commerce initiatives by broad generic functions: a business-process approach

Thirty-six business processes which can be carried out in an electronically mediated environment (eBPs) were thoroughly validated with the five focus groups. As shown in Fig. 1, these processes cover the five generic functions usually found in manufacturing firms: product development, engineering and design; procurement/purchasing; production/operations; sales, marketing and after-sales service; and distribution and logistics. Fig. 1 indicates that e-commerce could potentially pervade all five functions. Support functions such as human resources management or information and telecommunication services were not retained as they tend not to be formally organized in an SME context.

It can also be observed from Fig. 1 that some eBPs, such as ‘seek out new customers,’ are present in non-manufacturing firms while others, such as ‘automate the production floor,’ are specific to a manufacturing context. Hence, the proposed typology of the 36 eBPs is rather broad and subsets of eBPs could be derived for SMEs in the service sector or in wholesale and retail commerce.

4.1.2. E-commerce initiatives and the proposed adoption stage model

Results from the focus groups also allowed us to derive a stage model (upper part of Fig. 2) that differentiates non-adopters (stage 00 and stage 0) from adopters (stages 1, 2, 3 and 4). Stage 00 refers to non-adopters with no intention of getting involved in any e-commerce initiatives, whereas firms at stage 0 are not presently conducting any e-commerce activity but are planning to do so within the next 12 months. In order to capture the different stages of B-to-B e-commerce penetration among adopters, we have distributed the same 36 eBPs shown in Fig. 1 among stages 1, 2, 3 and 4 (middle part of Fig. 2). Stage 1 indicates that SMEs are only conducting activities related to electronic information search and content creation (eBP6, eBP7, eBP23 and eBP22, eBP24). Stage 2 represents simple e-transactions such as buying products/services using electronic catalogs (eBP8) while stage 3 includes more complex e-transactions such as participating in electronic auctions (eBP9, eBP26) or negotiating contracts on-line (eBP12, eBP28). Stage 4 considers a wider range of e-commerce capabilities that support e-collaboration with customers and suppliers. The panel of twelve experts confirmed the validity of the stage model.

Moving one step further into the validation of the proposed stage model, the panel of experts evaluated the relative level of complexity of each of the 36 eBPs (left-hand side of Fig. 2). The Delphi method yielded two iterations before reaching a broad consensus. Inter-rater reliability between the members of the panel proved to be excellent for most business processes (ranging from 0.7 to 1.0) and satisfactory for the remaining ones (≥0.6). The mean level of complexity for all stage 1 eBPs (as evaluated by the twelve experts) was 1.50; the mean levels were 2.83 for stage 2 eBPs, 3.55 for stage 3 eBPs and 4.70 for stage 4 eBPs. This supports the assumption that complexity generally increases with the stages. It can therefore be assumed that as SMEs adopt eBPs from more advanced stages, they have to assimilate more complex technologies and undertake more complex organizational changes. The SMEs therefore need not only to acquire new technologies but to engage in a learning process to accumulate additional skills and knowledge related to the more advanced e-commerce initiatives.

The bottom part of Fig. 2 indicates how two scores of e-commerce penetration can be derived. The first score of e-commerce penetration in one particular firm simply represents the sum of business processes that a firm conducts in an electronically mediated environment while the second score is weighted to reflect the level of complexity of each eBP. Hence, the weighted score is considered to be a more appropriate indicator of the level of e-commerce penetration.

Is the stage model proposed in Fig. 2 fully anchored in the reality of manufacturing SMEs? The second phase of the research design, i.e. the e-survey, provides some answers to that question.

4.2. Findings of the e-survey

4.2.1. Profile of manufacturing SMEs and validation of the stage model

The information displayed in Table 1 gives rise to a number of interesting observations:

(i) The group of non-adopters represents 19.8% of the responding firms (n_a = 38 + n_0 = 32), which is comparable with the data provided by Canadian national agencies. Surprisingly, most of the non-adopters (n_a = 38) show no interest in future e-commerce initiatives. Non-adopters (stages 00 and 0) are not significantly smaller than SMEs in the earlier stages of adoption (Stages 1 and 2).

