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Do organisational and environmental factors moderate the effects of Internet-based interorganisational systems on firm performance?

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Abstract
We developed a model of the relationships among several organisational, interorganisational and technological factors, the adoption of Internet-based interorganisational systems (IBIS) and various measures of firm performance. We used structural equation modelling to empirically test these relationships. The findings showed that adopting IBIS indirectly improves the operational performance of firms through business process performance. The positive effect on financial performance of adopting IBIS is not direct, but through the mediating effects of operational performance and business process performance. We also utilised multiple group analysis to test some of the model relationships across firms using several organisational and environmental factors as moderators. The organisational factors tested are firm type, age and ownership type. The environmental factors consisted of dynamism, complexity and hostility. We found that the organisational factors are significant moderators and that complexity and hostility are not significant moderators. However, the effects of dynamism as a moderator are less clear.
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Introduction

The Internet-enabled supply chain (SC) is a by-product of developments in Internet-based interorganisational information systems. The term interorganisational systems (IOS) has been used to describe information technology (IT) systems that cross organisational boundaries (Bakos, 1991); systems such as extranets and electronic data interchange (EDI). To compete effectively in the dynamic global markets, firms increasingly need to integrate their operations with those of their partners using IOS, since discrete functions within the SC such as manufacturing resource planning (MRPII) and just-in-time (JIT) are becoming insufficient (Williamson *et al.*, 2004). Some of the benefits of such IOS include search cost reduction, inventory reduction and closer relationships with customers (Johnston & Vitale, 1988). The U.S. Census Bureau reports that B2B activity (U.S.$2,716 billion) accounted for approximately 93% of online sales in the U.S. in 2006. Most of this took place through proprietary EDI systems via value-added networks and over the Internet. Comparatively,

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Statistics Canada reports that approximately 45% of Canadian firms in the private sector purchased goods and services online in 2006, whereas only 8% sold online. B2B sales totalled Can$31.4 billion that year – about 68% of total e-commerce sales conducted by private firms.

Thus, B2B e-commerce is playing an increasingly important role in the North American economy and is a significant factor in the evolution of SCs. The main difference between the electronic SC and the traditional one is that the former is founded on technology-based relationships whereas efficiency gains deeply affect the decisions made within the latter. Electronic linkages and the low costs associated with modifying them allow partners in electronic SCs to more easily change their SC configuration to adapt to changes in trends, consumer tastes and the competitive environment (Williams *et al*., 2002). Among the information channels in supply chain management (SCM) at their disposal are auctions, purchasing groups, electronic agents and trading exchanges. Firms can obtain real-time synchronised information through these online SCs by using extensible markup language (XML) on prices, delivery information, etc. Both large and small firms now use the Internet as a principal platform in their upstream, downstream and internal SCs (Williamson *et al*., 2004).

However, limited empirical research is available on the factors that affect the adoption of Internet-based inter-organisational systems (IBIS) and how their adoption affects various measures of performance when contextual factors might act as moderators. Both Melville *et al*. (2004) and Wade & Hulland (2004) emphasise the potential role of moderators. We surveyed North American firms to test a model of the relationships among factors that determine the adoption of IBIS, the adoption of IBIS itself, business process, operational and financial performance. Unlike many empirical studies on this subject, this study uses business process performance as a mediator between IBIS and other performance measures in line with suggestions in the relevant literature (e.g., Melville *et al*., 2004; Wade & Hulland, 2004).

We tested differences in some of the model relationships across firms based on the type (service firms *vs* manufacturing firms *vs* merchandising firms (the latter including retailers, wholesalers and distributors)), age (0–5 years *vs* 6–15 years *vs* more than 15 years), and type of ownership (publicly traded *vs* closely held *vs* sole proprietorship). We also tested if environmental factors, including dynamism (stable *vs* turbulent), complexity (low complexity *vs* high complexity) and hostility (low hostility *vs* high hostility) moderated these model relationships.

The ultimate goal of this research is to develop an empirically grounded conceptual framework that managers can use to better understand the adoption of IBIS and how IBIS affect various measures of performance in relation to organisational characteristics and the business environment. This will help them allocate their firm's resources to IBIS-related investments based on its performance goals, organisational characteristics and the business environment. In addition, this work will create a strong foundation for future empirical research in this area.

Research model

Some previous empirical studies (e.g., Barua *et al*., 2004; Iyer *et al*., 2004; Ranganathan *et al*., 2004; da Silveira & Cagliano, 2006) focused on the adoption and performance effects of Internet technologies in SCM. For example, Barua *et al*. (2004) tested a model positing that the abilities of firms to coordinate and use their resources (including processes, IT, and the readiness of customers and suppliers) created online informational capabilities that resulted in customer and supplier-side digitisation that also improved financial performance. Barua *et al*. (2004) found that firms were more advanced in their customer-side initiatives than in their supplier-side initiatives and that supplier-side digitisation had a positive effect on customer-side digitisation, which, in turn, contributed to financial performance. Ranganathan *et al*. (2004) tested a model in which they posited that the organisational and external environments led to the internal assimilation and external diffusion of Internet technologies in firms' SCs respectively, which then improved performance. Data from North American firms supported these model relationships.

The model shown in Figure 1 was developed through literature reviews to test a number of hypotheses. Accordingly, it encompasses the following six hypotheses:

H1: *A number of organisational, interorganisational, institutional and technological factors (i.e., adoption factors) directly and positively affect the adoption of IBIS.*

H2: *The adoption of IBIS directly and positively affects business process performance.*

H3: *The adoption of IBIS directly and positively affects financial performance.*

H4: *Business process performance directly and positively affects operational performance.*

H5: *Business process performance directly and positively affects financial performance.*

H6: *Operational performance directly and positively affects financial performance.*

Most of the previous studies did not analyse the effects of moderators on the extent of IBIS adoption and IBIS-performance relationships. Wade & Hulland (2004) claim that potential moderators might affect the relationship between IS resources and performance and, therefore, researchers must make identifying moderating constructs

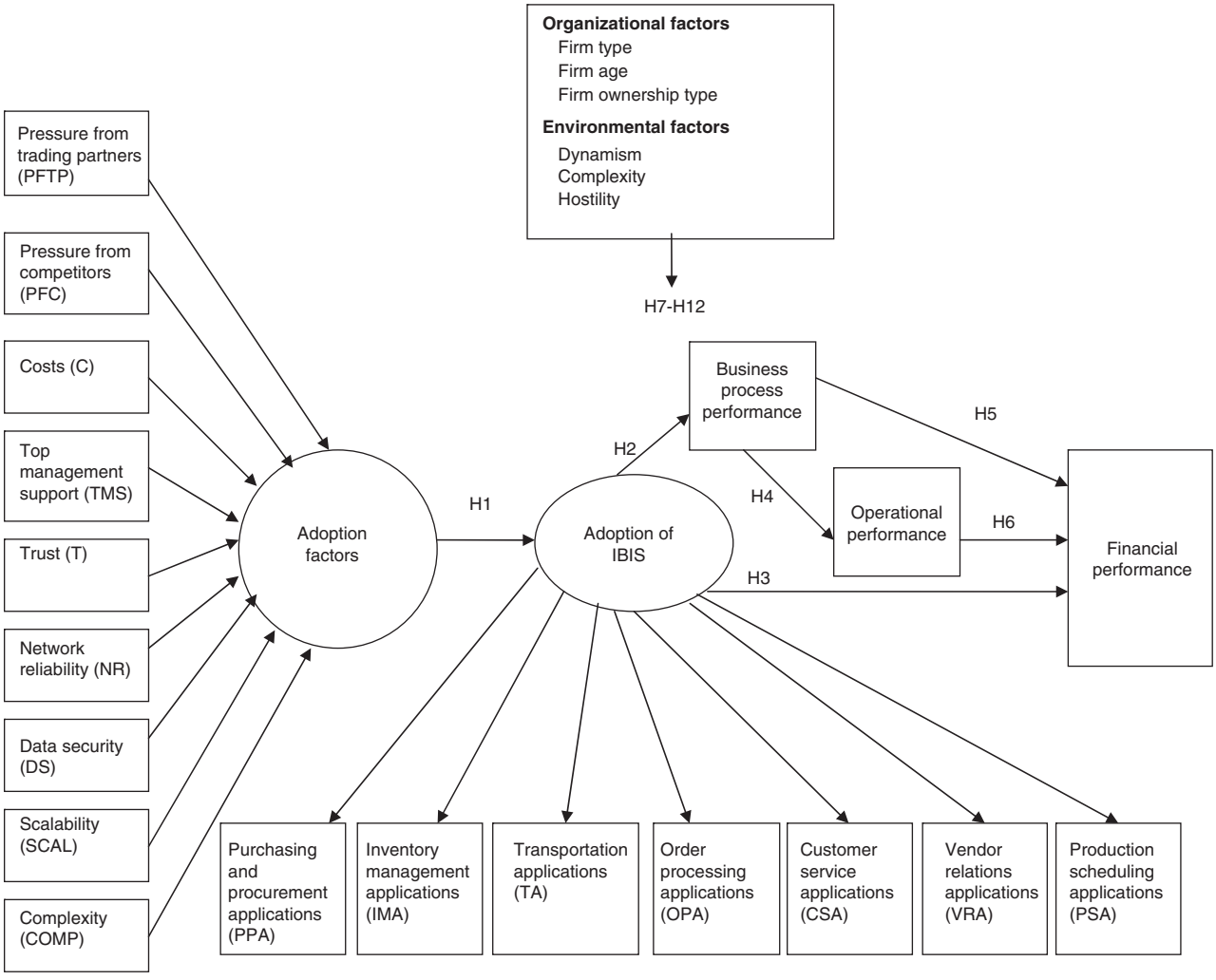

Figure 1 A model of IBIS and performance.

a top priority. In addition, Jean *et al*. (2008) state that analysing the effects of moderators is an emerging stream of research in the IT business value area and that these moderators have not been fully investigated. Since this is the main goal of this study, we used the model shown in Figure 1 to test the moderating effects of a number of contextual factors. The following section discusses the proposed hypotheses related to these effects.

