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HIGHER ORDER CONTROL LOOPS AS A DETERMINANT OF B2B E-COMMERCE PERFORMANCE: A COMPARATIVE MODEL FROM AUSTRALIAN EMPIRICAL EVIDENCE

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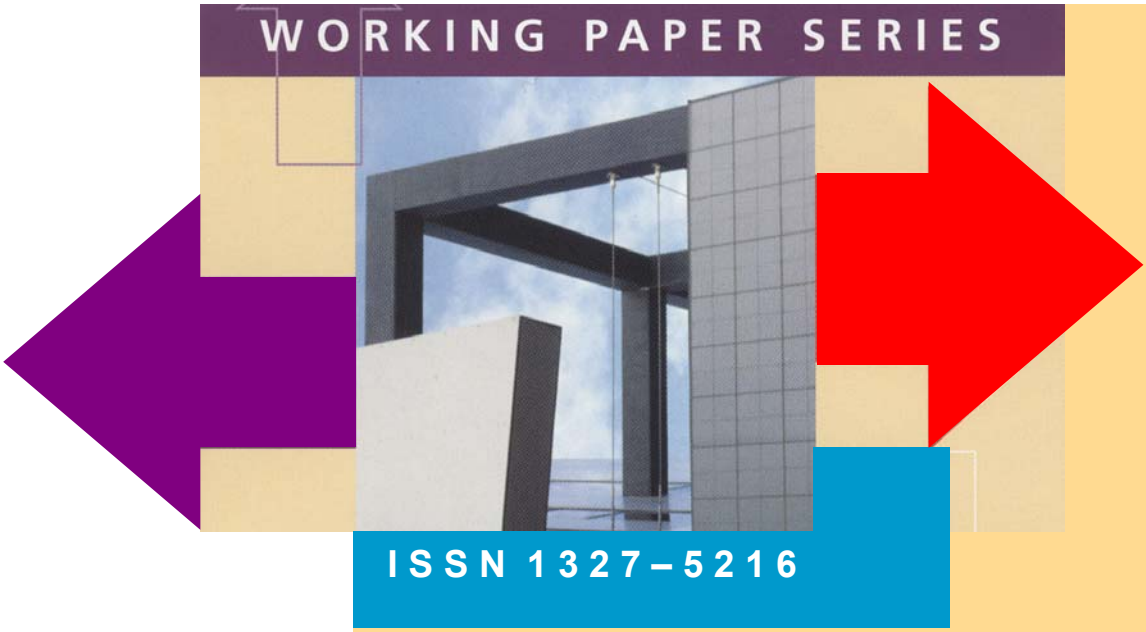

Abstract

Much of the literature relating to the implementation and use of business to business (B2B) e-commerce technologies focuses on benefits, outcomes and the use of technology. The purpose of this paper is to test the relationship between the use of B2B related techniques and methodologies and firm performance in the context of a "systems" view of managerial cognitive processes. This view of the strategic logic development process proposes that organizations faced with rapidly changing environments use "higher order control loops" to enable rapid and effective adaptation. Sanchez and Heene propose three approaches in order to allow managers to interpret data that is often subject to causal ambiguity and long dynamic response times: Benchmarking; Challenging Cognitive Frameworks; and Environmental Scanning (Sanchez and Heene, 1997, Sanchez, 1997). It is hypothesised in this paper that these three elements, (as well as an additional factor capturing the involvement of organizational stakeholders), have a significant relationship with the performance of organisations using B2B e-commerce methods. A model is developed testing the relative causal paths between these "higher order control loops" and firm performance, and a number of indicators of B2B adoption. The causal model developed, and the relationships tested, are derived from data collected from 335 Australian organizations involved in the use of B2B methods for the management of their supply chains. The results indicate that the use of "higher order control loops" are a significant determinant of performance related to B2B use and implementation, and that although B2B enablers such as technology investment, infrastructure investment and cooperative arrangements with suppliers and customers are significantly correlated with performance, they do not appear to determine it.