(ii) Among adopters, firm 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 in stages 3 and 4 are significantly more active with regard to exports and imports.

Table 1 also displays traditional indicators of e-commerce penetration: e-sales and e-procurement and the two e-commerce penetration scores. The results largely validate the proposed stage model, at least in the context of
Non-adopters

Stage 00: Non-adopters with no interest in e-commerce

Stage 0: Non-adopters with interest in e-commerce

Adopters

Stage 1: Electronic information search & content creation
- eBP6. Seek out new suppliers
- eBP7. Seek out products/services
- eBP22. Advertise the company and/or its products/services
- eBP23. Seek out new customers
- eBP24. Convert information on products/services into digital form

Stage 2: Electronic transactions
- eBP8. Buy products/services using electronic catalogs
- eBP11. Place and manage orders with suppliers
- eBP14. Access suppliers’ product/service databases
- eBP25. Sell products/services using electronic catalogs
- eBP29. Receive and manage customer orders
- eBP31. Access customers’ product/service databases
- eBP32. Offer customers after-sales service

Stage 3: Complex electronic transactions
- eBP9. Buy products/services by electronic auction
- eBP10. Buy products/services by issuing electronic calls for tenders
- eBP12. Negotiate contracts (price, volume, etc.) with suppliers
- eBP13. Make electronic payments to suppliers
- eBP18. Allow customers to access the company’s inventories
- eBP19. Access customers’ inventories
- eBP20. Allow suppliers to access the company’s inventories
- eBP21. Access suppliers’ inventories
- eBP26. Sell products/services by electronic auction
- eBP27. Sell products/services by responding to electronic calls for tenders
- eBP28. Negotiate contracts (price, volume, etc.) with customers
- eBP30. Receive electronic payments from customers

Stage 4: Electronic collaboration
- eBP1. Transfer documents and technical drawings to customers
- eBP2. Transfer documents and technical drawings to suppliers
- eBP3. Integrate software supporting product design (e.g. CAD/CAM, VPDM, PDM)
- eBP4. Do collaborative on-line engineering with suppliers
- eBP5. Do collaborative on-line engineering with customers
- eBP15. Automate the production floor using a manufacturing execution system (MES)
- eBP16. Integrate the MES into the management information system
- eBP17. Ensure the management of quality assurance using the management information system
- eBP33. Automate distribution/logistics using a logistics execution system (LES)
- eBP34. 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
- eBP35. Optimize returns management (“reverse logistics”)
- eBP36. Track products (purchased and sold) during transportation

Score of e-commerce penetration = \( \sum_{i=1}^{15} c_i \times eBP_i \) and weighted score of e-commerce penetration = \( \sum_{i=1}^{15} c_i \times eBP_i \)

Where eBP_i corresponds to the eBPs listed above (eBP_i = 0 when eBP_i is not conducted in one particular firm using electronic means and eBP_i = 1 when it is) and c_i = degree of complexity of each eBP as rated by a panel of 12 experts.

Fig. 2. Proposed stage model for e-commerce penetration among manufacturing SMEs.
manufacturing SMEs, since the relative volume of electronic transactions and the two scores of e-commerce penetration increase significantly from stage to stage.

4.2.2. E-commerce adoption trajectories

If we closely examine 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 Fig. 3:

(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 be reflected in future action.

(ii) Most SMEs (122 out of 154 firms or 79%) positioned at stages 0, 1, 2, 3 and 4 are following a trajectory: they will either progress within the same stage (i.e., they intend to perform electronically some additional business processes belonging to their current stage) or they will move 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 (32 out of 154 firms or 21%) will leap over one or even several stages. The more inexperienced they are with e-commerce, the more they tend to follow this kind of leap-frogging: this is particularly evident with SMEs currently positioned at stage 0.

The overall impression gained from Fig. 3 is that e-commerce adoption is purposely undertaken in a cumulative, and thus a path-dependent way, and does not seem to be the result of stochastic decisions. The results strongly suggest that SMEs follow e-commerce adoption trajectories; moreover, they clearly indicate a path dependency among SMEs that have adopted e-commerce. While most firms (79%) passed through the stages in order, a few (21%) have jumped stages (Fig. 4). Section 4.3 will shed some light on the phenomenon of SMEs jumping stages.