Hypotheses regarding the moderating effects of organisational factors

Firm type The literature reveals mixed results on the effect of firm type on the adoption of IT and IT-performance relationships. Some studies suggest that service firms rely more heavily on IS in general and that manufacturing firms tend more to use IS in production such as enterprise resource planning (ERP) (e.g., Rutner *et al*., 2001), and retail firms depend more on point-of-sale systems to transfer goods (Meroño-Cerdan & Soto-Acosta, 2007). Rai *et al*. (1997) find that expenditure on IT capital and client-server systems positively affected performance, whereas expenditure on IS staff, hardware, software and telecom did not. However, they found no differences in the IT investments of manufacturing and service firms or in the effect on performance of these investments. Sohal *et al*. (2001) state that although manufacturing and service sectors achieved moderate gains from IT investments, especially in productivity and cost reduction, service firms used IT to improve products and services more than manufacturers did. On the other hand, Bhatt (2000) finds that manufacturing firms used integrated communication networks to achieve better results than did service firms in their process improvement initiatives and customer focus. However, Dasgupta *et al*. (1999) discover that IT investments had a negative effect on performance in both manufacturing and service firms.

The results of studies that analysed the different uses and the impact of Internet-based technologies across different types of firms have also been mixed. Chatterjee *et al*. (2002) maintain that the online platform provided more opportunities for service firms in that they could use it to conduct a broader range of value chain activities than manufacturing firms. Chatterjee *et al*. (2002) claim, for instance, that an automobile or apparel manufacturer could only carry out marketing, customer support services and recruiting activities online, whereas a financial services firm could conduct marketing, sales, order processing, delivery, customer support services and recruiting. However, Frohlich & Westbrook (2002) report that Internet-enabled SC integration strategies led to higher performance in manufacturing firms than in service firms. As well, Huizingh (2000) expects firms with information-based products to take more advantage of the Internet than manufacturing firms. The study's empirical results did not support this. Although service firms had more information on their websites, manufacturing firms had more transactional features (Huizingh, 2000). However, Rutner *et al*. (2001) shows that manufacturing firms did not use the Internet as much as non-manufacturing firms to conduct sales or use extranet systems to communicate with their suppliers. On the other hand, Meroño-Cerdan & Soto-Acosta (2007) find no differences between the two types of firms in terms of the transactional features on their websites. Feng & Yuan (2006) also report no major differences in the use of information and communication technologies between manufacturing and transport logistics firms for their logistics management activities or in the benefits. Sengupta *et al*. (2006) show that using the Internet in SCM did not affect operational or financial performance in either manufacturing or service firms.

Different variables and a number of measurement instruments may have been used in these studies to come to such mixed results. However, given that some of the studies found differences across manufacturing and service firms, we expected that at least some components of the model in the current study would be different across these firms. A lack of empirical evidence exists on how merchandising firms compare to manufacturing and service firms in their adoption of IT and its impact on performance. However, a study by Closs & Xu (2000) compares the adoption of logistics IT among merchandising and manufacturing firms and finds that the former placed more importance on EDI, barcoding and real-time communications than the latter. The authors reasoned that this was probably because merchandisers were closer to the final customers in the SC and thus placed more emphasis on their logistics IT. Moreover, since merchandisers were more geographically diverse, they wanted more real-time communication. Thus:

H7: *The extent of adopting IBIS and their direct effects on performance differ across manufacturing, service and merchandising firms.*

Firm age Murphy *et al*. (2003) state that firm age is not often used as a contextual factor in SCM literature and that the literature generally shows that older firms implement IT more than younger firms (e.g., Franz & Robey, 1986). However, our analysis of the literature suggests that the findings are mixed since some studies suggest that younger firms are more capable of adopting IT than older ones and *vice versa*. Some of the reasons cited as to why older firms are better able to adopt IT than younger ones include their greater experience in integrating new processes into their operations (Evans, 1987) and their greater financial resources (Raymond, 1985). An empirical study by Sorensen & Stuart (2000) also finds that older firms were more innovative than younger ones. On the other hand, Goode & Stevens (2000) report that younger firms were more likely to adopt the Internet. Chatterjee *et al*. (2002) suggest that this could be because of older firms having 'entrenched structures of signification, legitimization, and domination' that would create barriers to the effective implementation of Internet technologies in these firms. In addition, Balasubramanian & Lee (2008) find that firm age had a negative impact on the effect of technological innovation on performance: as firms aged by one year, the positive impact of a 10% increase in R&D intensity on the their market value was reduced by more than 3%. Thus:

H8: *The extent of adopting IBIS and their direct effects on performance differ across younger and older firms.*

Firm ownership type We did not find any empirical literature on the moderating effect of ownership type on the adoption of IBIS and their impact on performance. Agency theory suggests that agency costs result when the principals (shareholders) cannot adequately monitor the behaviour of the agents (managers) who are motivated by self-interest (Jensen & Meckling, 1976). The conflict generated between shareholders and managers is expected to worsen when a firm's equity-to-debt ratio rises (i.e., when its ownership is more diversified) (Karake, 1994). Agency theory therefore has implications for a firm's resources in that failing to minimise agency costs consumes these resources and reduces competitiveness (Karake, 1994).

Jensen & Meckling's (1976) model implies that, compared to publicly traded firms, privately held, family-managed firms have no significant agency costs and are assumed to have one of the least costly or most efficient forms of organisational governance (Schulze *et al*., 2001). Schulze *et al*. (2001) and others (e.g., Jensen, 1993, 1998) challenge this implication and argue that private firms still face agency costs. For instance, they face no market control and are controlled by their owners, which may cause these owner-managers to act in ways that may harm themselves and others around them. Schulze *et al*. (2001) contend that agency problems may be even more pronounced in privately

held, family-managed firms for these reasons and problems created by altruism. On the other hand, although Lauterbach & Vaninsky (1999) also agree on the existence of agency problems in closely held firms, they believe these problems tend to be smaller than in publicly traded firms because of the close relationship between the owners and managers and thus closer monitoring. The exploratory findings of empirical studies by Chrisman *et al*. (2004) and Fleming *et al*. (2005) suggest that family involvement in a business does indeed reduce overall agency problems and costs. In fact, Nagar *et al*. (2008) affirm that, according to the law and finance literature, the main governance problem in closely held firms is between the majority and minority shareholders, not between the management and shareholders because the small number of shareholders allows them all to participate in management and operations (Nagar *et al*., 2008). Nagar *et al*. (2008) also provide empirical evidence for the presence of governance problems among shareholders in closely held firms. Thus, if it is indeed true that closely held firms have fewer agency problems and costs, they should be using IT resources more efficiently since there would be fewer conflicts in how these resources are managed.

The results were different for sole proprietorships. An empirical study by Danielson & Scott (2007) reports that even though small firms had little or no agency costs, they were more likely to underinvest in new projects. Sole proprietorships may need to expand their operations or to hire new employees, who may not always act in the best interests of the owner, should they invest in new IT. Based on Danielson & Scott's (2007) findings, we could argue that such small firms would not invest in IBIS if they believed that the agency costs could outweigh the benefits. Even after investing in IBIS, sole proprietorships may be less willing to continue investing in these technologies because of fears of potential agency costs.

Danielson & Scott (2007) also find that, as the ownership and control structures of these small firms became less concentrated (as in closely held firms) overinvestment in projects became a management concern. For example, agents were more likely to be overly optimistic in promoting the benefits of investing in these projects than if they had personal financial stakes in the results. These firms were more likely to create internal budgeting and monitoring systems to control agency costs and decrease the risk of overinvestment (Danielson & Scott, 2007). Thus, we could argue that closely held firms are more likely to use IT resources more efficiently than sole proprietorships and publicly traded firms because of their ability to control agency costs more easily. These costs tend to be larger and more difficult to control in publicly traded firms, resulting in less efficient use of IT resources.

