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WHEN INFORMATION TECHNOLOGY IS COUNTERPRODUCTIVE: REVISITING THE INNOVATION PARADIGM IN MANUFACTURING SMEs

In theory, IT for business process integration, through applications such as EDI and ERP, provides an organization with the ability to exploit innovation opportunities. Based on survey data obtained from 309 Canadian manufacturing SMEs, this study aims at a deeper understanding of the integrative role played by IT with regard to product and process innovation.

Introduction

Innovation has long been considered as the key factor for the survival, growth and development of small and medium-sized enterprises (SMEs) (Acs and Audretsch, 1990; Becheikh, Landry and Amara, 2006). For these organizations, a greater innovation capacity is deemed to counterbalance their greater vulnerability in a global business environment and in an economy that is now knowledge-based (Hoffman, Parejo, Bessant and Perren, 1998; Roper and Love, 2002). Innovation is defined as “the economic application of a new idea” (Subrahamaya, 2005, p. 270). It encompasses two components: product and process innovation, where product innovation refers to a new or modified version of a product; and process innovation looks into a new or modified way of making a product (Subrahamaya, 2005).

In response to increased competitive pressures brought about by globalization, the manufacturing strategy of SMEs in the last decade has been implemented in part through the adoption and assimilation of information technology in the form of planning and logistics applications such as ERP and EDI (Muscatello, Small and Chen, 2003; Raymond, 2004), primarily designed to integrate cross-functional and inter-organizational business processes (Banker, Bardhan, Chang and Lin, 2003; Barki and Pinsonneault, 2005; Park and Kusiak, 2005). In IT innovation research, the dominant paradigm is that such innovations “are assumed to be beneficial” (Fichman, 2004, p. 314). But while information technologies are deemed to enable manufacturing SMEs to grow and be more productive by creating business value in synergy with other organizational factors (Kohli and Grover, 2008), what is their specific role with regard to product and process innovation? Implementing IT for business process integration (BPI) is aimed at providing an organization with the “ability to accomplish speed, accuracy, and cost economy in the exploitation of innovation opportunities” (Sambamurthy, Bharadwaj and Grover, 2003, p. 246).

Based on survey data obtained from 309 Canadian manufacturing SMEs, the present study aims at a deeper understanding of the role played by the assimilation of IT for BPI with regard to product and process innovation. The first objective of this research is to identify the enabling (and/or disabling) effect of this technology upon innovation in manufacturing SMEs, that is, in terms of growth and productivity outcomes. The second objective is to verify if this effect is subject to industry influences, given that mechanisms such as investments in R&D and IT constitute an "innovation system" in a given industry or sector (Baldwin and Hanel, 2003). Therefore, the research question is formulated as follows: To what extent does the assimilation of IT for BPI have an enabling effect with regard to innovation in manufacturing SMEs?

Innovation in Manufacturing

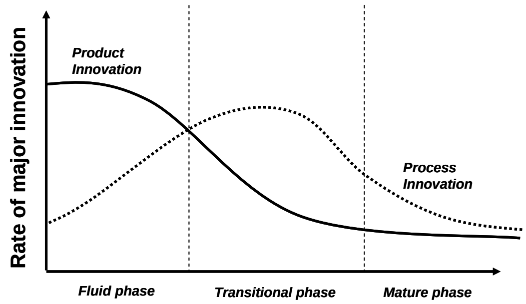
In a business environment that is becoming more and more complex, manufacturing SMEs may act strategically in two basic ways. Growth-oriented firms increase their competitiveness by seeking new markets and putting the emphasis on technological leadership and product innovation (Özsomer, Calantone and Di Benedetto, 1997). Other manufacturing SMEs, more defensive in their outlook, focus on productivity in terms of reduced costs and improved delivery capabilities, by increasing the flexibility of their productive apparatus and emphasizing process innovation (De Sarbo, Di Benedetto, Song and Sinha, 2005; Sum, Kow and Chen, 2004).

Hence, *product innovation* allows SMEs to improve or maintain their position in the market and their relationship with customers, and thus grow, while *process innovation* aims to improve their productivity by reducing production costs and increasing their operational agility, thus becoming more competitive (OECD, 2005a). Also, best product development practices such as concurrent engineering are founded on the coordination and integration of both product innovation and process innovation (Lim, Garnsey and Gregory, 2006).

The distinction between innovation that affects the product itself and innovation in the process of manufacturing this product is highlighted by Abernathy and Utterback (1978). In the innovation life cycle model described by these authors, product and process innovations are distinct and follow a different path over time, as illustrated in Figure 1. This was later confirmed by Martinez-Ros (1999). At the early stage of an innovation, that is, during the "fluid" phase, efforts are mainly concentrated on product innovation while the production process is still elementary and often inadequate in terms of quality. In the context of market acceptance, a change in focus from product to process innovation is necessary to benefit from mass manufacturing. This happens during the "transitional" phase where the product is sufficiently experimented and tested to be developed and greater process innovation efforts are needed. Towards the end, that is, during the "mature" phase, product innovations are generally incremental while process innovations concentrate more on productivity and quality to manufacture a final product with greater efficiency and at a lower cost. With the emergence of enabling technologies, efforts related to product innovation are usually reduced and the shift toward process innovation occurs earlier than without the use of such technologies (Utterback, 1994).

In empirical studies of innovation in SMEs, researchers have sought to explain why certain firms innovate more successfully than others by identifying certain strategic capabilities as "critical success factors" of innovation (Bhattacharya and Bloch, 2004), including technological integration capabilities in particular (Swink and Nair, 2007). A review of empirical studies in the manufacturing sector reveals that 43% of SMEs aimed at both product and process innovation, 37% aimed at product innovation solely, and only 1% at process innovation exclusively (Becheikh, Landry and Amara, 2006).