DEPARTMENT OF MANAGEMENT

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INTRODUCTION

The importance of understanding and applying a systemic approach to the management of organisations is amplified in an operational environment characterised by rapid technological change, the need for organisations to think and operate globally, and the need for strategies to be developed that are sustainable as well as profitable. Implied in this model is the notion of "strategic flexibility" of resources at first articulated by writers such as Penrose who developed a view of the firm as a "collection of productive resources" (Penrose, 1959). This notion was further extended by more recent authors in general terms (Sanchez, 1993, Sanchez, 1995, Maira and Scott-Morgan, 1996, Smith, 1997). "Strategic Flexibility" is made up of two major elements – "resource flexibility" and "coordination flexibility". Flexible resources are said to have more than one use and are able to be used in many applications with a minimum of changeover time. The ability of managers to deploy and coordinate these resources quickly and effectively is reflected by the concept of "coordination flexibility". Inherent in the concept of "resource flexibility" in a systems context is the likelihood of the overall flexibility of the organisation being limited by the "least flexible' resource (Sanchez and Heene, 1997). Many authors have examined the importance of such interrelationships examining issues such as; the relationship between production flexibilities and product strategies (Wheelwright and Hayes, 1985, Gerwin, 1987, Gerwin, 1988, Gerwin, 1989); production and product development (Hayes et al., 1990, Clark et al., 1992); and technological change, manufacturing flexibility and product strategies (Sanderson and Uzumeri, 1997). The model developed of an organisation as a collection of stocks and flows (Dierickx et al., 1989) has been further developed by Sanchez and Heene to reflect the impact on organisational change of the following issues:

"Managerial cognitive processes *to determine what kinds of stocks and flows* an organisation should try to achieve and *what uses* they will be applied to."

"Managerial abilities *to coordinate intra-organisational and inter-organisational flows* of assets and capabilities in processes of organisational change."

"Managerial abilities *to support organisational learning and to manage existing knowledge assets* effectively in processes for qualitatively changing an organisation's asset stocks and flows." (Sanchez and Heene, 1997 p.22)

The concept put forward by Sanchez and Heene that captures these elements is that of "higher and lower order control loops". Higher order control loops reflect the need for managers to:

"…..interpret often highly ambiguous data in an effort to discover plausible interpretations about the states of the systems higher order elements" (Sanchez and Heene, 1997 p.33)

Sanchez and Heene (Sanchez and Heene, 1997) propose that organisational flexibility will be promoted by using such control loops comprised of three methods of challenging and/or altering strategic logic – namely Benchmarking, Environmental Scanning and Challenging Cognitive Frameworks. They state that organisations using current operating data (i.e. lower order control loops) to adapt to changing environments can encounter problems such as: failing to recognise deterioration in these metrics driven by environmental change; or recognising such change too late to be able to effectively respond. They note that organisations seeking effective strategic responses in dynamic environments will need to cope with the combined effects of increasing causal ambiguity and dynamic response times. In other words, strategic decision making is subject to what Senge describes as "dynamic complexity", "…….situations where cause and effect are subtle, and where the effects over time of interventions are not obvious…….When obvious interventions produce non-obvious consequences, there is dynamic complexity…….*The real leverage in most management situations lies in understanding dynamic complexity"* (Senge, 1990/ p.71). In order to overcome this problem, Sanchez and Heene propose the use of Benchmarking, Environmental Scanning and Challenging Cognitive Frameworks as means of anticipating, understanding and responding to change in the

environment, and of overcoming such complexity. In the context of managing supply chains and using emerging B2B e-commerce technologies, such change and ambiguity confront organisations as a matter of course. This paper focuses on testing the relative importance of aspects of the Sanchez and Heene model in determining business outcomes for companies in this type of environment.

METHODOLOGY

A survey was conducted within Australian companies that are members of EAN Australia. As members of this organisation (EAN Australia is the local organisation that administers and controls the European Article Numbering standard) these companies are involved in the use of B2B e-commerce technologies and methods (at least to a minimum level). This survey covered a broad range of issues relating to the strategic and operational aspects of the use and implementation of B2B e-commerce technologies. There were 553 responses received, indicating an estimated response rate of 16.5%. The sample size was reduced to 335 companies for the analysis using the structural model. This was done in order to reduce the proportion of missing data for some constructs, as the AMOS package used for this model requires a complete data set. The components of the structural model were initially developed using exploratory factor analysis. From this process the composition of the factor variables making up the observed and unobserved variables within the model was determined. Confirmatory factor analysis was conducted to establish the integrity of the unobserved construct "Process" (representing the Sanchez and Heene model elements), and the structural model formed based on the hypothesised relationships.