Previous studies also indicate that the attitude of small-business owners played an important role in the success of their IT efforts. For example, Cragg & King (1993) and Winston & Dologite (1999) report that owners with a positive attitude towards IT were knowledgeable about it and did not hesitate to invest. However, those who had a negative attitude did not invest because they did not fully grasp how IT could benefit their business (Cragg & King, 1993). Winston & Dologite (2002) find that owners who were uncertain towards IT had mostly inherited family businesses older than 40 years and did not feel comfortable making any changes. Nor did they want to adopt any technology that would give employees easy access to sensitive information. Owners who had either a negative attitude or an uncertain one did not commit to a successful implementation even if they made an initial investment in new IT (Cragg & King, 1993). Therefore:

H9: *The extent of adopting IBIS and their direct effects on performance are greater in closely held firms than in publicly traded firms and sole proprietorships.*

Hypotheses regarding the moderating effects of environmental factors

Environmental dynamism In stable business environments, change generally occurs gradually and linearly, whereas in turbulent environments, it is fast and intermittent (Modarres *et al*., 2003). As a result, firms in a turbulent environment tend to be more innovative to keep up with market and competitive forces (Myers & Marquis, 1969) and have a stronger relationship between 'outside-in' IT resources and performance than those in stable environments (Wade & Hulland, 2004). In a stable environment, management's main focus is on creating a competitive advantage. Since change tends to be slow, firms that already have one can sustain it. On the other hand, firms in a turbulent environment must continually find ways of staying ahead of the competition since advantages do not last. These firms use different assets and capabilities, whereas firms in stable environments tend to use their current knowledge and capabilities and not search for alternatives. They focus on 'inside-out' IT resources that include, for instance, IT technology skills, IT development and IS infrastructure. However, those in turbulent environments seek to improve their competitive position by focusing on 'outside-in' IT resources (Wade & Hulland, 2004), such as IBIS.

Thus, turbulent business environments characterised by great uncertainty require product, service and managerial innovations, increasing the need for information processing capability, and make firms rely more on IT (Galbraith, 1977; Tushman & Nadler, 1978; Kearns & Lederer, 2004). Stonebraker & Liao (2004) state that firms in turbulent environments can use SC integration to minimise transaction costs and would therefore be expected to implement IBIS more rigorously. Several studies (e.g., Li & Ye, 1999; Zhang, 2007) confirm that such environmental dynamism may moderate the relationship between IT investments and performance. The empirical findings of Li & Ye (1999) and Zhang (2007) corroborate the notion that investing in IT has a stronger

effect on performance in turbulent environments since these investments

- provide top managers with timely and relevant information;
- help them respond quickly to changes in markets and competition;
- reduce uncertainty; and
- increase their firm's competitiveness (Li & Ye, 1999; Zhang, 2007).

In addition to giving top managers a fast response capability, IT support allows them to evaluate and adjust their mental models. This ability is more important for managers who work in turbulent environments and should lead to greater business value for their firms than for firms operating in stable environments (Zhang, 2007). Thus:

H10: *The extent of adopting IBIS and their direct effects on performance are greater in firms operating in turbulent business environments than in those operating in stable business environments.*

Environmental complexity Environmental complexity deals with the extent to which an industry or firm's activities are heterogeneous in terms of inputs and outputs needed for operations and its blend of suppliers, customers and competitors. In highly complex environments, firms need reliable and efficient outside-in IT resources to manage the plethora of information they exchange with SC partners (Wade & Hulland, 2004). Firms that operate in various markets are exposed to different ideas from competitors and customers and are more likely to adopt innovations (Miller & Friesen, 1983).

The resource-based view suggests that the more complex the environment, the harder it is for competitors to recognise the key resources that give a firm a competitive advantage and therefore, the harder it is for them to imitate, acquire or substitute these resources. Thus, firms that operate in highly complex environments have a stronger and longer lasting link between these resources and performance (Wade & Hulland, 2004). In addition, since SC partners need to share proprietary information to design and produce complex and customised goods (Bensaou, 1999; Novak & Eppinger, 2001) and since demand for these goods is never assured (Saeed *et al*., 2005), SC partners feel more pressure to collaborate closely to decrease coordination costs (Closs *et al*., 2008). Using IBIS may help them increase efficiency and reduce costs, but not their performance if they are dealing with standard products that have a stable and predictable demand. This is because SC partners can coordinate through rules, procedures and preplanning without major supplier-specialised investments when such standard products are involved (Bensaou & Anderson, 1999).

Some empirical studies tested the effects of complexity on IT. Kearns & Lederer (2004) and Kearns & Sabherwal (2007) report that, in highly complex environments, top managers were forced to recognise the importance of IT and integrate IT planning into business planning. As a result, they were more likely to cooperate with IT managers to formulate business plans by attending meetings and having closer contact with them (Kearns & Sabherwal, 2007). Kearns & Lederer (2004) conclude that their results support the rational adaptive theory that information-intense firms operating in highly complex environments are successful in their formal and informal IT planning.

H11: *The extent of adopting IBIS and their direct effects on performance are greater in firms operating in high complexity environments than in those operating in low complexity environments.*

Environmental hostility Environmental hostility deals with the extent of threat that firms face from competition and the cycles of the industry in which they operate, for example, intense competition in price, product, technology and distribution (Ozsomer *et al*., 1997). An empirical study by Burke *et al*. (2002) shows that IT adoption by American hospitals was related to market competition in that urban hospitals and highly competitive markets had higher adoption rates of administrative, clinical and strategic IT relative to rural hospitals and hospitals operating in markets with very low competition. In addition, Grover (1993) and Chwelos *et al*. (2001) find that firms in competitive environments were more likely to implement EDI.

Melville *et al*. (2004) claim that we understand little of how an industry's characteristics affect the business value of its IT. The X-efficiency theory suggests that lack of competition leads to slack, inefficiencies and higher costs. Similarly, the efficiency benefits from using IT resources in these environments with high industry concentration and thus low competition are expected to be low (Melville *et al*., 2004). In fact, an empirical study by Melville *et al*. (2007) finds that IT helped improve the productivity of firms in more competitive industries. This stands to reason since firms in competitive environments are usually more innovative than those in less competitive environments to stay ahead of the competition (Myers & Marquis, 1969). However, gains in efficiency do not necessarily result in higher profitability in the long term since the profits made from efficient IT may be lost to intense competition. In contrast, firms in less competitive environments may not achieve productivity from using IT but they may increase profitability because of their monopoly power (Melville *et al*., 2004). Therefore, we posit the following:

H12: *The extent of adopting IBIS and their direct effects on performance are greater in firms operating in highly hostile environments than in those operating in less hostile environments.*

Methodology

Variable measures and research instrument

The survey instrument contained a set of demographic questions followed by 23 items (see Appendix) that measured the nine factors affecting the adoption of IBIS. These factors were operationalised by Soliman & Janz (2004) through a survey study. Seven factors were used to measure the adoption of IBIS based on the categories of IBIS used by Lancioni *et al*. (2003). The respondents were asked to rate the extent to which they used IBIS in their SCM activities.

Performance measures were based on the literature about the business value of IT and the works of authors such as Barua *et al*. (1995), Melville *et al*. (2004) and Wade & Hulland (2004). Eleven items in the survey measured the level of performance of firms in different areas (compared to that of their major competitors after these firms' implementation of IBIS):

- five items for business process performance (which measured the efficiency of specific business processes);
- three items for operational performance (which measured overall firm operational performance); and
- three items for financial performance.

Seven items measured environmental factors:

- three items for environmental dynamism;
- one item for environmental complexity; and
- three items for environmental hostility (Miller & Friesen, 1983).

Using Jaworski & Kohli's (1993) approach, a split-group analysis was performed for each environmental factor. For example, for the complexity factor, the sample was sorted in ascending order and split at the median to form two subgroups, one with relatively low complexity and the other with relatively high complexity. A 1–7 Likert scale was used for all the items. Each organisational factor was measured by a single question.

Data collection and sample

A sample of 3000 firms was randomly selected from the Council of Supply Chain Management Professionals's mailing list and Industry Canada's website (http://strategis.gc.ca) and sent a Web-based survey by email. To increase the response rate, two reminders were emailed after the initial message. One week separated each reminder; the survey closed another week after that. Of the 420 responses obtained, 99 were not deemed usable because of missing data or because these firms did not use IBIS to conduct transactions with their customers and suppliers. In addition, two of the cases were outliers and therefore deleted. This reduced the usable number of responses to 319. Table 1 shows a profile of these respondents. Non-response bias was tested by dividing the responses into early and late respondents and *t*-testing their mean responses to 10 randomly selected survey questions (Armstrong & Overton, 1977). The results showed that the two groups were similar and that non-response bias was likely to be minimal.

Table 1 Profile of the respondents

Industries	Agriculture: 4, Automotive: 11, Aviation: 5, Building materials: 4, Chemicals & plastics: 19, Clothing & textiles: 19, Construction: 7, Consulting: 23, Cosmetics: 3, Design: 7, Electronics: 19, Energy: 2, Engineering: 6, Environmental management:9, Financial services: 2, Food & beverage: 8, Furniture: 5, General merchandise: 11, Hardware: 7, Industrial equipment: 7, Machine tools: 4, Medical devices: 5, Metals: 4, Mining: 3, Office equipment: 2, Paper products: 6, Petroleum: 10, Pharmaceuticals: 5, Printing: 9, Repair:3, Rubber: 3, Sporting goods: 2, Telecommunications: 3, Toys: 4, Transportation: 3, Others: 75
Job titles	CEO: 37, President: 96, Vice president: 23, Director: 31, Corporate manager: 12, Other manager: 53, Coordinator: 5, Supervisor: 6, Others: 56
Site's sales (in millions of dollars)	0–1: 124, 2–10: 78, 11–20: 23, 21–50: 22, 51–100: 11, 101–500: 16, 501–1000: 11, 1001–2500: 8, 2501–5000: 6, Over 5000: 12, Unspecified: 8
Number of employees at the site	0–20: 170, 21–100: 71, 101–500: 33, 501–1000: 14, 1001–2500: 9, 2501–5000: 14, Unspecified: 8

EQS 6.1 for Windows was used to assess the unidimensionality and reliability of the scales, their convergent, discriminant and criterion-related validity (Anderson & Gerbing, 1982). Confirmatory factor analysis (CFA) was used to assess the unidimensionality of the scales. The χ^2 significance test, comparative fit index (CFI) and standardised root mean square residual (SRMR) were used to assess model fit. CFI and SRMR are relatively unaffected by sample size and minimise the effect of sample size in assessing model adequacy (Hu & Bentler, 1998). Citing Hu & Bentler's (1999) study, Kline (2005) states that CFI 'values greater than roughly 0.90 may indicate reasonably good fit of the researcher's model'. The same study states that 'values of the SRMR less than 0.10 are generally considered favorable'. Therefore, an acceptable goodness-of-fit in this study was defined as $CFI \geqslant 0.90$ and $SRMR < 0.10$.