Figure 1
Pattern of product and process innovation
(adapted from Utterback and Abernathy, 1978)



With regard to process innovation, a number of manufacturing SMEs have been found to adopt and assimilate advanced manufacturing technologies such as computer-aided design and manufacturing (CAD/CAM) and flexible manufacturing systems (FMS) that enable them to achieve a competitive advantage with more flexibility, reduced delay (from product design to introduction on the market) and quick response to market changes (Ariss, Raghunathan and Kunnathar, 2000).

Integrative Role of IT

As defined by Zhu and Kraemer (2005), technology integration indicates the degree of inter-connectivity between the information systems and databases of a firm and those integrated with the firm's business partners. The benefit of technology integration is to reduce the prior incompatibility between legacy systems and to increase the responsiveness of information systems (Goodhue, Wybo and Kirsh, 1992), thus creating operational efficiencies and organizational synergies through the sharing of resources and capabilities across functional units (Bharadwaj, 2000). However, integration may also have a "downside" (Singletary, 2004) or be detrimental in that "monolithic IT architectures may hinder agility by limiting the range of responses available to a firm" (Overby, Bharadwaj and Sambamurthy, 2006, p. 127).

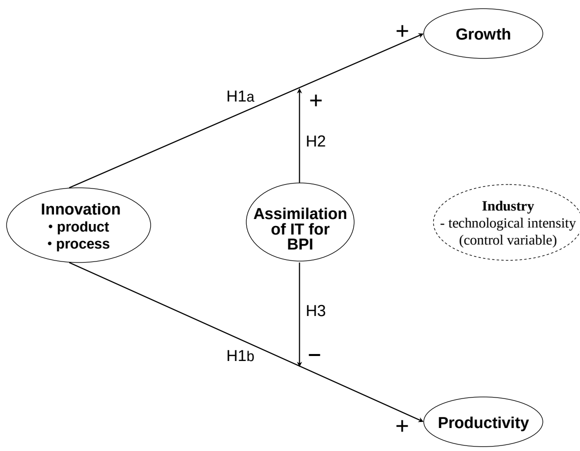
Previous results indicate that the integrative role of IT allows a firm to improve its performance by reducing its cycle time, improving its customer service, and lowering its procurement costs (Barua, Konana, Whinston and Yin, 2004). An extensive research surveying 1,857 organizations from 10 countries indicates that the integration of IT was the strongest factor facilitating assimilation of e-business innovations in developed countries. More specifically, the key factor of this assimilation was the shift from accumulation of various technologies to their integration (Zhu, Kraemer and Xu, 2006). A similar study was conducted amongst 1757 manufacturers to assess the integrative role of IT and lean/just-in-time practices on lead-time performance (Ward and Zhou, 2006). Results indicate that the customer lead-time is not directly reduced by within-firm IT integration or between-firm IT integration. However it was argued that manufacturing companies that aim at reducing their lead times would have better results when using IT integration in collaboration with lean/JIT practices.

The integrative role of IT calls upon the theory of technology assimilation (Cooper and Zmud, 1990; Fichman and Kemerer, 1997). IT assimilation signifies that IT applications must be infused and diffused into business processes and therefore enhance the organizational performance (Khalifa and Liu, 2003). IT assimilation is defined as the degree to which the use of IT is integrated within business processes and becomes part of the activities associated with those processes (Tornatzky and Klein, 1982; Chatterjee, Grewal, and Sambamurthy, 2002).

Research Model and Hypotheses

Because product and process innovation are interdependent yet closely linked, both product and process must be distinctively factored into innovation (Abernathy and Utterback, 1978; Martinez-Ros, 1999). As presented in Figure 2, the research model hypothesizes that the effect of product and process innovation upon the firm's growth and productivity will be respectively enabled and disabled by its assimilation of IT for business process integration (BPI), that is, by its use of applications such as MRP-II, ERP and EDI whose ultimate aim resides in the "seamless" integration of business processes across functions and across organizations (Markus, 2001).

Figure 2
Research Model



Product innovation, be it incremental or fundamental (Ferguson and Ferguson, 1994), implies the introduction of a new product that maintains or increases a market share which translates into growth (Subrahmanyan, 2005). Process innovation is known to lead to improved productivity (Heygate, 1996). As both product and process innovation are closely interrelated, both should positively factor into innovation which should contribute to an increase in growth and productivity. Therefore the first hypothesis is the following:

Hypothesis 1a - There is a positive relationship between innovation and growth.

Hypothesis 1b - There is a positive relationship between innovation and productivity.

The role of the assimilation of IT for BPI is two-fold. It first refers to a technical aspect that includes the standardization of technology and data access (Goodhue et al., 1992; Ross, 2003). It is also related to standardization of the core business processes within a firm and/or with its business partners (Barki and Pinsonneault, 2005; Ross, 2003). However, the implementation of integrative IT does not always translate into a true integration (Bagchi and Skjoett-Larsent, 2002). Complete integration normally increases the visibility of the information but also the flexibility in accessing it (Evgeniou, 2002). This does not happen easily; in fact it often turns out to be contradictive unless the organization reaches a high level of agility (Ross, 2003; Evgeniou, 2002).