4.2.3. The gradual unfolding of B-to-B e-commerce initiatives

Which business processes are now conducted in an electronically mediated environment? For which ones will SMEs rely on electronic means in the near future? Appendix A provides detailed information on the current and intended use of each BP for all e-commerce adopters. Appendix A reveals that all 36 eBPs without exception could be carried out electronically: these eBPs are either currently used or are intended to be used within the next twelve months by the 122 SMEs in our sample. This remark further validates the proposed typology of business processes (Fig. 1).
Moreover, the frequencies for intended use are greater for each business process than the ones for the actual use: B-to-B e-commerce adoption seems to progress cumulatively and firms migrate towards more sophisticated e-commerce initiatives in all five functional areas. Are firms’ intentions aligned with current use? The ranking is rather similar, as shown in the second and fourth columns of Appendix A. In fact, there is a significant agreement between the current and future behavior of SMEs with respect to B-to-B e-commerce ($p = 0.00$, $w = 0.985$ for Kendall’s test of concordance in which $p = 0$ indicates complete agreement and $p = 1$ indicates complete disagreement). Hence, the future behavior of SMEs appears to be conditioned by their experience today.

Going one step further, it is possible to obtain the same information as in Appendix A but for each of the four stages of the proposed stage model. In order to convey the information more effectively, Fig. 4 shows only the most frequently used business processes in each stage, i.e. those that are actually used by a critical mass.

---

**Fig. 3.** E-commerce adoption trajectories.

**Fig. 4.** The cumulative unfolding of the most frequently adopted eBPs per stage.
of the SMEs in each stage (at least 20%). SMEs in stage 1 mainly use five eBPs, all of which involve information search and content creation activities related to two functional areas, namely marketing, sales and after-sales service (eBP22, eBP23, eBP24) and procurement/purchasing (eBP6, eBP7). In addition to these five business processes, firms at stage 2 also rely on electronic means for simple e-transactions related to procurement/purchasing (eBP8, eBP11, eBP14) and to sales, marketing and after-sales service (eBP25, eBP29, eBP31, eBP32). Firms at stage 3 not only build on the eight business processes displayed in stages 1 and 2 (Fig. 4), but undertake more complex e-transactions with their customers by negotiating on-line contract conditions (eBP28) and receiving electronic payments (eBP30). Firms in stage 4 place a strong emphasis on the 14 eBPs listed in stages 1, 2 and 3 as well as on two eBPs related to product development, engineering and design (eBP1, eBP2).

Fig. 4 strongly suggests that SMEs adopt more and more e-commerce initiatives, and these eBPs become increasingly complex, as they move through stages 1–4. Additional observations can be made. First, e-commerce initiatives seem to be strongly biased towards marketing, sales and after-sales service. This may be explained by the fact that SMEs tend to be ‘customer-centric’. Second, e-commerce initiatives related to product development, engineering and design are adopted by a critical mass of SMEs only in stage 4, whereas those related to distribution and logistics are, for the time being, non-existent. This implies that SMEs are still not embracing the full range of B-to-B e-commerce initiatives. Third, intra-firm business processes (eBP3, eBP15, eBP16, eBP17) are also absent in Fig. 4, suggesting that internal electronic integration is rather low in an SME context. The lack of electronic integration which is often required to move to more complex eBPs (such as reverse logistics, for instance), may very well restrain SMEs from moving more quickly along their e-commerce adoption trajectories.

4.2.4. Benefits of e-commerce

Do SMEs derive benefits from e-commerce adoption?

Participating CEOs were asked to evaluate, on a 7-point scale (with 7 being the highest), ten potential benefits derived from their e-commerce initiatives. Appendix B presents the results for this exercise for each adoption stage. Fig. 5 summarizes Appendix B and displays only the benefits that received an average score of 3 or higher. A closer look at Fig. 5 and at Appendix B reveals some interesting results:

(i) The number of concurrent benefits increases with each stage of e-commerce penetration. Although stages 1 and 2 share the same benefits for customer-related activities, firms in stage 3 benefit from reduced delivery time and an increase in market share and revenues. The scope of derived benefits culminates in stage 4 with additional perceived benefits in engineering, manufacturing, and logistics efficiency.