STRUCTURAL MODEL

Rationale

A model was developed for testing incorporating a construct ("named "Process") capturing the "higher order control loops" proposed by the Sanchez and Heene model. Three other constructs capturing the propensity for organisations to invest in both technology and infrastructure, and extent of involvement in cooperative arrangements with trading partners, were also included. These were placed in the model on the basis of being indicative of typical methodological elements of B2B e-commerce implementations. The final construct captured business outcomes perceived to be accruing from the use of these methodologies. The rationale for this model was to test the relative importance of each of the constructs as determinants of the performance construct, and to find to what extent the Process construct determined involvement in each of the B2B methodology elements. The purpose was to gain some insight into the relative importance of higher order control loops in the context of B2B e-commerce implementation.

Factor Variables – Components of the Structural Model

Process

In the model this dimension is an unobserved variable made up of three observed factor variables. These are comprised of four separate factors, namely; Challenging Cognitive Frameworks Using External Resources (observed variable "ccframeext"); Environmental Scanning (observed variable "envscan"); Benchmarking and Stakeholder Involvement combined to create the construct Challenging Cognitive Frameworks Using Internal Resources (observed variable "ccframeint").

CHALLENGING COGNITIVE FRAMEWORKS USING EXTERNAL RESOURCES (code in model "ccframeext"): ALPHA = 0.8596

The three factors making up the unobserved variable PROCESS draw on the Sanchez and Heene (Sanchez and Heene, 1997) model. This model proposes three dimensions used by managers to overcome causal ambiguities (between strategies and outcomes) in highly dynamic environments. The first of these dimensions is CHALLENGING COGNITIVE FRAMEWORKS USING EXTERNAL RESOURCES, and it captures the need for companies to use outside sources, (such as consultants), to question basic business assumptions in order to remain flexible. Exploratory factor analysis found 11 variables coming together to

form a single construct covering many ways in which organisations may seek new ideas from outside sources.

ENVIRONMENTAL SCANNING (code in model "envscan"): ALPHA = 0.9344
The second element of the Sanchez and Heene model captures the need for organisations to scan their environment in order to be as aware as possible of impending change, and how that change could affect competitive positioning. As a result of exploratory factor analysis 9 variables loaded together to represent a range of issues in a firm's competitive environment that could typically be considered important. In this case the 9 items making up this scale had a particular focus on the competitive environment of the firm, and specific competitor activities.

BENCHMARKING (code in model "ccframeint"): ALPHA = 0.8687
Benchmarking is the third dimension of the Sanchez and Heene model, and it covers the gathering of information on "best practices" from within (as well as beyond) a firms industry. This construct was made up of four variables measuring benchmarking activities at different levels of the organisation.

STAKEHOLDER INVOLVEMENT (code in model "ccframeint"): ALPHA = 0.8614
The 11 variables capture the construct labelled STAKEHOLDER INVOLVEMENT based on the fact that they represent degrees of involvement of customers, suppliers and internal stakeholders (e.g. employees).
These final two factors were combined in the model to capture a broader concept of combining benchmarking and involvement of stakeholders to create the construct CHALLENGE COGNITIVE FRAMEWORKS USING INTERNAL RESOURCES, rather than using external resources as captured by the first construct in the group. There was also found to be a high degree of covariance evident between them during model testing, indicating some degree of overlap between the two constructs in the context of the model. The combination of these two factors attempts to capture the idea from the Sanchez and Heene model of challenging cognitive frameworks from within as well as from external means (Sanchez and Heene, 1997, Sanchez, 1997), and extends the concept of benchmarking to a broader one of organisation wide stakeholder involvement.

COOPERATIVE ARRANGEMENTS ALPHA = 0.7354
This dimension of the model is made up of one observed factor variable. This factor variable is composed of two individual survey variables covering the degree to which respondents have cooperative partnership arrangements with suppliers and customers.

INFRASTRUCTURE INVESTMENT ALPHA = 0.6867
Seven questions from the survey related to the percentage allocation of expenditure to a range of areas during the implementation process. After exploratory factor analysis two factors were extracted. Four variables loaded together to form a factor variable, and this was labelled on the basis of each variable representing non-technical or "soft" aspects of implementation. This construct was felt to be of importance for capturing the propensity for an organisation to invest in the necessary infrastructure (human and human process based) to support effective implementation.

TECHNOLOGY INVESTMENT ALPHA = 0.7088
The other half of the spending equation relates to expenditure on computer related software and hardware – the technical or "hard" side of the spending mix. It was judged to be an important indicator of organisational capability for implementation.