Implementing integrative IT such as ERP helps most organizations to improve the synchronization of data and systems amongst their suppliers, customers and partners. Those efforts are translated into an increased level of access to the information which permits them to better and quickly adjust to the market and therefore increase its growth (Lee, Farhoomand and Ho, 2004). The second research hypothesis follows:

Hypothesis 2 - *The greater the firm's assimilation of IT for BPI, the greater the impact of innovation on its growth.*

Business process integration is a characteristic of manufacturing organizations that bears both an opposing and a complementary relationship to manufacturing flexibility or operational agility. On one hand, integrated processes allow for greater sharing of new information, thus insuring quicker response to changes in the environment and increasing the organization's flexibility. On the other hand, the more an organization is integrated, the harder it is to "disconnect" itself (Markus, 2000). IT for BPI such as ERP has thus been qualified as "rigid" rather than "malleable" technology (Elbana, 2006). It has also been found that the more firms adopt integrated technologies, the less flexible they are (Brandyberry, Rai and White, 1999), hence the third hypothesis:

Hypothesis 3 - *The greater the firm's assimilation of IT for BPI, the lesser the impact of innovation on its productivity.*

Note that these hypotheses imply a "fit as moderation" alignment perspective (Venkatraman, 1989), wherein fit is conceptualised as the interaction between IT and innovation. Thus, following Bharadwaj, Bharadwaj and Konsynski's (1995) seminal IT alignment research proposition, the assimilation of IT for BPI is hypothesized to moderate the relationship between the SME's strategic capabilities, in terms of innovation, and its organizational performance, in terms of growth and productivity.

Innovation is susceptible to industry effects, as observed in many studies that have demonstrated the influence of the industrial sector's technological intensity, growth, and structure (Becheikh et al., 2006). For instance, product innovation is deemed to be stronger in sectors of higher technological intensity such as electronics and biotechnology (Subrahmanya, 2005). Also, prior research has confirmed the theoretical and empirical importance of industry as a contingency factor in the relationship between innovation and organizational performance (Kalantaridis and Pheby, 1999; Tidd, Bessant and Pavitt, 2005). It is thus important to be able to distinguish between firm and industry effects when testing the research hypotheses (Mauri and Michaels, 1998), which is why the research model includes the technological intensity of the industrial sector as a control variable.

Research Method

Data Collection

The research data were obtained from a database created by a university research center, containing information on 309 Canadian manufacturing SMEs. With the collaboration of an industry association to which most of these firms belong, the database was created by having the SMEs' chief executive and functional executives such as the controller, human resources manager, and production manager fill out a questionnaire to provide data on the practices and results of their firm and add their firm's financial statements for the last five years. Anonymity and confidentiality is preserved by having the questionnaires transit through the industry association so that firms are known by the research center only by an alphanumeric identifier assigned by the association. Once all the questionnaire data and financial statements have been manually verified by the research center's personnel, they are typed in via validation software and entered in the database as valid data, ready for benchmarking. In exchange for these data, the firms are provided with a complete comparative diagnostic of their overall situation in terms of performance and vulnerability.[1]

Measurement

Based upon the effect of R&D investments on the subsequent growth of the firm, as confirmed in the literature (Co and Chew, 1997), these investments can be used as an indicator of the SME's capacity or propensity to innovate (Qian and Li, 2003; Wolff and Pett, 2006), and particularly in the context of SMEs (De Jong and Vermeulen, 2007). Investment in R&D is in fact one of the most important mechanisms that constitute the innovation system in a given sector or industry (Baldwin and Hanel, 2003). Innovation is thus measured in this study by product R&D and process R&D as surrogate indicators. In line with common measurement practice with regard to R&D and innovation (OECD, 2005a), the intensity of product and process R&D activities is measured by two ratios, namely product R&D budget over number of employees and process R&D budget over number of employees.

Following Brandyberry, Rai and White (1999), the assimilation of IT for BPI is measured by asking the operations manager to evaluate the extent to which advanced manufacturing applications implemented are actually assimilated by the organisation, on a scale of 1 (low) to 5 (high). By summing these evaluations over six "planning and logistics" applications, using Kotha and Swamidass' (2000) categorisation of advanced manufacturing technology, one thus obtains a score (ranging from 0 to 30) of the assimilation by the firm of IT for BPI.

The most widely-used productivity indicator was selected, directly related to the firm's manufacturing systems, that is, the productivity of the workforce as measured by the gross profit per employee ratio. The indicator of growth is also one that is most commonly used, that is, the average growth in sales over the last three years.

Sample

For the study's purposes, a manufacturing SME is defined as an enterprise with 20 or more employees and less than 500, corresponding to the lower bound used by the European Union (Kalantaridis, 2004) and the upper bound used in North American research (Mittelstaedt, Harben and Ward, 2003). The size of the sampled firms thus varies between 20 and 405 employees, with a median of 49, whereas annual sales vary from 0.4 to 55 million Canadian dollars, with a median of 6. More than fifteen industrial sectors are represented, including metal products (27.5% of the sampled firms), wood (14%), plastics and rubber (13%), electrical products (6.5%), food and beverage (6%), and machinery (5.5%). Being relatively representative of Canadian manufacturing SMEs with regard to size and industry, 104 of the sampled firms (34%) operate in a sector whose technological level is low, 153 (49%) in a medium to low-tech sector, and 52 (17%) in a medium to high-tech sector, there being no high-tech firms (OECD, 2005b). The various industrial sectors represented in the sample are shown in Appendix A.

Results and Discussion

As shown in Table 1, the first descriptive results pertain to the levels of IT adoption and assimilation in manufacturing SMEs, including manufacturing planning and logistics applications such as computer-based production scheduling, bar-coding, EDI, MRP, MRP-II and ERP that aim to and thus constitute

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[1] Further information on the diagnosis system and on data collection and validation can be found in St-Pierre and Delisle (2006).

“plant information systems” (Banker et al., 2003). It seems that it is still a minority of SMEs that have adopted IT for purposes of integration, including EDI (22% adoption rate), MRP-II (10%) and ERP (9%). One could surmise that the sampled SMEs, in responding to the challenges of globalization, would be oriented more on manufacturing flexibility or operational agility than on integration.