(ii) The fact that no additional benefit is experienced at stage 2 warrants further investigation. One explanation could be the time lag required to achieve additional benefits from the e-commerce initiatives conducted at stage 2. Capturing benefits from e-procurement and e-sales initiatives in stage 2 (eBP8, eBP11, eBP14, eBP25, eBP29, eBP31, eBP32) may require, on one hand, a longer learning process and, on the other, integration with other business processes that need to be conducted.

Fig. 5. The cumulative benefits derived from e-commerce adoption.
1452

electronically as well. Section 4.3 will take a closer
look at this phenomenon.

(iii) Appendix B also shows that the level of intensity
increases for most of the benefits as SMEs progress
through the stages. This observation reveals a
learning process whereby firms evolve and obtain
improved benefits from their e-commerce initiatives.

These observations suggest that, as SMEs expand their
e-commerce initiatives and assimilate and integrate the
corresponding technologies, they experience mounting
benefits with respect to both scope (number of benefits)
and intensity (score of the benefits).

4.3. Findings of the multiple case study

After briefly providing some additional background
information on the twelve SMEs involved in the case
studies, we will attempt to shed some light on some of the
most puzzling results of the e-survey.

4.3.1. Additional background information

Two SMEs were randomly selected from each stage of
the model presented in Fig. 2. In addition to the
characteristics of the 192 SMEs displayed in Fig. 2, three
observations can be made based on findings from the
multiple case study:

(i) These firms are relatively mature. Most have been in
operation for at least 10 years and three of them for
more than 25 years. In particular, they have well-
established business relationships.

(ii) When firms are active on international markets, these
activities are carried out in the US, Canada’s largest
commercial partner, which is very active in
e-commerce. Only three SMEs import from other
international markets and two export to Europe and
Asia.

(iii) A minority of these firms are involved in small
networks of five customers or fewer (three firms) or
five suppliers or fewer (four firms).

4.3.2. The logic behind e-commerce initiatives

4.3.2.1. Stage 00: a wait-and-see strategy. The CEOs of the
two SMEs at stage 00 are reluctant to engage in even the most
basic B-to-B e-commerce initiatives. They do not feel any
pressure from their business partners, although they know
that some larger customers are involved in e-commerce.
They do not foresee that any economic payback could be
generated at present from e-commerce initiatives. One CEO
even stated that e-commerce initiatives are ‘counterproduct-
active as long as the business partners do not agree on one
consolidated set of e-business solutions.’ Both CEOs and
most of the employees have access to the Internet but only for
e-mail: they simply view e-mail systems as a faster, cheaper
and more convenient way of communicating. In summary,
their strategy is essentially a reactive wait-and-see strategy
but they are convinced that they will have to eventually
engage in e-commerce, ‘once the way is smoothly paved.’

4.3.2.2. Stage 0: an optimistic outlook. In the next stage
(stage 0), the CEOs are planning, with rather comfortable
optimism, to be involved in several e-commerce initiatives.
They say that they are essentially being ‘pushed’ by their
business partners and that they can no longer wait. They
seem to consider e-commerce as a competitive necessity,
since most of their direct competitors and business partners
are already firmly engaged in e-commerce.

4.3.2.3. Stages 1, 2, 3 and 4: an increasingly cautious and
realistic approach in the later stages. Of the eight SMEs that
represent the group of adopters (stages 1, 2, 3 and 4), five
SMEs have a Web site and, for three of them, the Web site can
be described as elaborate. One firm had even implemented a
trilngual transactional Web site. Nevertheless, three SMEs
without a Web site had no intention of creating one in the near
future. Among the reasons for not having a Web site, the three
CEOs stated that it was unnecessary as they could link to their
customers’ and suppliers’ Web sites or to electronic platforms
to perform all electronic transactions or other related activities,
including e-collaboration activities. The overall approach to
e-commerce is increasingly down-to-earth, realistic and
cautious as SMEs move from stage 1 to stage 4.