Analyses

Preliminary analyses

All the items except trust and complexity had statistically significant factor loadings on their assigned constructs (see Table 2). Table 2 shows CFI values of 0.90 to 1 and

Table 2 Summary of goodness-of-fit statistics for CFA of model constructs

Model constructs and their indicators	χ^2	*d.f.*	χ^2/*d.f.*	*P-value*	*CFI*	*SRMR*	*Factor loading*	*Cronbach's alpha*
Adoption factors	60.30	13	4.64	0.00000	0.91	0.051		0.81
Pressure from trading partners							0.43*	
Pressure from competitors							0.66*	
Costs							0.63*	
Top management support							0.73*	
Trust							0.27	
Network reliability							0.76*	
Data security							0.38*	
Scalability							0.73*	
Complexity							0.23	
Adoption of IBIS	50.90	14	3.64	0.00000	0.90	0.063		0.77
Purchasing and procurement applications							0.311*	
Inventory management applications							0.612*	
Transportation applications							0.467*	
Order processing applications							0.612*	
Customer service applications							0.550*	
Vendor relations applications							0.752*	
Production scheduling applications							0.673*	
Business process performance	19.65	5	3.93	0.00146	0.94	0.043		0.77
Inventory turnover							0.462*	
Customer service							0.753*	
Supplier relationships							0.697*	
Quality of design processes							0.657*	
Cycle time							0.623*	
Operational performance[a]	0.421	1	0.4211	0.51638	1.00	0.022		0.70
Efficiency							0.551*	
Productivity							0.856*	
Cost reduction							0.610*	
Financial performance[b]	2.053	1	2.053	0.15191	0.995	0.027		0.81
Profitability							0.663*	
Return on investment							0.795*	
Market share							0.851*	

*$P<0.001$.

[a]Since the model was just identified, the factor loadings of efficiency and cost reduction were set equal to achieve model overidentification (Kenny, 1970). When the model was run with this constraint, the standardised parameter estimates of these two items demonstrated nearly identical factor loadings.

[b]The factor loadings of return on investment and market share were set equal to achieve model overidentification. The model run yielded similar factor loadings for both items.

SRMR values of 0.022 to 0.063, suggesting that all the constructs were unidimensional. Cronbach's alpha was used to evaluate the reliability of the constructs (Cronbach, 1951). A minimum alpha value of 0.70 is needed to assure reliability (O'Leary-Kelly & Vokurka, 1998). The alpha values ranged from 0.70 to 0.81, indicating that all the constructs were reliable (see Table 2). Deleting any of the items did not improve the reliability of the constructs.

Convergent validity analysis was conducted to evaluate 'the degree to which two or more attempts to measure the same concept … are in agreement' (Bagozzi & Phillips, 1982, p. 468). CFA can be used to assess the convergent validity of the constructs (Bagozzi *et al.*, 1991). Convergent validity is achieved when items load significantly on their corresponding constructs. Table 2 shows that all the factor loadings were significant at $P<0.001$.

Discriminant validity analysis was used to evaluate the degree to which a construct in the model differed from another construct. A series of χ^2 difference tests was conducted between nested CFA models for all pairs of constructs, that is, a nested CFA model was run first by allowing two constructs to correlate freely and then by constraining their correlation to 1, after which the difference in χ^2 between the two models was determined (Bagozzi *et al.*, 1991). Table 3 indicates that the χ^2 difference tests between all pairs of constructs are significant at $P<0.001$, pointing to the presence of strong discriminant validity.

Criterion-related validity evaluates the extent to which items in a construct scale correlate with an external

Table 3 Discriminant validity analysis

Construct scale pairs	*Unconstrained*		*Constrained*		$\Delta\chi^2$
	χ^2	*d.f.*	χ^2	*d.f.*	
Adoption factors					
Adoption of IBIS	198.95	76	307.62	77	108.67*
Business process performance	124.78	53	247.76	54	122.98*
Operational performance	103.34	34	234.27	35	130.93*
Financial performance	99.77	34	206.53	35	106.76*
Adoption of IBIS					
Business process performance	119.84	53	197.90	54	78.06*
Operational performance	90.08	34	157.34	35	67.26*
Financial performance	88.19	34	156.45	35	68.26*
Business process performance					
Operational performance	46.59	19	67.28	20	20.69*
Financial performance	56.40	19	76.27	20	19.87*
Operational performance					
Financial performance	70.00	8	82.24	9	12.24*

*$P<0.001$.

criterion (Nunnally, 1978). In this study, the IBIS construct is the predictor and the three performance measures are the relevant criteria. The bivariate correlations between IBIS and business process, operational and financial performance were 0.431, 0.321 and 0.369 ($P<0.001$) respectively, indicating that criterion-related validity was present.

The reliability and validity of all the scales were established based on these analyses. In addition, the variables were all tested for assumptions of multivariate analysis, including normality, linearity, multicollinearity and singularity. The results revealed no statistically significant violations of these assumptions. Although there was no univariate non-normality, higher-than-acceptable Mardia's coefficient values (greater than 3) showed some multivariate non-normality. Therefore, robust statistics, including the Satorra-Bentler chi-square (S-Bχ^2) statistic and robust CFI (Satorra & Bentler, 1994), both of which adjust standard errors to calculate parameter estimates were used. The corresponding items of all the variables except those of adoption of IBIS (as single-item variables) were also parcelled to reduce them to a manageable level (Hall *et al*., 1999).

The data were tested for common method bias using a marker variable (Lindell & Whitney, 2001; Podsakoff *et al*., 2003; Malhotra *et al*., 2006). A marker variable is deemed to have no theoretical relationship with at least one of the variables in the study. The presence of common method variance is evaluated using the correlation between the marker variable and a study variable that are unrelated. If a marker variable has not been identified *a priori*, it can be estimated *post hoc* by using the smallest correlation among the manifest variables or the second-smallest correlation as a more conservative estimate (Lindell & Whitney, 2001). This correlation (r_M) is then used to adjust the correlations among the manifest variables (r_U) and thus partial out the common method variance by using the following equation (Malhotra *et al*., 2006):

$$r_A = r_U - \frac{r_M}{1 - r_M}.$$

With a sample size of n, the t statistic for r_A (the adjusted correlation) is computed using

$$t_{\alpha/2,\,n-3} = \frac{r_A}{\sqrt{(1 - {r_A}^2)/(n-3)}}.$$

Malhotra *et al*. (2006) extend Lindell & Whitney's (2001) framework to test a causal model. They use the adjusted correlations to rerun their causal model and compute adjusted path coefficients to determine if common method variance affected their conclusions. We adopted this approach for this study. Tables 4 and 5 display the unadjusted and adjusted correlation matrices (adjusted using the second-smallest correlation among the manifest variables, so $r_M = -0.003$) respectively, for the 17 manifest variables. A comparison of the two tables shows that the significant correlations remained significant and non-significant correlations did not become significant. The model was also run using the unadjusted and adjusted correlation matrices and the resulting model parameter estimates (factor loadings and structural paths) compared. Table 6 indicates that both correlation matrices produced similar results. These findings point to the absence of common method variance.