Table 1
Levels of Adoption and Assimilation of IT for Business Process Integration

Logistics/Planning applications (n = 309) [*IT forBPI*]	Adoption rate	Assimilation[a]
Computer-based production scheduling	37 %	3.3
Computer-based bar-coding	29 %	3.7
Electronic data interchange (EDI)	22 %	3.5
Materials requirement planning (MRP)	20 %	3.1
Manufacturing resource planning (MRP-II)	10 %	2.8
Enterprise resource planning (ERP)	9 %	3.3

[a]Perceived assimilation of the technology or application adopted (low : 1, 2, 3, 4, 5 : high)

The descriptive statistics of the research variables are presented in Table 2, the mean being broken down by industry. SMEs in medium to high-tech sectors show the highest levels of product innovation and productivity, while their level of process innovation is equal to those in the medium to low-tech sectors. Note also that 22% of the variance in product innovation is explained by industry effects rather than by firm effects, whereas there are no industry effects with regard to the assimilation of IT.

Estimation of Model Parameters

Linear regression was used to test the relationships proposed in the research model, including the interaction effects between innovation and assimilation of IT for BPI, in the form of the following equations:

$$\text{Growth} = ß_0 + ß_1\text{Prod.Innov.} + ß_2\text{ Proc. Innov.} + ß_3[\text{Prod.Innov. x ITforBPI}] + ß_4[\text{Proc.Innov. x IT for BPI}] + \varepsilon$$

$$\text{Productivity} = ß_0 + ß_1\text{Prod.Innov.} + ß_2\text{ Proc. Innov.} + ß_3[\text{Prod.Innov. x ITforBPI}] + ß_4[\text{Proc.Innov. x IT for BPI}] + \varepsilon$$

The potential influence of industry on the results were estimated by testing the model anew for each of three sub-samples, that is, for the SMEs operating in industrial sectors of low, medium-low and medium-high technological intensity respectively.

Test of Research Hypotheses

The three research hypotheses are tested by assessing the direction, strength and level of significance of the standardized regression coefficients (betas), as shown in Table 3. This research investigates the effect of the assimilation of IT for BPI on the relationship between SMEs’ process and product innovation, and organizational performance in terms of growth and productivity. Overall, the main results indicate that both product and process innovation have a positive and significant effect on growth, thus confirming $H1_a$, whereas only product innovation has a similar effect on productivity, thus partly confirming $H1_b$. Assimilation of IT for BPI has a positive and significant interaction effect with process innovation but not with product innovation in terms of growth, thus partly confirming H_2. Whereas the assimilation of IT for BPI has a negative and significant interaction effect with process innovation but not with product innovation in terms of productivity, thus partly confirming H_3.

Table 2
Descriptive Statistics and Breakdown of the Research Variables by Industry

Industry[a] / Variable	All SMEs (n = 309) mean / min	s.d. / max	low-tech SMEs (n = 104) mean	medium to low-tech (n = 153) mean	medium to high-tech (n = 52) mean	Anova F	% of variance explained by Industry
Growth[b]	0.17	0.23	0.17	0.17	0.18	0.1	0%
	-0.29	1.85					
Productivity[c]	47022	45651	39173_2	$44857_{2,1}$	69089_1	8.1***	5%
	-3641	390261					
Product innovation[d]	1155	2805	302_3	768_2	4001_1	41.8***	22%
	0	26800					
Process innovation[e]	381	681	192_2	482_1	462_1	6.3***	4%
	0	5714					
Assimilation of IT for BPI[f]	7.0	5.7	6.7	7.1	7.1	0.2	0%
	0	28					

***: $p < 0.001$

$_{1,2,3}$*Nota*. Within rows, different subscripts indicate significant ($p < 0.05$) pairwise differences between means on Tamhane's T2 (*post hoc*) test.

[a]technological intensity associated to the industrial sector following the OECD's (2005b) classification
- low-tech: wood, food and beverage, furniture, clothing, textile, printing, paper, leather and others
- low to medium-tech: metal products and transformation, rubber and plastics, mining products, construction, mineral products and others
- medium to high-tech: electrical products, machinery, chemical products, transportation equipment and others

[b]average growth in net sales over the last 3 years
[c]gross profit per employee = (sales - cost of goods sold) / no. of production employees
[d]product R&D budget / no. of employees
[e]process R&D budget / no. of employees
[f]$\Sigma_{k=1,6}$[assimilation of application$_k$]

Table 3
Results of Testing the Research Model – All SMEs (n =309)

Predictor	Growth (Beta)	Productivity (Beta)
Product Innovation	0.124*	0.199***
Process Innovation	0.114*	0.078
Product Innovation x Assimilation of IT for BPI	-0.001	-0.080
Process Innovation x Assimilation of IT for BPI	0.105[a]	-0.245**
	R^2 = 0.04 F = 2.9*	R^2 = 0.12 F= 10.3***

[a]$p < 0.1$ *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Although innovation leads to growth and productivity, the level of assimilation of IT for BPI in the firms plays a different role dependent upon the performance objectives (growth vs. productivity) and types of innovation (product vs. process). In terms of growth, the assimilation of IT for BPI exerts a positive interaction effect, in that organizations conducting process innovation in a more integrated IT environment show higher growth than organizations conducting process innovation in a less integrated IT environment. The assimilation of IT for BPI is therefore beneficial to SME innovation in that respect. However, the opposite is observed for productivity. The results indicate that the assimilation of IT for BPI exerts a negative effect on productivity; organizations conducting process innovation in a more integrated IT environment having a lower productivity than organizations conducting process innovation in a less integrated IT environment.

These relationships vary however, depending upon the technological intensity of the SMEs as is shown in Tables 4, 5 and 6. The main relationships are as follows: The relationship between product innovation and growth changes from slightly negative (ß = -0.101, Table 4) in the case of low-tech SMEs to strongly positive (ß = 0.538, Table 6) for high-tech SMEs. The opposite is true for productivity, where the relationship between innovation and productivity changes from strongly positive (ß = 0.344, Table 4) for the low-tech SME to a non-significant relationship (ß = 0.014, Table 6) for the high-tech SME.