As mentioned by one CEO, ‘if one moves beyond the
e-commerce myth, it is crucial to consider what is really
accomplished with e-commerce. Business processes refer to
the core activities in our business: they are where the value
is created and they are where our e-commerce involvement
is directed. We analyze the potential of e-commerce
initiatives process by process and only move forward if
the benefits outweigh the costs, especially hidden costs.’

4.3.3. Why do some SMEs leap over stages?

The vast majority of SMEs (79%) in the survey followed
the e-commerce adoption trajectories, but a few firms jumped
over one or even several stages. Why? Based on the findings
of the case studies, three main explanations can be posited:

4.3.3.1. Inexperience creates high expectations. SMEs with
no or limited prior experience with e-commerce (i.e. SMEs
in stages 1 and 2) tend to move more quickly. As a CEO puts
it bluntly: ‘We’d move back if we could. Our decision was
made hastily based on misconceptions about technology,
but, more importantly, about the in-depth implications on
our internal activities. Our internal processes were simply
not geared towards e-commerce.’ Another SME experi-
enced an excessive workload, with unsolicited requests and
with necessary upgrades and maintenance, despite the fact
that three key managers had expected a reduction in staff
time further to an aggressive e-commerce strategy.
4.3.3.2. E-commerce adoption is largely influenced by powerful stakeholders. In order to comply with the requirements of large customers and prime contractors, some SMEs have to leap over one or two stages but usually with a limited focus on one or two business processes. For instance, one firm had to electronically transfer and modify 3D product designs (eBP1, stage 4) although it only had hands-on experience with 2D designs faxed back and forth to its main customers (stage 0). In addition, customers may also require their own specific business solution to be used, whether it is paper-based or electronic. As a result, an SME can face a mixture of traditional procedures (mail, faxes) and various digital procedures. The mix of procedures ranging from stage 0 to stage 3, or even stage 4, is counterproductive, has hidden costs and can be frustrating for SMEs.

4.3.3.3. Electronic platforms offer some advanced e-commerce functionalities in a rather user-friendly fashion. Two SMEs are offering products and services on sectorial electronic platforms. The first SME gained increased visibility, was successful in bidding in reverse electronic auctions (eBP26, stage 3), obtained several large contracts and expanded its market share abroad. From its experience, the CEO concluded: ‘Although our previous experience with B-to-B e-commerce was limited, electronic bidding is not difficult per se, at least in this particular platform, but the reengineering of our internal processes in order to respond to the electronic bidding is much harder.’ The second SME, which also had very limited experience in e-commerce (stage 2), gained access to sophisticated e-collaboration tools and within six months was performing on-line collaborative engineering with its main customer (stage 4). The user-friendliness and the low annual membership fees of this sectorial electronic platform largely explained the leap over one stage.

4.3.4. Why do benefits seem to stall at stage 2?
According to the two SMEs at stage 2, there is a ‘backlash’ effect at stage 2. Hidden costs for maintenance and upgrades and the excessive workload generated by stage 1 initiatives such as a Web presence (eBP22) seem to offset the additional benefits that could be gained at stage 2. Stage 2 basically reinforces the benefits of stage 1 and hidden costs ‘pop up’ at stage 2 due to a time lag effect. When CEOs from more experienced SMEs (stages 3 and 4) reflect back on their own experience in stage 2, they state that e-commerce tends to pervade all business activities and generate wider impacts than anyone had expected.

5. Conclusion
The study findings should be interpreted in the light of certain limitations, as the research design clearly corresponds to exploratory research. In particular, the sample size ($n=192$) is rather small and may preclude one from making comprehensive generalizations. However, considerable efforts were made to obtain multiple sources of empirical evidence. Triangulation increases internal validity.