PERFORMANCE
This dimension of the model is made up of one observed factor variable. As a result of exploratory factor analysis of 17 variables, two factors were extracted and named OPERATIONAL OUTCOMES and BOTTOM LINE OUTCOMES.
OPERATIONAL OUTCOMES: ALPHA = 0.9700
BOTTOM LINE OUTCOMES: ALPHA = 0.8540
These two variables were combined to create one factor variable capturing a wide range of performance outcomes. This element of the model covers many of these areas, and draws on both operational and bottom line (or profit/revenue) related issues.

Confirmatory Factor Analysis

In order to test the integrity of the unobserved construct "Process", confirmatory factor analysis was conducted. Figure 1 below shows a graphic of this part of the model, and Table 1 provides some of the major goodness of fit statistics.

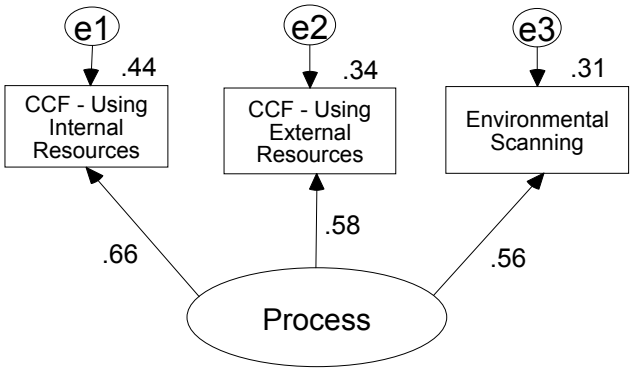

Figure 1: Confirmatory Factor Analysis

GFI	AGFI	RMSR
0.997	0.991	0.024

Table 1: Goodness of Fit statistics for CFA

Structural Model

Figure 2 below shows the full structural model, while Table 2 contains the Goodness of Fit statistics for the full model.

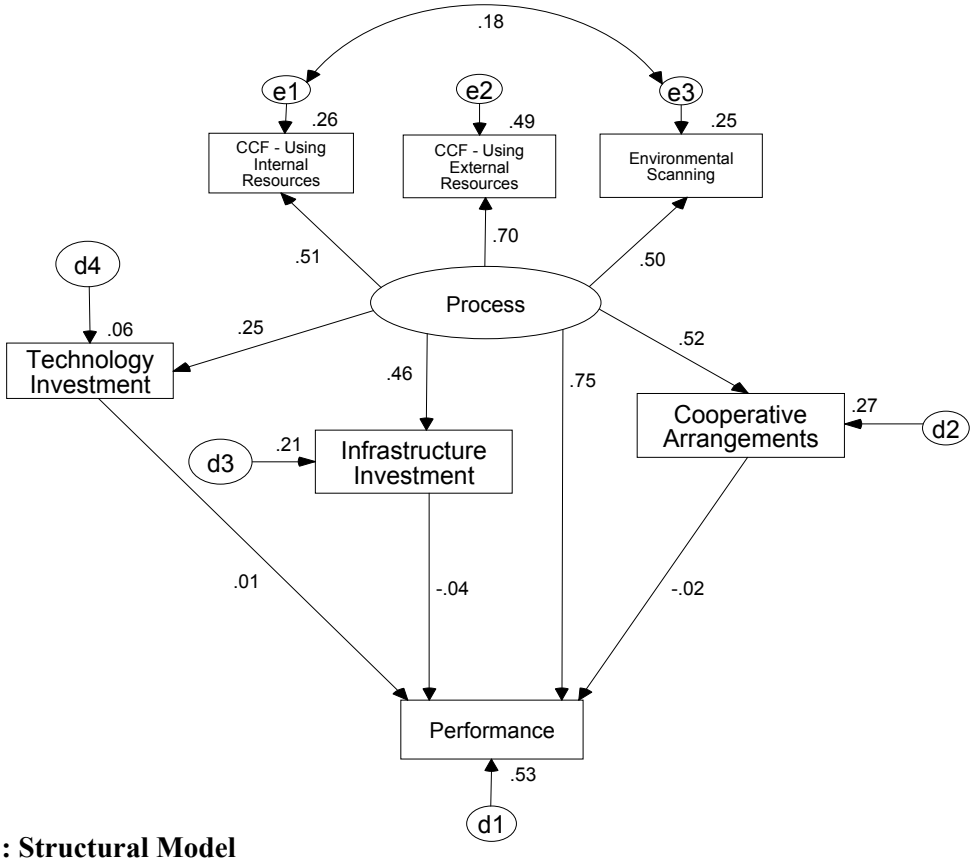

Figure 2: Structural Model

GFI	AGFI	RMSR	RMSEA	TLI	NFI	CHI^2	DF	SIG.	CHI^2/DF
0.987	0.962	0.026	0.044	0.965	0.959	16.39	10	0.089	1.639

Table 2: Goodness of Fit statistics for the Structural Model

Analysis

The goodness of fit statistics for this model indicate that it is a plausible representation of the theoretical relationships proposed. Table 3 below shows the direct and indirect effects recorded in the model.