Table 4
Results of Testing the Research Model – Low-tech SMEs (n =104)

Predictor	Growth (Beta)	Productivity (Beta)
Product Innovation	-0.101	0.344***
Process Innovation	0.097	-0.036
Product Innovation x Assimilation of IT for BPI	-0.141	0.073
Process Innovation x Assimilation of IT for BPI	0.316**	-0.262*
	$R^2 = 0.11$ F = 2.9*	$R^2 = 0.18$ F= 5.5***

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Innovation was defined in this study in terms of both product and process innovation, and the observed direct relationships with growth and productivity can be interpreted with these two kinds of innovation processes in mind. However, all conclusions concerning the interaction between the assimilation of IT for BPI, growth and productivity relate only to process innovation, since the interaction between the assimilation of IT for BPI and product innovation was not found to be a predictor of growth nor of productivity. Therefore, the IT for BPI interaction effect with productivity and growth specifically concerns process innovation only. The fact that process innovation is the only significant factor is in conformity with Utterback's (1994) revised model of the innovation life cycle where process innovation efforts are deemed to occur earlier and have greater effect due to the enabling role of IT.

Table 5
Results of Testing the Research Model – Medium to Low-tech SMEs (n =153)

Predictor	Growth (Beta)	Productivity (Beta)
Product Innovation	-0.033	0.207*
Process Innovation	0.147[a]	-0.041
Product Innovation x Assimilation of IT for BPI	-0.018	-0.062
Process Innovation x Assimilation of IT for BPI	0.074	-0.087
	$R^2 = 0.02$ F = 0.9	$R^2 = 0.06$ F= 2.4[a]

[a]$p < 0.1$ *: $p < 0.05$

Table 6
Results of Testing the Research Model – Medium to High-tech SMEs (n =52)

Predictor	Growth (Beta)		Productivity (Beta)	
Product Innovation	0.538***		0.014	
Process Innovation	-0.090		0.065	
Product Innovation x Assimilation of IT for BPI	-0.118		-0.001	
Process Innovation x Assimilation of IT for BPI	-0.113		-0.590***	
	R^2 = 0.25	F = 3.8**	R^2 = 0.40	F= 7.9***

**: $p < 0.01$ ***: $p < 0.001$

The present research model, as an interaction effects model, is an alternative to the baseline or "main effects" model in which both innovation and IT assimilation are assumed not to interact but to have a direct causal influence on performance (Venkatraman, 1989). Using the same data, an estimation of the main effects model through regression yielded the results presented in Table 7. Comparing these with those presented in Table 3 illustrates this model to explain less variance in growth (R^2 = 0.03 versus 0.04) and significantly less in productivity (R^2 = 0.05 versus 0.12), and to show less fit as demonstrated by strength and significance of the path coefficients, suggesting that this model is to be rejected in favor of the interaction effects model ("fit as moderation").

Table 7
Results of Testing the Direct Effects Model – All SMEs (n = 309)

Predictor	Growth (Beta)		Productivity (Beta)	
Product Innovation	0.119*		0.177**	
Process Innovation	0.096[a]		0.126*	
Assimilation of IT for BPI	0.020		0.025	
	R^2 = 0.03	F = 2.8*	R^2 = 0.05	F= 5.7***

[a]$p < 0.1$ *: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Note in particular that the assimilation of IT for BPI has no direct effect on growth and neither on productivity, in line with a "contingency" rather than a "universalistic" or "best practices" argument for the business value of IT (Delery and Doty, 1996). Note also that these last results also confirm the mutual independence of the innovation and the assimilation of IT for BPI variables, as there is almost no correlation between them (see Appendix B). These results support the authors' theoretical justification of their interaction-based research model, as this justification is a pre-requisite step in choosing an IT alignment perspective (Bergeron, Raymond and Rivard, 2001).

One can make several interpretations of the results summarized in Table 8. Overall, the assimilation of IT for BPI shows a positive relationship with growth and a negative one with productivity. This might be due to the fact that a highly integrated firm hampers the possibility to increase productivity where the proposed changes in the processes might conflict with actual processes. The human and technical problems as well as the time needed to introduce the new processes directly affect the gross profit per employee. The more the actual processes are integrated, the less it is possible to change them without decreasing productivity, at least in the short term. However, this conflict does not show up in the relationship with growth. It might be that highly integrated processes allow the firm to rapidly introduce new products on the market. This is observed overall (ß = 0.105) and specifically for low-tech SMEs (ß = 0.316). The assimilation of IT for BPI includes both internal and external integration. Thus, the time needed to launch a new product resulting from product innovation can be shortened significantly if the internal processes are highly integrated with the external processes, i.e. the backbone of the extended value chain. In this case, organizational growth, measured in terms of increased sales, show positive improvements.

Table 8
Summary results of testing the research hypotheses

Hypothesis	**All SMEs (n = 309)**	low-tech SMEs (n = 104)	medium to low-tech SMEs (n = 153)	medium to high-tech SMEs (n = 52)
H_{1a} - *There is a positive relationship between innovation and growth*	Confirmed for *product* and *process innovation*		Confirmed for *process innovation*	Confirmed for *product innovation*
H_{1b} - *There is a positive relationship between innovation and productivity*	Confirmed for *product innovation*	Confirmed for *product innovation*	Confirmed for *product innovation*	
H_2 - *The greater the firm's assimilation of IT for BPI the greater the impact of innovation on its growth*	Confirmed for *process innovation*	Confirmed for *process innovation*		
H_3 - *The greater the firm's assimilation of IT for BPI the lesser the impact of innovation on its productivity*	Confirmed for *process innovation*	Confirmed for *process innovation*		Confirmed for *process innovation*

The target period of the measurements may bring another explanation. While the assimilation of IT for BPI seems a legitimate goal, it might not be profitable at least in the short run. In the long run, adjustments can likely be made where new processes are implemented and streamlined for a greater organizational productivity.