Table 4 Unadjusted correlation matrix for manifest variables

	PFTP	*PFC*	*C*	*TMS*	*NR*	*DS*	*SCAL*	*PPA*	*IMA*	*TA*	*OPA*	*CSA*	*VRA*	*PSA*	*BPP*	*OP*	*FP*
PFTP	1.000																
PFC	0.295[a]	1.000															
C	0.313[a]	0.470[a]	1.000														
TMS	0.357[a]	0.500[a]	0.423[a]	1.000													
NR	0.346[a]	0.426[a]	0.569[a]	0.518[a]	1.000												
DS	0.203[b]	0.195[b]	0.156[c]	0.256[a]	0.296[a]	1.000											
SCAL	0.189[b]	0.520[a]	0.349[a]	0.565[a]	0.580[a]	0.353[a]	1.000										
PPA	0.237[a]	0.143[c]	0.106	0.181[b]	0.246[a]	0.241[a]	0.172[b]	1.000									
IMA	0.085	0.293[a]	0.161[b]	0.159[b]	0.136[c]	0.020	0.223[a]	0.281[a]	1.000								
TA	0.082	0.115[c]	0.151[c]	0.218[a]	0.157[b]	0.015	0.174[b]	0.212[a]	0.294[a]	1.000							
OPA	0.163[b]	0.181[b]	0.207[a]	0.251[a]	0.177[b]	0.106	0.278[a]	0.312[a]	0.450[a]	0.403[a]	1.000						
CSA	0.079	0.103	0.090	0.212[a]	0.158[c]	−0.002	0.173[b]	0.130[c]	0.239[a]	0.213[a]	0.232[a]	1.000					
VRA	0.088	0.242[a]	0.195[b]	0.237[a]	0.161[c]	−0.003	0.221[a]	0.123[c]	0.412[a]	0.349[a]	0.442[a]	0.515[a]	1.000				
PSA	0.131[c]	0.268[a]	0.105	0.236[a]	0.195[b]	0.094	0.307[a]	0.192[b]	0.453[a]	0.227[a]	0.353[a]	0.422[a]	0.526[a]	1.000			
BPP	0.093	0.191[b]	0.106	0.283[a]	0.300[a]	0.024	0.291[a]	0.256[a]	0.281[a]	0.166[b]	0.217[a]	0.266[a]	0.285[a]	0.264[a]	1.000		
OP	0.103	0.182[b]	0.132[c]	0.222[a]	0.236[a]	0.023	0.246[a]	0.170[b]	0.268[a]	0.148[c]	0.199[a]	0.268[a]	0.291[a]	0.329[a]	0.744[a]	1.000	
FP	0.098	0.249[a]	0.165[b]	0.332[a]	0.331[a]	0.080	0.360[a]	0.213[a]	0.276[a]	0.131[b]	0.178[a]	0.251[a]	0.247[a]	0.257[a]	0.800[a]	0.734[a]	1.000

[a] $P<0.001$.
[b] $P<0.01$.
[c] $P<0.05$.

Table 5 Adjusted correlation matrix for manifest variables

	PFTP	*PFC*	*C*	*TMS*	*NR*	*DS*	*SCAL*	*PPA*	*IMA*	*TA*	*OPA*	*CSA*	*VRA*	*PSA*	*BPP*	*OP*	*FP*
PFTP	1.000																
PFC	0.297[a]	1.000															
C	0.315[a]	0.471[a]	1.000														
TMS	0.359[a]	0.501[a]	0.424[a]	1.000													
NR	0.347[a]	0.427[a]	0.570[a]	0.520[a]	1.000												
DS	0.205[a]	0.198[a]	0.159[b]	0.259[a]	0.298[a]	1.000											
SCAL	0.192[a]	0.521[a]	0.351[a]	0.567[a]	0.581[a]	0.355[a]	1.000										
PPA	0.239[a]	0.145[b]	0.109	0.184[a]	0.248[a]	0.244[a]	0.174[b]	1.000									
IMA	0.087	0.295[a]	0.164[b]	0.162[b]	0.139[c]	0.022	0.225[a]	0.283[a]	1.000								
TA	0.085	0.118[c]	0.154[b]	0.220[a]	0.160[b]	0.018	0.176[b]	0.214[a]	0.296[a]	1.000							
OPA	0.165[b]	0.183[a]	0.209[a]	0.253[a]	0.179[b]	0.109	0.280[a]	0.314[a]	0.452[a]	0.404[a]	1.000						
CSA	0.082	0.105	0.092	0.214[a]	0.160[b]	0.001	0.175[b]	0.132[c]	0.241[a]	0.215[a]	0.234[a]	1.000					
VRA	0.091	0.244[a]	0.197[a]	0.239[a]	0.164[b]	0.000	0.223[a]	0.126[c]	0.414[a]	0.351[a]	0.444[a]	0.516[a]	1.000				
PSA	0.134[c]	0.270[a]	0.108	0.238[a]	0.197[a]	0.097	0.309[a]	0.194[a]	0.454[a]	0.230[a]	0.354[a]	0.423[a]	0.527[a]	1.000			
BPP	0.096	0.193[a]	0.109	0.286[a]	0.302[a]	0.027	0.293[a]	0.259[a]	0.283[a]	0.168[b]	0.219[a]	0.268[a]	0.287[a]	0.266[a]	1.000		
OP	0.105	0.185[a]	0.134[c]	0.224[a]	0.239[a]	0.026	0.248[a]	0.173[b]	0.270[a]	0.151[b]	0.201[a]	0.270[a]	0.293[a]	0.331[a]	0.745[a]	1.000	
FP	0.100	0.251[a]	0.168[b]	0.334[a]	0.333[a]	0.082	0.362[a]	0.215[a]	0.278[a]	0.134[c]	0.180[b]	0.254[a]	0.250[a]	0.259[a]	0.800[a]	0.735[a]	1.000

[a] $P<0.001$.
[b] $P<0.01$.
[c] $P<0.05$.

Structural path model analyses

The model was first run using the full data ($n=319$), then using each subgroup data as shown in Table 7. The adequate model fit for each subgroup, which is a precursor to conducting multiple group analysis (MGA), is discussed in the next section. The same fit indices used for CFA were used for structural path model analyses. Table 7 shows that the robust CFI values for subgroups ranged from 0.72 to 0.93 and the SRMR values from 0.069 to 0.145, indicating that five of the 16 subgroups did not have adequate model fits (i.e., robust CFI$<$0.90 or SRMR$>$0.10 or both). Therefore, these subgroups were not used in the MGAs discussed in the next section. Three of these subgroups ('Merchandising firms' with robust CFI$=$0.89 and SRMR$=$0.102, '$>$15 years' with robust CFI$=$0.89 and SRMR$=$0.075, and 'high hostility' with

Table 6 Comparison of model parameters based on unadjusted and adjusted correlation matrices

	Uncorrected standardised estimates	*Adjusted standardised estimates with marker variable ($r_M = -0.003$)*
Factor loadings		
PFTP	0.424*	0.426*
PFC	0.665*	0.666*
C	0.620*	0.620*
TMS	0.732*	0.734*
NR	0.753*	0.753*
DS	0.367*	0.370*
SCAL	0.738*	0.740*
PPA	0.350*	0.353*
IMA	0.620*	0.621*
TA	0.467*	0.469*
OPA	0.615*	0.617*
CSA	0.544*	0.545*
VRA	0.728*	0.728*
PSA	0.671*	0.671*
Structural paths		
H1	0.470*	0.474*
H2	0.431*	0.434*
H3	0.029	0.031
H4	0.744*	0.745*
H5	0.561*	0.559*
H6	0.306*	0.307*

*$P < 0.001$.

Table 7 Goodness-of-fit indices for structural path model analyses using the full sample and subgroup samples

Contextual factor	*Subgroup*	*n*	*S-Bχ^2*	*d.f.*	*S-Bχ^2/d.f.*	*P-value*	*Robust CFI*	*SRMR*	*Model fits?*
All data		319	275.01	116	2.37	0.00000	0.90	0.069	Yes
Firm type	Service firms	69	191.16	116	1.65	0.00001	0.78	0.145	No
	Manufacturing firms	173	209.44	116	1.81	0.00000	0.90	0.076	Yes
	Merchandising firms	62	149.31	116	1.29	0.02020	0.89	0.102	Close
Firm age	0–5 years	58	215.96	116	1.86	0.00000	0.72	0.132	No
	6–15 years	77	177.85	116	1.53	0.00020	0.90	0.099	Yes
	>15 years	184	210.09	116	1.81	0.00001	0.89	0.075	Very close
Firm ownership type	Closely held	144	192.08	116	1.66	0.00001	0.90	0.083	Yes
	Publicly traded	60	173.94	116	1.50	0.00040	0.81	0.118	No
	Sole proprietorship	65	195.68	116	1.69	0.00001	0.79	0.126	No
Dynamism	Stable environment	170	189.64	116	1.63	0.00002	0.91	0.080	Yes
	Turbulent environment	147	217.10	116	1.87	0.00000	0.86	0.097	No
Complexity	Low complexity	204	209.43	116	1.81	0.00000	0.90	0.085	Yes
	High complexity	108	167.48	116	1.44	0.00126	0.90	0.078	Yes
Hostility	Low hostility	190	178.96	116	1.54	0.00016	0.93	0.078	Yes
	High hostility	127	188.61	116	1.63	0.00002	0.88	0.089	Close

robust CFI = 0.88 and SRMR = 0.089) had fit indices close to the acceptable cut-off points and were retained for further analysis. Dropping two subgroups from firm ownership type and one subgroup from dynamism meant that MGA could not be conducted for these two factors.