The empirical results of all three phases of the research design validate the proposed typology of the 36 eBPs to measure B-to-B e-commerce adoption in the specific context of manufacturing SMEs. The proposed typology indicates that e-commerce is indeed a highly pervasive innovation since the 36 business processes cover all major functional areas as well as intra- and inter-firm electronic integration initiatives. The proposed stage model of e-commerce adoption receives also some extensive validation: the vast majority of SMEs (79%) follow cumulative linear adoption patterns moving progressively from stage 0 to stage 4. However, some SMEs (21%) did not follow linear patterns as they jumped over one and even several stages. Evidence from the multiple case studies show that these firms were either inexperienced or influenced by external forces and would probably have preferred to gain experience gradually before moving to the next stage. Future behavior seems largely conditioned by their current experience. One other important finding is that SMEs are reaping benefits derived from e-commerce in a cumulative fashion which is coherent and aligned with their e-commerce initiatives. Both the scope and intensity of these benefits increase in the later stages of e-commerce adoption as organizational learning gradually takes place. Finally, and this may be the most important result, there is no indication that any of the SMEs were likely to regress to a previous stage. The process of B-to-B e-commerce penetration seems irreversible, as the CEOs of those SMEs clearly indicate that they intend to engage in even more e-commerce activities.

Several contributions emerge from the study. First, we have attempted to derive improved metrics of e-commerce adoption based on an integrative and process-based approach, and metrics are essential if research is to progress. Both the stage model for e-commerce adoption and the scores of e-commerce penetration may represent valuable first efforts to capture one dimension of the digital economy. Second, our findings suggest logical evolutionary paths to the gradual unfolding of B-to-B e-commerce in SMEs. The cumulative and self-reinforcing nature of both e-commerce initiatives (i.e. eBP) and the benefits derived therefrom points to the existence of e-commerce adoption trajectories.

Acknowledgements
The authors gratefully acknowledge grants from FQRSC, NSERC and SSHRC.
### Appendix A. Actual and future use of eBPs ($n = 122$)

<table>
<thead>
<tr>
<th>Process #</th>
<th>eBPs by broad generic functional activities</th>
<th>Actual use</th>
<th>Intended use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Frequency</td>
<td>Rank</td>
</tr>
<tr>
<td>Product development, engineering &amp; design</td>
<td>eBP1 Transfer documents and technical drawings to customers</td>
<td>31%</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>eBP2 Transfer documents and technical drawings to suppliers</td>
<td>32%</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>eBP3 Integrate software supporting product design</td>
<td>18%</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>eBP4 Do collaborative on-line engineering with suppliers</td>
<td>16%</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>eBP5 Do collaborative on-line engineering with customers</td>
<td>21%</td>
<td>16</td>
</tr>
<tr>
<td>Procurement/purchasing</td>
<td>eBP6 Seek out new suppliers</td>
<td>43%</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>eBP7 Seek out products/services</td>
<td>45%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>eBP8 Buy products/services using electronic catalogs</td>
<td>34%</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>eBP9 Buy products/services by electronic auction</td>
<td>6%</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>eBP10 Buy products/services by issuing electronic calls for tenders</td>
<td>2%</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>eBP11 Place and manage orders with suppliers</td>
<td>34%</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>eBP12 Negotiate contracts (price, volume, etc.) with suppliers</td>
<td>16%</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>eBP13 Make electronic payments to suppliers</td>
<td>11%</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>eBP14 Access suppliers’ product/service databases</td>
<td>31%</td>
<td>12</td>
</tr>
<tr>
<td>Production/operations</td>
<td>eBP15 Automate the production floor using a manufacturing execution system (MES)</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP16 Integrate the MES into the management information system</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP17 Ensure the management of quality assurance using the management information system</td>
<td>4%</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>eBP18 Allow customers to access the company’s inventories</td>
<td>3%</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>eBP19 Access customers’ inventories</td>
<td>5%</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>eBP20 Allow suppliers to access the company’s inventories</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP21 Access suppliers’ inventories</td>
<td>8%</td>
<td>25</td>
</tr>
<tr>
<td>Sales, marketing &amp; after-sales service</td>
<td>eBP22 Advertise the company and/or its products/services</td>
<td>60%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>eBP23 Seek out new customers</td>
<td>52%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>eBP24 Convert information on products/services into digital form</td>
<td>33%</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>eBP25 Sell products/services using electronic catalogs</td>
<td>24%</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>eBP26 Sell products/services by electronic auction</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP27 Sell products/services by responding to electronic calls for tenders</td>
<td>12%</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>eBP28 Negotiate contracts (price, volume, etc.) with customers</td>
<td>26%</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>eBP29 Receive and manage customer orders</td>
<td>51%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>eBP30 Receive electronic payments from customers</td>
<td>21%</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>eBP31 Access customers’ product/service databases</td>
<td>33%</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>eBP32 Offer customers after-sales service</td>
<td>37%</td>
<td>6</td>
</tr>
<tr>
<td>Distribution &amp; logistics</td>
<td>eBP33 Automate distribution/logistics using a logistics execution system</td>
<td>4%</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>eBP34 Allow distribution/transportation partners to access the information they need</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP35 Optimize returns management (‘reverse logistics’)</td>
<td>None</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>eBP36 Track products (purchased and sold) during transportation</td>
<td>12%</td>
<td>22</td>
</tr>
</tbody>
</table>