The nature of the sample might provide added explanation. In this research, firms of an entrepreneurial or aggressive strategic type are seemingly more represented than they would be in a random sample. These organizations need to innovate to stay ahead of the crowd and the assimilation of IT for BPI may not be their main priority since they may instead favor flexibility. Also, the assimilation of IT for BPI might be counterproductive in a context where the manufacturing SME must renew its productive apparatus in order to become more agile in view of increasingly complex demands from customers. Such renewal however would be made more difficult by the process "discipline" imposed by the assimilation of IT for BPI, for instance by the "best practices" embedded in an ERP system. In other contexts, such as in a production environment where the SMEs are more of the managerial or defensive type, it might be that the assimilation of IT for BPI is a plus. Thus, the type of business strategy might be a contingency factor to consider when designing a plan to assimilate IT for BPI.

Implications and Future Research

These results have several implications for future research. In line with Fichman (2004) who suggests that researchers go "beyond the dominant paradigm for information technology innovation research", we propose that the counterproductive effect of the assimilation of IT for BPI on innovation effectiveness be more closely studied. As this study is cross-sectional, we are left with a number of questions about the whether, when, and how product and process innovation as well as IT innovation and implementation can be beneficial and profitable to organizations (Swanson and Ramiller, 2004). At first glance, the negative effect of process innovation on business productivity in a highly integrated IT environment is counter-intuitive and somewhat paradoxical. On one hand, it is well known that innovation is correlated with business performance. On the other hand, IT integration software such as ERPs is strongly advocated to streamline activities and boost firm performance. In this case, medium to low tech organizations that combine both end up with lower productivity.

As suggested by Fichman (2004), several perspectives can be adopted to study innovation. While contagion effects, management fashion and innovation mindfulness have already come to the attention of innovation researchers, other areas such as innovation configurations, technology destiny, quality of innovation, and technology savvy (Weill and Aral, 2006) and performance impacts are yet to be analyzed. These perspectives, as they relate to organizational performance, seem promising avenues to develop a more comprehensive and sounder understanding of the "innovation paradox", illustrated here by the lower productivity of highly IT integrated firms that innovate in their processes.

Limitations and Conclusion

This study has certain limitations that must be mentioned. Given that the sample is composed of self-selected firms, there could thus be a sample bias in that these firms may differ from the general population in regard to their innovativeness, assimilation of IT for BPI, and performance (Cassell, Nadin and Gray, 2001). Other than the nature of the sample, another limit associated to survey research pertains to the use of a perceptual measure of IT assimilation that demands prudence in generalising results. The cross-sectional rather than longitudinal nature of the study moreover implies that the results do not necessarily reflect the long-term enabling effects of IT on innovation. There may also be a time lag between the investment in R&D, as a measure of innovation, and its realized impacts.

One can conclude from the results of this study that IT "does matter" for innovation in manufacturing SMEs. IT matters in different ways however, depending upon the firm's innovation strategy. This aspect of the firm's competitive strategy may be outward-bound and growth-oriented, say for the "prospector" type of SME as defined in Miles and Snow's (1978) strategic typology, or it may be inward-bound and productivity-oriented, say for the "defender" type. While the assimilation of IT for BPI is seen to enable product innovation by increasing the growth of manufacturing SMEs, it tends to disable process innovation by decreasing the productivity of these organizations. The integrative role of IT in manufacturing is also shown here to vary across industries, and thus the need for future research to take industry effects into account. In confronting the dominant paradigm in IT innovation research, evidence has been provided that the assimilation of IT for BPI such as ERP systems can indeed be counterproductive, and "seamless integration" can induce rigidities that run counter to process innovation aims. Further understanding of the potential dialogic between the assimilation of IT for BPI and the use of IT for flexibility is needed if these technologies are to effectively enable the operational and managerial processes of SMEs, thus improving the organizational performance of these firms and helping them achieve "world-class" manufacturing status.

References

Abernathy, W.J. and Utterback, J.M. (1978), Patterns of industrial innovation, *Technology Review*, Vol. 80, No. 7, pp. 2-9.

Acs, Z.J. and Audretsch, D.B. (1990), *Innovation and Small Firms*, MIT Press, Cambridge, Massachusetts.

Ariss, S.S., Raghunathan, T.S. and Kunnathar, A. (2000), Factors affecting the adoption of advanced manufacturing technology in small firms, *SAM Advanced Management Journal*, Vol. 56, No. 2, pp. 14-21

Bagchi, P.K. and Skjoett-Larsen, T. (2002), Integration of information technology and organizations in a supply chain, *The International Journal of Logistics Management*, Vol. 14, No. 1, pp. 89-108.

Baldwin, J.R. and Hanel, P. (2003), *Innovation and Knowledge Creation in an Open Economy: Canadian Industry and International Implications*, Cambridge University Press, Cambridge, United Kingdom.

Banker, R., Bardhan, I., Chang, H. and Lin, S. (2003), Impact of manufacturing practices on adoption of plant information systems, *Proceedings of the Twenty-Fourth International Conference on Information Systems*, pp. 233-245.

Barki, H. and Pinsonneault, A. (2005), A model of organizational integration, implementation effort, and performance, *Organization Science*, Vol.16, No. 2, pp. 165-179.

Barua, A., Konana, P., Whinston, A.B. and Yin, F. (2004), An empirical investigation of net-enabled business value, *MIS Quarterly*, Vol. 28, No. 4, pp. 585-620.

Becheikh, N., Landry, R. and Amara, N. (2006), Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993-2003, *Technovation*, Vol. 26, No. 5/6, pp. 644-664.