IV	DV	DIRECT	INDIRECT	TOTAL
PROCESS	TECHNOLOGY INVESTMENT	.25		.25
	INFRASTRUCTURE INVESTMENT	.46		.46
	COOPERATIVE ARRANGEMENTS	.52		.52
	PERFORMANCE	.75	-.03*	.72
TECHNOLOGY INVESTMENT	PERFORMANCE	.01*		.01*
INFRASTRUCTURE INVESTMENT	PERFORMANCE	-.04*		-.04*
COOPERATIVE ARRANGEMENTS	PERFORMANCE	-.02*		-.02*

Table 3: Direct and Indirect effects from the structural model (*Note:* * denotes non-significant effect)

These results indicate that the construct "Process" is a strong and significant determinant of business outcomes (as captured by the construct "Performance") within this group of companies. By comparison, the three constructs "Technology Investment", "Infrastructure Investment" and "Cooperative Arrangements" have no significant direct effect on this construct. There is, however, a moderately strong and highly significant correlation recorded between each of these three constructs with "Performance" (see Table 4 below).

	TECHNOLOGY INVESTMENT	INFRASTRUCTURE INVESTMENT	COOPERATIVE ARRANGEMENTS
PERFORMANCE	.194**	.304**	.360**

Table 4: Correlations between e-commerce enablers and business outcomes (*Note:* ** denotes significant at p<.01)

"Process" is also observed to be a significant determinant of each of these three constructs. In the context of the Sanchez and Heene model, the strength of the effect of the "Process" construct on business outcomes indicates the importance of effective strategy formulation. At the same time, this process is found to be important in determining whether organisations will invest in technology, and whether they are inclined to become involved in cooperative arrangements with suppliers and/or customers. The literature (i.e. in supply chain management and/or B2B e-commerce) stresses the combination of technology and partnerships as being critical for extracting value from e-commerce implementations. This model indicates that business performance will more likely be determined by what Sanchez and Heene describe as "higher order control loops", rather than by the technology, it's supporting infrastructure or by the nature of arrangements with trading partners. This is not to say that these are not important issues (as shown by their significant correlation with "Performance"), but rather that they will not of themselves provide significant results without effective strategy formulation processes. In other words, organisations that derive significant benefits from e-commerce implementations can be also expected to be involved in cooperative partnerships, as well as investing in technology and infrastructure – but that these benefits derive not from these activities themselves, but from the strategy development processes that led to them.

The model also provides some evidence to support the notion that "resource flexibility" and "coordination flexibility" are mutually dependent and complementary concepts. The direct relationship between the "Process" construct and "Performance" could be interpreted as being indicative of the coordination flexibility provided by using higher order control loops for strategy development. The fact that the elements making up this construct appear to directly determine performance (in the context of this model) may be partly explained by them providing effective and timely data that can be applied within organisational decision processes. The relationship between this same construct and the three B2B e-commerce related elements could also be interpreted as representative of higher order control loops enabling resource flexibility by informing resource selection, management and deployment processes. The fact that these three resource related constructs are found to have no direct determining influence on business outcomes also indicates the importance of organisational cognitive processes in determining the effective deployment of resources. The resources do not add any significant value of themselves, but can do if guided and driven by effective strategic logic.

CONCLUSIONS

The importance of organisational cognition being informed by the use of higher order control loops (as proposed by the Sanchez and Heene model) is highlighted in this research. The data indicates that (within the limitations of this model) the process by which organisations formulate their strategic logic is an important determinant of both how resources are selected and deployed, and of business performance. At the same time, it is evident that these same resources are not likely to yield significant benefits without such a process, and in fact that their effectiveness is very much a function of the nature of this process. The implication for organisations looking to implement e-commerce related methodologies is that focusing on developing effective methods for informing strategic logic can be expected to yield better ultimate performance, rather than concentrating on the technologies, supporting infrastructures, and trading partner relationships themselves.

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