### Appendix B. Derived benefits per stage

<table>
<thead>
<tr>
<th>Benefits derived from e-commerce adoption</th>
<th>Stage 1 ($n_1 = 8$)</th>
<th>Stage 2 ($n_2 = 17$)</th>
<th>Stage 3 ($n_3 = 47$)</th>
<th>Stage 4 ($n_4 = 50$)</th>
<th>$p^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in customer service quality</td>
<td>3.67</td>
<td>4.17</td>
<td>3.91</td>
<td>4.68</td>
<td>NS</td>
</tr>
<tr>
<td>Reduction in marketing, sales &amp; after-sales costs</td>
<td>3.67</td>
<td>3.00</td>
<td>3.26</td>
<td>3.90</td>
<td>NS</td>
</tr>
<tr>
<td>Reduction in delivery time (improved speed/dependability)</td>
<td>2.33</td>
<td>2.58</td>
<td>3.35</td>
<td>4.10</td>
<td>*</td>
</tr>
<tr>
<td>Increase in market share</td>
<td>2.83</td>
<td>2.92</td>
<td>3.51</td>
<td>3.78</td>
<td>*</td>
</tr>
<tr>
<td>Increase in revenues</td>
<td>2.33</td>
<td>2.58</td>
<td>3.37</td>
<td>3.78</td>
<td>*</td>
</tr>
<tr>
<td>Reduction in procurement costs</td>
<td>2.83</td>
<td>2.67</td>
<td>2.91</td>
<td>3.63</td>
<td>NS</td>
</tr>
<tr>
<td>Reduction in eng., product develop. &amp; design costs</td>
<td>2.00</td>
<td>2.25</td>
<td>2.24</td>
<td>3.97</td>
<td>***</td>
</tr>
<tr>
<td>Reduction in manufacturing &amp; inventory costs</td>
<td>2.00</td>
<td>2.00</td>
<td>2.15</td>
<td>3.31</td>
<td>**</td>
</tr>
<tr>
<td>Reduction in product manufacturing cycle time</td>
<td>2.17</td>
<td>2.42</td>
<td>2.38</td>
<td>3.26</td>
<td>NS</td>
</tr>
<tr>
<td>Reduction in logistics &amp; distribution costs</td>
<td>2.50</td>
<td>2.50</td>
<td>2.68</td>
<td>3.45</td>
<td>NS</td>
</tr>
</tbody>
</table>

* $p = $level of significance of the Kruskal–Wallis Test (non-parametric ANOVA) $^*p < 0.10; **p < 0.05; ***p < 0.01; ****p < 0.001.
References


Louis-A. Lefebvre is a full professor at the École Polytechnique de Montréal and the co-director of ePoly, the École Polytechnique de Montréal Centre of Expertise in Electronic Commerce.

Élisabeth Lefebvre is a full professor at the École Polytechnique de Montréal and the co-director of ePoly.

Elie Elia is a professor of information systems at the ESG, Université du Québec à Montréal (UQAM) and a researcher at ePoly.

Harold Boeck is a professor of marketing at the Université de Sherbrooke and a researcher at ePoly.