Figure 2 shows the parameter estimates for the full sample, including factor loadings, coefficients for the structural paths and the amount of explained variance (R^2) for the dependent variables. Tables 8 and 9 indicate the parameter estimates for all the subgroups, including

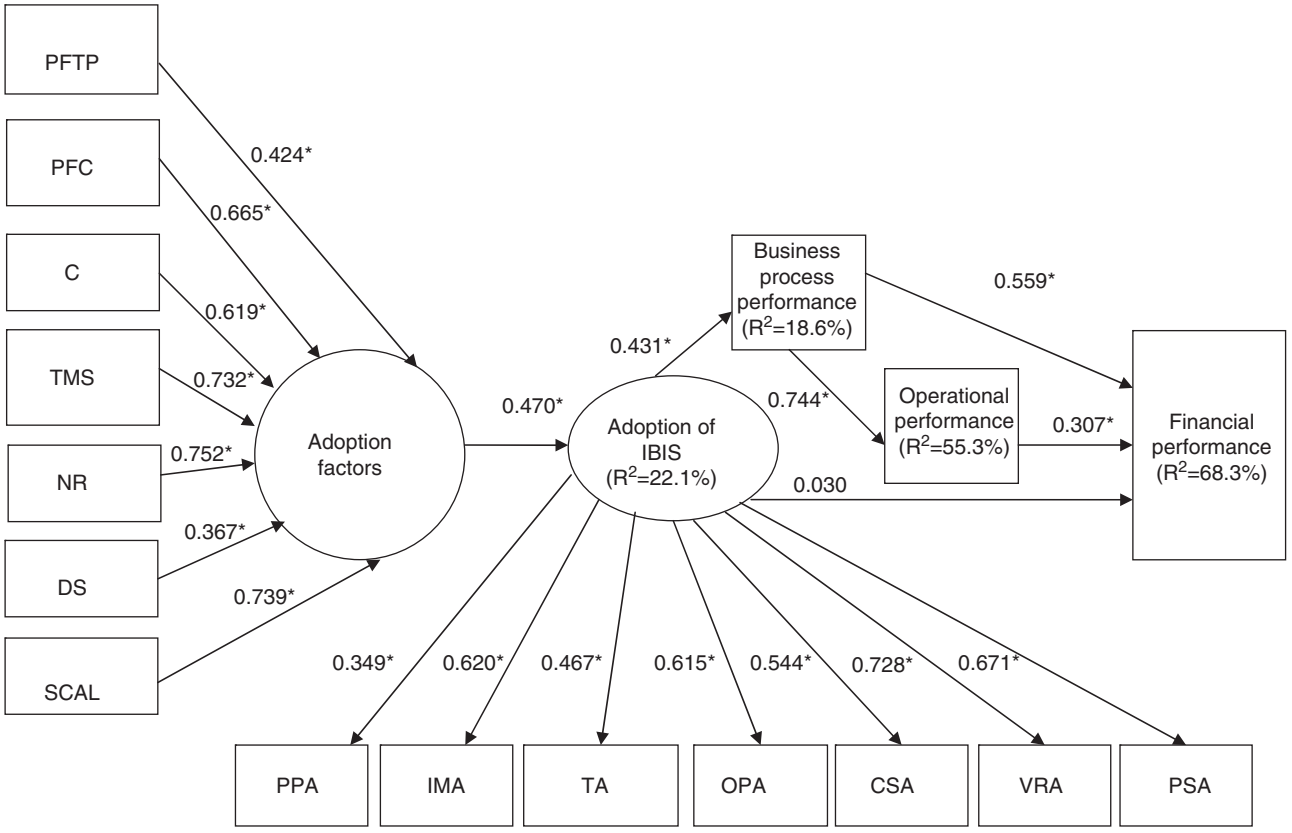

Figure 2 Structural path analysis results for the full sample.
*$P<0.001$.

the full sample. The seven adoption factors were significant across all the subgroups except service firms (only costs and top management support were significant factors in service firms). None of the seven types of IBIS was statistically significant in service firms and only order-processing applications were significant in 0–5-year-old firms. Although transportation applications were the only non-significant type of IBIS in merchandising firms, all seven applications were significant in the other subgroups. Although the results of the structural path model for the six hypotheses varied slightly across subgroups, in general, adopting IBIS affected operational performance indirectly through business process performance. In addition, adopting IBIS did not affect financial performance directly but indirectly through the mediating effects of both business process performance and operational performance.

Multiple group analyses

Moderated regression analysis and MGA are two empirical methods used to test the effects of moderators. Although moderated regression analysis is widely accepted in various fields of research, MGA was chosen as the more appropriate method for this study since the relationships among one latent construct and several measures are being analysed (Homburg & Giering, 2001).

In the previous section, the model was tested using single samples. MGA is a useful method for testing the invariance of the components of the measurement model and the structural model across multiple samples (Byrne, 1994). It works well when the moderators being tested are categorical variables (as opposed to continuous variables) (Williams *et al.*, 2003), as in this study. Several studies (e.g., Lee & Shim, 2007; Hernandez *et al.*, 2009) used this method to test the effects of moderators on model relationships within a structural equation modelling (SEM) framework.

MGA compares model parameters across subgroups. It can determine the invariance across subgroups for parameters such as factor loadings, structural paths, factor variances or covariances, factor residuals and error variances or covariances (Byrne, 1994). Based on this study's objectives, equality constraints were imposed only on the seven factor loadings of the adoption of IBIS and two of the structural paths (H2 and H3). EQS estimates these parameters simultaneously to obtain 'efficient estimates' (Byrne, 1994). Thus, the subgroups of each contextual factor were tested simultaneously to determine the invariance of factor loadings and structural

Table 8 Standardised factor loadings

Sample	*Factor loadings (λs) for adoption factors*							*λs for Adoption of IBIS*						
	PFTP	*PFC*	*C*	*TMS*	*NR*	*DS*	*SCAL*	*PPA*	*IMA*	*TA*	*OPA*	*CSA*	*VRA*	*PSA*
All data	0.424[a]	0.665[a]	0.619[a]	0.732[a]	0.752[a]	0.367[a]	0.739[a]	0.349[a]	0.620[a]	0.467[a]	0.615[a]	0.544[a]	0.728[a]	0.671[a]
Service firms	0.316	0.559	0.729[c]	0.818[c]	0.545	0.140	0.631	0.098	0.585	0.476	0.641	0.423	0.891	0.631
Manufacturing	0.438[a]	0.674[a]	0.574[a]	0.748[a]	0.784[a]	0.312[b]	0.722[a]	0.504[a]	0.643[a]	0.538[a]	0.602[a]	0.518[a]	0.634[a]	0.687[a]
Merchandising	0.484[b]	0.824[b]	0.631[b]	0.718[a]	0.647[b]	0.535[b]	0.795[b]	0.339[c]	0.557[a]	0.321	0.621[a]	0.660[a]	0.753[c]	0.669[a]
0–5 years	0.452[b]	0.643[b]	0.624[a]	0.624[a]	0.855[b]	0.539[b]	0.726[b]	0.220	0.455	0.267	0.376[c]	0.692	0.826	0.616
6–15 years	0.552[a]	0.794[a]	0.702[a]	0.824[a]	0.714[a]	0.463[a]	0.825[a]	0.306[c]	0.536[c]	0.501[c]	0.692[b]	0.682[c]	0.800[c]	0.654[c]
>15 years	0.301[c]	0.608[c]	0.572[b]	0.704[c]	0.761[c]	0.278[c]	0.724[c]	0.402[a]	0.717[a]	0.522[a]	0.611[a]	0.454[a]	0.702[a]	0.689[a]
Closely held	0.369[b]	0.733[b]	0.564[b]	0.808[a]	0.698[b]	0.368[b]	0.760[b]	0.377[a]	0.682[a]	0.367[b]	0.662[a]	0.507[b]	0.679[a]	0.613[a]
Publicly traded	0.617[b]	0.762[b]	0.662[a]	0.698[a]	0.794[a]	0.389[c]	0.667[b]	0.476[b]	0.726[b]	0.593[c]	0.496[b]	0.471[c]	0.599[c]	0.775[b]
Sole proprietorship	0.504[a]	0.502[a]	0.725[a]	0.603[a]	0.831[a]	0.553[a]	0.741[a]	0.420[c]	0.460[c]	0.565[c]	0.720[c]	0.562[c]	0.809[c]	0.616[c]
Stable	0.482[a]	0.691[a]	0.651[a]	0.732[a]	0.717[a]	0.293[b]	0.699[a]	0.294[b]	0.598[b]	0.521[b]	0.580[a]	0.576[b]	0.831[b]	0.657[b]
Turbulent	0.334[b]	0.635[b]	0.556[b]	0.743[b]	0.729[b]	0.436[c]	0.800[c]	0.420[a]	0.629[a]	0.428[a]	0.676[a]	0.485[a]	0.591[a]	0.665[a]
Low complexity	0.377[a]	0.689[a]	0.610[a]	0.726[a]	0.749[a]	0.310[b]	0.751[a]	0.278[b]	0.628[b]	0.465[b]	0.577[a]	0.499[b]	0.770[b]	0.707[b]
High complexity	0.510[a]	0.628[a]	0.618[a]	0.752[a]	0.684[a]	0.467[b]	0.740[a]	0.456[a]	0.613[a]	0.481[a]	0.616[a]	0.591[a]	0.640[b]	0.605[a]
Low hostility	0.483[a]	0.698[a]	0.614[a]	0.704[a]	0.682[a]	0.308[b]	0.696[a]	0.287[b]	0.579[b]	0.541[b]	0.586[a]	0.603[b]	0.719[b]	0.661[b]
High hostility	0.358[c]	0.639[c]	0.618[b]	0.768[b]	0.773[b]	0.420[c]	0.802[c]	0.413[a]	0.656[a]	0.373[b]	0.633[a]	0.471[b]	0.732[a]	0.658[a]

[a] $P<0.001$.
[b] $P<0.01$.
[c] $P<0.05$.