Bergeron, F., Raymond, L. and Rivard, S. (2001), Fit in strategic information technology management research: An empirical comparison of perspectives, *Omega*, Vol. 29, No. 2, pp. 125-142.

Bharadwaj, A. (2000), A resource-based perspective on the information technology capability and firm performance: An empirical investigation, *MIS Quarterly*, Vol. 24, No. 1, pp. 169-196.

Bharadwaj, A.S., Bharadwaj, S.G. and Konsynski, B.R. (1995), The moderator role of information technology in firm performance: A conceptual model and research propositions, *Proceedings of the Sixteenth International Conference on Information Systems*, Amsterdam, pp. 183-188

Bhattacharya, M. and Bloch, H. (2004), Determinants of innovation, *Small Business Economic*s, Vol. 22, No. 2, pp. 155-162.

Brandyberry, A., Rai, A. and White, G.P. (1999), Intermediate performance impacts of advanced manufacturing technology systems: an empirical investigation, *Decision Sciences*, Vol. 30, No. 4, pp. 993-1020.

Cassell, C., S. Nadin and Gray, M.O. (2001), The use and effectiveness of benchmarking in SMEs, *Benchmarking: An International Journal*, Vol. 8, No. 3, pp. 212-222.

Chatterjee, D., Grewal, R. and Sambamurthy, V. (2002), Shaping up for e-commerce: Institutional enablers of the organizational assimilation of web technologies, *MIS Quarterly*, Vo. 26, No. 2, pp. 65-89.

Cooper, R.B. and Zmud, R.W. (1990), Information technology implementation research: A technological diffusion approach, *Management Science*, Vol. 36, No. 2, pp. 123-139.

Delery, J.E. and Doty, D.H. (1996), Modes of theorizing in strategic human resource management: Tests of universalistic, contingency and configurational performance predictions, *Academy of Management Journal*, Vol. 39, No. 4, pp. 802-835.

DeSarbo, W.S., Di Benedetto, C.A., Song, M. and Sinha, I. (2005), Revisiting the Miles and Snow strategic framework: Uncovering interrelationships between strategic types, capabilities, environmental uncertainty, and firm performance, *Strategic Management Journal*, Vol. 26, pp. 47-74.

Elbanna, A.M. (2006), The validity of the improvisation argument in the implementation of rigid technology: the case of ERP systems, *Journal of Information Technology*, Vol. 21, pp. 165-175.

Evgeniou, T. (2002), Information integration and information strategies for adaptive enterprises, *European Management Journal*, Vol. 20, No. 5, pp. 486-494.

Fergurson, P.R. and Fergurson, G.J. (1994), *Industrial Economics: Issues and Perspectives*, 2nd edition, Palgrave, Hampshire.

Fichman, R.G. (2004), Going beyond the dominant paradigm for information technology innovation research: Emerging concepts and methods, *Journal of the Association for Information Systems*, Vol. 5, No. 8, pp. 314-355.

Fichman, R.G. and Kemerer, C.F. (1997), The assimilation of software process innovations: An organizational learning perspective, *Management Science*, Vol. 43, No. 10, pp. 1345-1363.

Goodhue, D., Wybo, M. and Kirsch, L. (1992), The impact of data integration on the costs and benefits of information systems, *MIS Quarterly*, September, pp. 293-310.

Heygate, R. (1996), Why are we bungling process innovation? *The McKinsey Quarterly*, Vol. 2, pp. 130-141.

Hoffman, K., Parejo, M. Bessant, J. and Perren, L. (1998), Small firms, R&D, technology and innovation in the UK: a literature review, *Technovation*, Vol. 18, No. 1, pp. 39-55.

Kalantaridis, C. and Pheby, J. (1999), Processes of innovation among manufacturing SMEs: the experience of Bedfordshire, *Entrepreneurship & Regional Development*, Vol. 11, pp. 57-78.

Khalifa, M. and Liu, V. (2003), Determinants of successful knowledge management programs, *Electronic Journal on Knowledge Management*, Vol. 1, No. 2, pp. 103-112.

Kohli, R. and Grover, V. (2008), Business value of IT: An essay on expanding research directions to keep up with the times, *Journal of the Association for Information Systems*, Vol. 9, No. 1, pp. 23-39.

Kotha, S. and Swamidass, P.M. (2000), Strategy, advanced manufacturing technology and performance: empirical evidence from U.S. manufacturing firms, *Journal of Operations Management*, Vol. 18, No. 3, pp. 257-277.

Lee, H., Farhoomand, A. and Ho, P. (2004), Innovation through supply chain recognition, *MIS Quarterly Executive*, Vol. 3, No. 3, pp. 131-142.

Lim, L.P.L., Garnsey, E. and Gregory, M. (2006), Product and process innovation in biopharmaceuticals: a new perspective on development, *R&D Management*, Vol. 36, No. 1, pp. 27-36.

Markus, M.L. (2000), Paradigm shifts: e-business and business systems integration, *Communications of the Association for Information Systems*, Vol. 4, article 10, pp. 1-44.

Markus, M.L. (2001), Reflections on the systems integration enterprise, *Business Process Management Journal*, Vol. 7, No. 3, 2001, pp. 171-180.

Martinez-Ros, E. (1999), Explaining the decisions to carry out product and process innovations: the Spanish case, *Journal of High Technology Management Research*, Vol. 10, No. 2, pp. 223-242.

Mauri, A.J. and Michaels, M.P. (1998), Firm and industry effects within strategic management: An empirical examination, *Strategic Management Journal*, Vol. 19, No. 3, pp. 211-219.

Miles R. E. and Snow C.C. (1978), *Organizational Strategy, Structure, and Process*, McGraw-Hill, New York.

Mittelstaedt, J.D., Harben, G.N. and Ward, W.A. (2003), How small is too small? Firm size as a barrier to exporting from the United States, *Journal of Small Business Management*, Vol. 41, No.1, pp. 68-84.