Table 9 Standardised structural path estimates and explained variance of dependent variables (DVs)

Sample	*Standardised structural path estimates (β)*						*R^2 of DVs*			
	H1	*H2*	*H3*	*H4*	*H5*	*H6*	*IBIS*	*BPP*	*OP*	*FP*
All data	0.470[a]	0.431[a]	0.030	0.744[a]	0.559[a]	0.307[a]	0.221	0.186	0.553	0.683
Service firms	0.401	0.331	−0.057	0.830[a]	0.734[a]	0.151	0.160	0.110	0.689	0.717
Manufacturing	0.473[a]	0.511[a]	−0.004	0.740[a]	0.563[a]	0.316[a]	0.278	0.261	0.548	0.676
Merchandising	0.400	0.229	0.215[c]	0.604[a]	0.329[b]	0.535[a]	0.160	0.053	0.365	0.718
0–5 years	0.218	0.432[b]	0.082	0.768[a]	0.641[a]	0.225[c]	0.047	0.187	0.590	0.748
6–15 years	0.552[b]	0.392[b]	0.064	0.812[a]	0.315[a]	0.615[a]	0.305	0.153	0.660	0.836
>15 years	0.466[c]	0.426[a]	−0.012	0.701[a]	0.646[a]	0.181[c]	0.217	0.181	0.492	0.606
Closely held	0.411[c]	0.347[a]	0.012	0.730[a]	0.429[a]	0.468[a]	0.169	0.121	0.533	0.703
Publicly traded	0.528[c]	0.401[b]	0.084	0.730[a]	0.657[a]	0.197[c]	0.278	0.161	0.532	0.720
Sole proprietorship	−0.106	−0.076	−0.151	0.761[a]	0.535[a]	0.291[c]	0.011	0.006	0.580	0.649
Stable	0.449[b]	0.381[b]	−0.006	0.770[a]	0.615[a]	0.276[b]	0.202	0.145	0.593	0.712
Turbulent	0.480[b]	0.453[a]	0.078	0.708[a]	0.476[a]	0.380[a]	0.230	0.205	0.501	0.686
Low complexity	0.409[c]	0.353[b]	−0.015	0.744[a]	0.538[a]	0.367[a]	0.168	0.125	0.553	0.709
High complexity	0.532[b]	0.510[a]	0.140	0.743[a]	0.536[a]	0.275[b]	0.283	0.260	0.552	0.708
Low hostility	0.484[b]	0.426[b]	−0.030	0.768[a]	0.582[a]	0.315[a]	0.235	0.181	0.590	0.698
High hostility	0.376[c]	0.424[a]	0.088	0.710[a]	0.494[a]	0.353[a]	0.180	0.180	0.504	0.707

[a] $P<0.001$.
[b] $P<0.01$.
[c] $P<0.05$.

paths across them. The significance of the equality constraints were determined by analysing the LM χ^2 associated with each constraint, which is obtained from the EQS output. A probability value greater than 0.05 (significance level) for an LM χ^2 means that the factor loading or the structural path hypothesised to be equal across subgroups is indeed equal (Byrne, 1994). Goodness-of-fit indices used to assess the adequacy of model fit in MGA are the same as those used in a regular structural model path analysis, as described in the previous section.

The results in Table 10 show that the MGA fit indices for all the moderators are very close to the cut-off points (i.e., close to robust CFI $\geqslant$ 0.90 and SRMR $<$ 0.10). Thus, although the fit indices for the overall model for the four contextual factors are not excellent, they are acceptable given its complexity. We can therefore argue that the

subgroups within each contextual factor in Table 10 most likely have similar overall model fits. A Lagrange Multiplier test for releasing constraints was conducted for each model to better visualise the invariance of the constrained model parameters. The results (Table 11) indicate that the constrained parameters are, in fact, largely invariant across the subgroups compared in Table 10.

Summary of the results

Within firm type, service firms had a very poor model fit and were not included in the MGA. The MGA results showed that both manufacturing and merchandising firms had well-fitting models and that the model relationships for merchandising firms were similar to those for manufacturing firms (robust CFI = 0.89 and SRMR = 0.102), hence, partially supporting H7. Within firm age (robust CFI = 0.89 and SRMR = 0.091), firms aged 6–15 and >15 years had adequate and similar model fits, whereas firms 0–5 years old did not, therefore, supporting H8. Within firm ownership type (for which the MGA could not be conducted), only closely held firms had an adequate model fit, which supported H9.

As for the environmental factors, the subgroups within complexity (robust CFI = 0.90 and SRMR = 0.091) and hostility (robust CFI = 0.91 and SRMR = 0.087) had similar model fits, which did not support H11 or H12. Within dynamism, only the 'stable environment' subgroup had a well-fitting model, which did not support H10.

Table 10 Goodness-of-fit indices for multiple group analysis

Contextual factor[a]	*S-B*χ^2	*d.f.*	*S-B*χ^2*/d.f.*	*P-value*	*Robust CFI*	*SRMR*
Firm type[b]	372.14	240	1.55	0.00000	0.89	0.102
Firm age[c]	394.81	240	1.65	0.00000	0.89	0.091
Complexity	393.66	240	1.64	0.00000	0.90	0.091
Hostility	374.87	240	1.56	0.00000	0.91	0.087

[a]Firm ownership type was excluded from the analysis, since 'publicly owned' and 'sole proprietorship' subgroups had inadequate model fits. Dynamism was also excluded because the 'turbulent environment' subgroup had a poor model fit.

[b]The 'service firms' subgroup was not used in the analysis, since it had a poor model fit.

[c]The '0–5 years' subgroup was excluded from the analysis because it had a poor model fit. Even though the '>15' years subgroup did not have a very good model fit, it was still included in the analysis together with the '6–15 years' group, since its CFI index (0.89) was very close to the cutoff point of 0.90.

Discussion and implications

Findings from structural path analyses

All the factors except trust and complexity were key determinants of adopting IBIS. In this study, complexity was measured as the ease of adoption of Internet standards, which are deemed easier to use relative to EDI (Soliman & Janz, 2004). That complexity was not significant may suggest that firms did not perceive adopting IBIS to be easier than adopting EDI. In other words, complexity (e.g., technological difficulties because of switching from a proprietary network to the Internet, lack of previous Internet experience, etc.) is still likely to be an important issue in implementing IBIS. In addition, although trust was found to be an important factor in the literature on adopting IOS, it was not a significant factor in adopting IBIS in this study. This may be because of

- the increased use of these technologies in many firms, which may have eased some of the trust issues between SC partners;
- the different characteristics of the technologies being studied across different studies (e.g., Internet *vs* EDI); or
- cultural and market differences across firms in different studies.

Some recent studies find that trust did not play a significant role in adopting e-business in the SC of

Table 11 Comparison of model parameter estimates across subgroups

Parameters	*Firm type (Manufacturing vs Merchandising)*	*Firm age (6–15 years vs >15 years)*	*Complexity (Low complexity vs High complexity)*	*Hostility (Low hostility vs high hostility)*
Adoption of IBIS				
PPA	Invariant	Invariant	Invariant	Invariant
IMA	Invariant	Invariant	Invariant	Invariant
TA	Invariant	Invariant	Invariant	Invariant
OPA	Invariant	Noninvariant	Invariant	Invariant
CSA	Invariant	Invariant	Invariant	Invariant
VRA	Invariant	Invariant	Invariant	Invariant
PSA	Invariant	Invariant	Invariant	Invariant
Hypotheses				
H2	Invariant	Invariant	Invariant	Invariant
H3	Invariant	Invariant	Invariant	Invariant

Malaysian SMEs (Chong *et al*., 2009) nor did it influence information-sharing among SC partners (Madlberger, 2009).

This study finds that adopting IBIS did not affect financial performance directly, but indirectly through business process performance and operational performance. This will affect how managers assess the impact of their IBIS implementation decisions.

Findings from MGAs

Firm type The hypothesis that manufacturing, service and merchandising firms differed from each other in terms of model fit was partially supported – that is, service firms were different but the latter two were similar. In fact, the findings show that service firms had a very poor model fit. This is in line with the findings of studies, such as Bhatt (2000), that reports that integrated communication networks were more effective at improving processes and customer focus in manufacturing firms than in service firms. Frohlich & Westbrook (2002) also find that Internet-enabled SC integration strategies produced better performance results in manufacturing firms than in service firms. Possible reasons for this may be that

- since demand for their products and services is less certain and cannot be determined through these technologies service firms rely less on them;
- service processes are generally less standardised and require face-to-face interaction with customers; and
- service customers prefer to speak directly to sales representatives or consultants, particularly if the service entails consultation (Bhatt, 2000).

Data limitations may also explain why the model was not a good fit for service firms: 23 of the 69 service firms in the sample were consulting firms that may not rely on IBIS as much as other service firms in their operations, as suggested in Bhatt (2000). Hence, future studies should use a larger and a more diverse sample of service firms. It would be even more informative to compare different industries if enough data could be collected.

Firm age As hypothesised, the model fit was different for younger and older firms: very poor for the 0–5-year subgroup, but adequate and similar for firms 6–15 years old and those >15 years. Of the seven IBIS tested, only order processing applications were significant in the youngest group of firms, but all seven were significant in the two groups of older firms. This finding supports previous studies (e.g., Sorensen & Stuart, 2000) that state that younger firms were at a disadvantage when it came to implementing new IT. As mentioned before, some studies state that older firms had more experience with integrating new processes into their operations and more financial resources than younger firms, making it easier for them to implement IBIS and achieve performance gains. Younger firms can learn by benchmarking their IT functions against those of older firms that have successfully implemented IBIS.