Muscatello, J.R., Small, M.H. and Chen, I.J. (2003), Implementing enterprise resource planning (ERP) systems in small and midsize manufacturing firms, *International Journal of Operations & Production Management*, Vol. 23, No. 8, pp. 850-871.

OECD (2005a), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, OECD, Paris.

OECD (2005b), *OECD Science, Technology and Industry Scoreboard 2005*, OECD, Paris. http://puck.sourceoecd.org/vl=380292/cl=28/nw=1/rpsv/scoreboard/index.htm

Overby, E, Bharadwaj, A. and Sambamurthy, V. (2006), Enterprise agility and the enabling role of information technology, *Eiropean Journal of Information Systems*, Vol. 15, pp. 120-131.

Özsomer, A., Calantone, R.J. and Di Benedetto, A. (1997), What makes firms more innovative? A look at organizational and environmental factors, *Journal of Business & Industrial Marketing*, Vol. 12, No. 6, pp. 400-416.

Park, K. and Kusiak, A. (2005), Enterprise resource planning (ERP) operations support system for maintaining process integration, *International Journal of Production Research*, Vol. 43, No. 19, pp. 3959-3982.

Qian, G. and Li, L. (2003), Profitability of small and medium-sized enterprises in high-tech industries: The case of the biotechnology industry, *Strategic Management Journal*, Vol. 24, No. 9, pp. 881-887.

Raymond, L. (2004), Operations management and advanced manufacturing technologies in SMEs: A contingency approach, *Journal of Manufacturing Technology Management*, Vol. 16, No. 8, pp. 936-955.

Roper, S. and Love, J.H. (2002), Product innovation and small business growth: A comparison of the strategies of German, U.K. and Irish companies", *Research Policy*, Vol. 31, pp. 1087-1102.

Ross, J.W. (2003), Creating a strategic IT architecture competency: learning in stages, *MIS Quarterly Executive*, Vol. 2, No. 1, pp. 31-43.

Sambamurthy, V., Bharadwaj, A. and Grover, V. (2003), Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms, *MIS Quarterly*, Vol. 27, No. 2, pp. 237-263.

Singletary, L.A. (2004), Applications integration: Is it always desirable?, *Proceedings of the 37th Hawaii International Conference on System Sciences*, 1-9.

St-Pierre, J. and Delisle, S. (2006), An expert diagnosis system for the benchmarking of SMEs' performance, *Benchmarking: An International Journal*, Vol. 13, No. 1/2, pp. 106-119.

Subrahmanya, M.H.B. (2005), Pattern of technological innovations in small enterprises: a comparative perspective of Bangalore (India) and Northeast England (UK), *Technovation*, Vol. 25, pp. 269-280.

Sum, C., Kow, L.S.-J. and Chen, C.-S. (2004), A taxonomy of operations strategies of high performing small and medium enterprises in Singapore, *International Journal of Operations & Production Management*, Vol. 24, No. 3, pp. 321-345.

Swanson, E.B. and Ramiller, N.C. (2004), Innovating mindfully with information technology, *MIS Quarterly*, Vol. 28, No. 4, pp. 553-583.

Swink, M. and Nair, A. (2007), Capturing the competitive advantage of AMT: Design-Manufacturing integration as a complementary asset, *Journal of Operations Management*, Vol. 25, No. 3, pp. 736-754.

Tidd, J., Bessant, J. and Pavitt, K. (2005), *Managing Innovation: Integrating Technological, Market and Organizational Change*, 3rd Edition, John Wiley, Chichester, U.K.

Tornatzky, L.G. and Klein, K. (1982), Innovation characteristics and innovation implementation: A meta-analysis of findings, *IEEE Transactions on Engineering Management*, Vol. 29, No. 1, pp. 28-45.

Utterback, J.M. (1994), *Mastering the dynamics of innovation*, Harvard Business School Press, Boston, Massachusetts.

Venkatraman, N. (1989), The concept of fit in strategy research: toward verbal and statistical correspondence, *Academy of Management Review*, Vol. 14, No. 3, pp. 423-444.

Ward, P. and Zhou, H. (2006), Impact of information technology integration and lean/just-in-time practices on lead-time performance, *Decision Sciences*, Vol. 37, No. 2, pp. 177-203.

Weill, P. and Aral, S. (2006), Generating premium returns on your IT investments, *Sloan Management Review*, Vol. 47, No. 2, pp. 38-48.

Wolff, J.A. and Pett, T.L. (2006), Small-firm performance: modeling the role of product and process improvements, *Journal of Small Business Management*, Vol. 44, No. 2, pp. 268-284.

Zhu, K. and Kraemer, K.L. (2005), Post-adoption variations in usage and value of e-business by organizations: Cross-country evidence from the retail industry, *Information Systems Research*, Vol. 16, No. 1, pp. 61-84.

Zhu, K., Kraemer, K.L. and Xu, S. (2006), The process of innovation assimilation by firms in different countries: A technology diffusion perspective on e-business, *Management Science*, Vol. 52, No. 10, pp. 1557-1576.

Appendix A: Industrial sectors represented in the sample

Low technology sectors	Medium to low technology	Medium to high technology
wood food and beverage furniture clothing textile printing paper leather others	metal products plastics and rubber metal transformation mining products construction mineral products others	electrical products machinery chemical products transport equipment others

Appendix B: Correlations of the Research Variables (n = 309)

	Prod. Innov.	Proc. Innov.	Assimilation of IT for BPI	Growth	Productivity
Product Innovation	-				
Process Innovation	0.11*	-			
Assimilation of IT for BPI	0.04	0.01	-		
Growth	0.13*	0.11*	0.03	-	
Productivity	0.19***	0.15**	0.03	-0.02	-

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$