Firm ownership type To the best of our knowledge, the moderating effect of ownership type on the IT-performance relationship has not been empirically studied before. The hypothesis that the extent and direct effects of adopting IBIS on business process performance and financial performance would be greater in closely held firms than in publicly traded firms and sole proprietorships was supported. From an agency point of view, the finding that the model had a good fit for closely held firms but not for publicly traded firms may be explained by higher agency costs in publicly traded firms. These potential costs were not directly measured in this study. Future studies would benefit from designing instruments to control for the moderating effects of agency costs in assessing model fit.

In addition, other structural factors may moderate success with IT investments. For example, Karake (1994) finds that firms with higher equity-to-debt ratio tended to have a decentralised decision-making and IT structures because the shareholders pushed for this to prevent management from using the firm's resources for its own benefit. On the other hand, Karake (1994) also claims that firms with significant management ownership preferred a centralised structure to retain more power in decision making. The IT structure in these firms tended to be centralised. Therefore, future studies could control for the moderating effects of equity-to-debt ratio as well as those of centralised and decentralised IT structures on model fit.

Some researchers recommend other approaches to assess the effects of agency costs on closely held firms. For example, Schulze *et al*. (2001) recommend that 'more fully specified' agency models for different types of owner-managed or privately held firms, such as new ventures, need to be developed. Durand & Vargas (2003) even advise that researchers should not use agency theory to explain the efficient use of resources in private firms since these simply display different characteristics from publicly traded firms from an agency point of view. These arguments can be explored further within the context of IBIS.

The finding that sole proprietorships did not have a good model fit could be because of potential agency costs that deter them from investing in IT. These firms could create systems to improve how their investments are planned and monitored. As they expand their operations by making new IT investments, they would be in a better position to control potential agency costs. Lack of know-how and resources to successfully implement IBIS may also explain the poor model fit. As well, IT implementations in small businesses were largely driven by the owners' attitude towards IT, and their lack of full commitment to implementation will likely result in the failure of these investments.

Dynamism, complexity and hostility Contrary to expectations, firms operating in more stable environments had a better model fit than those operating in turbulent environments. The model fit was similar for firms operating in low and high complexity environments. It is possible that firms in more stable and less complex environments realise that, to counter the challenges posed by the global markets, they need to make IBIS an important part of their business planning and they believe these systems bring increased performance. On the other hand, firms in turbulent and more complex environments may view using IBIS as part of normal business activity and do not particularly perceive them as technologies that give them a competitive edge. As well, no differences were found between firms operating in low or high hostility environments. This suggests that more intense competition does not necessarily affect how rigorously firms implement IBIS and the performance benefits these technologies bring.

Thus, the effects of these three environmental factors as moderators are mixed. Dembla *et al*. (2007) report that environmental uncertainty (which combined hostility, complexity and dynamism into one independent variable) had no effect on the perceived usefulness of Web-enabled transaction processing systems. The authors deduce that these systems may be a requirement to be competitive in turbulent markets rather than an advantage. Future studies should explore this issue further, especially taking into account other factors, such as industry structure and firm size, as control variables. The effects of such factors should probably be controlled before the role of environmental factors can be better explained. New frameworks may also be used to understand the effects of environmental factors on the adoption of IBIS. For example, Goldsmith & Mechling (2008) propose four levels of environmental change (stable, evolutionary, revolutionary and turbulent) and that each level requires different approaches to innovation and leadership. Future studies could analyse the adoption of IBIS in these four environments rather than only in the two extremes.

Conclusion

This study created a model of the relationships among organisational, interorganisational and technological factors, the adoption of IBIS and several performance measures in firms. These hypotheses were tested using data from a sample of North American firms. We rigorously analysed various organisational and environmental factors and the role they play in moderating the hypothesised model relationships. The results indicate that all three organisational factors (firm type, age and ownership type) are significant moderators. Although two of the environmental factors (complexity and hostility) were not significant moderators, the effects of dynamism as a moderator are less clear. More research is needed to better understand the role various moderators play in adopting IBIS and other interorganisational information systems, and on their eventual effects on performance.

About the author

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Appendix

Survey items

IBIS adoption factors Please indicate your response to the following items on a scale of 1 to 7, where 1 = Strongly Disagree, 4 = Neutral, and 7 = Strongly Agree. There are no right or wrong answers, so please only state your opinion.

Pressure from trading partner

1. My main trading partner usually sets the mode of communication (e.g., fax, e-mail, etc.)
2. My main trading partner decides on pricing, delivery schedules, etc.
3. My main trading partner decides on the rules and regulations for using an interorganisational system in order processing.
4. My main trading partner decides on what information systems applications are to be exchanged with my firm.

Pressure from competition

1. An industry move to utilise the Internet for inter-organisational communications would put pressure on my firm to do the same.
2. There is a trend in my industry to more utilise the Internet more for business-related activities and business communications.

Costs

1. Establishing Internet-based business-to-business operations with my trading partners would be cost effective.
2. It would be less expensive to conduct business with several trading partners utilising the Internet than using EDI.

Top management support

1. Our top management is likely to invest funds in IT.

2. Our top management is willing to take risks involved in the adoption of the Internet.
3. Our top management is likely to be interested in adopting the Internet-based business-to-business transactions in order to gain competitive advantage.
4. Our top management is likely to consider the adoption of Internet-based business-to-business applications as strategically important.

Trust

Please indicate your response to the following item on a scale of 1 to 7, where 1 = Extremely Weak, 4 = Moderate, and 7 = Extremely Strong.

1. How would you characterise the degree of mutual trust between your firm and your trading partner?

Please indicate your response to the following item on a scale of 1 to 7, where 1 = Very Uncomfortable, 4 = Moderate, and 7 = Extremely Comfortable.

2. What is the degree of comfort about sharing sensitive information in your area with your trading partner?

Network reliability

1. The Internet is considered to be a reliable communication medium to conduct business with trading partners along the supply chain.
2. Current Internet communication speeds are sufficient to handle the data movement necessary for our company to communicate with our trading partner.

Data security

1. The nature of the business data regularly exchanged between our firm and our trading partners requires a secured communication medium.
2. Internet security is a major concern to our firm when deciding to adopt Internet-based business-to-business transactions.

Scalability

1. The availability of the Internet as a business communication medium is likely to increase the number of trading partners with whom we can do business.
2. The Internet is likely to facilitate linking several of our firm's business units together (e.g., branch offices, remote sites, etc.).

Complexity

1. The existence of several communication standards when using EDI makes it more difficult to establish links with several trading partners.
2. The Internet's one common communication standard (TCP/IP) would make it easier to communicate with multiple trading partners.
3. Internet-based business-to-business communication would be considered less complex to implement than alternative methods such as EDI.

Adoption of IBIS

Please indicate your response to the following items on a scale of 1 to 7, where 1 = Strongly Disagree, 4 = Neutral, and 7 = Strongly Agree.

We use the following *Internet* applications in our supply chain management activities:

1. Purchasing and procurement applications (e.g., purchasing from catalogs, communicating vendors, with checking vendor price quotes, etc.).
2. Inventory management applications (e.g., JIT delivery programs, communicating stock-outs, raw material and finished goods inventory levels, etc.).
3. Transportation applications (e.g., monitoring pickups, drop-offs and on-time arrivals, managing claims, etc.).
4. Order processing applications (e.g., Monitoring vendor orders, checking customer and vendor credit, tracking returned customer merchandise, etc.).
5. Customer service applications (e.g., Receiving customer complaints, providing technical service, notifying customers of emergencies, etc.).
6. Vendor relations applications (e.g., Monitoring vendor deliveries to depots, receiving queries from vendors, monitoring vendor raw material stock levels etc.).
7. Production scheduling applications (e.g., Coordinating schedules with vendors and field depots, coordinating with JIT of vendors, etc.).

Firm performance measures

For each of the following dimensions, using a scale of 1 = Below Average, 4 = Average, 7 = Above Average, indicate the level of your site's performance since the implementation of Internet applications in your supply chain management activities compared to that of major industry competitors.

Business process performance

1. Inventory turnover
2. Customer service
3. Supplier relationships
4. Quality of design processes
5. Cycle time

Operational performance

1. Productivity
2. Operational efficiency
3. Cost

Financial performance

1. Profitability
2. Return on investment
3. Market share

Environmental factors

Using the following scales, please indicate the extent to which the following changed in your firm's external environment over the past 5 years.

Dynamism

1.	Market activities of your key competitors:	Have become far more predictable 1 2 3 4 5 6 7	No change	Have become far less predictable
2.	The tastes and preferences your customers in your principal industry:	Have become much more stable and predictable 1 2 3 4 5 6 7	No change	Have become much of more hard to forecast
3.	Rate of innovation of new operating processes and new products or services in your principal industry:	Rate has fallen dramatically 1 2 3 4 5 6 7	No change	Rate has increased dramatically

Complexity

1.	Needed diversity in your production methods and marketing tactics to cater to your different customers:	Diversity has dramatically decreased 1 2 3 4 5 6 7	No change	Diversity has dramatically increased

Hostility

1.	Your principal industry's downswings and upswings:	Have become far more predictable 1 2 3 4 5 6 7	No change	Have become far less predictable
2.	Market activities of your key competitors:	Have become far more hostile 1 2 3 4 5 6 7	No change	Have become far less hostile
3.	Market activities of your key competitors: (e.g. pricing, delivery, service, quality, etc.)	Now affect the firm in far fewer areas 1 2 3 4 5 6 7	No change	Now affect the firm in many more areas