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THE ADOPTION OF TRADENET BY THE TRADING COMMUNITY: AN EMPIRICAL ANALYSIS

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ABSTRACT

TradeNet, an electronic data interchange (EDI) system, has been touted as one of the most successful implementations of information technology at a nationwide level. To date, assessments of the benefits arising from TradeNet are anecdotal and focus primarily on the benefits accruing to the sponsor, i.e., the government agency. Notably absent is a systematic assessment of TradeNet from the perspective of the trading community.

This paper reports on an empirical investigation of the adoption of TradeNet by the trading community in Singapore. Two issues are investigated. First, we examine the factors that determine the timing of TradeNet adoption by the trading community in a coercive institutional environment. Second, we analyze post-adoption performances of the trading community. Lessons on the implementation of IT at a nationwide level ensue.

1. INTRODUCTION

TradeNet, a nationwide electronic transfer system for trade clearance, has been widely documented as a successful implementation of information technology. Developed with the sponsorship of the Trade Development Board (TDB), a government agency established to promote Singapore as an international trading hub, TradeNet electronically links the trading community to relevant government authorities.

To date, research on TradeNet has been descriptive in nature. In a series of Harvard case studies, King and Konsynski (1989) and Neo, King and Applegate (1993) offered rich, historical analyses of how TradeNet utilizes different forms of information technology to support and redesign the process of trade documentation and trade clearance. These studies also presented anecdotal accounts of the benefits as a result of TradeNet. Some of these benefits include tangible cost savings and significant changes in TDB's role from that of trade control to trade facilitation.

In this study, we contend that, to evaluate any IT which connects two or more parties, the implementation must be assessed by all parties utilizing the system. As pointed out by O'Callaghan, Kaufmann and Konsynski (1992), the adoption of an interorganizational electronic linkage is significantly different from the adoption of an innovative internal technology because interorganizational electronic systems such as EDI produce changes that affect all parties in the exchange relationship. This study analyzes the impact of TradeNet from the perspective of the trading community comprising traders, cargo agents, freight forwarders, and shipping agents. The benefits inherent of any information system hinge on the trading community's (i.e., end users') ability to utilize the new system. Benefits derived by the users are necessary not only for justifying the implementation of such a high capital-intensive IT application but also for justifying future IT applications of systemic, nationwide proportions.

The primary objective of this paper is to provide an empirical assessment of the adoption and the post-adoption effects of TradeNet from the perspective of the trading community. By viewing TradeNet as an innovation, we examine the determinants of the timing of adoption as well as the factors which affected post-adoption performance of the trading community. In the next section, we described

the TradeNet system and the unique circumstances that differentiate TradeNet from other forms of innovation adoption. Then, drawing on theories of innovation and institutionalization, we develop a research model which delineates the determinants of timing of adoption, as well as factors affecting the performance of the trading community.

2. THE TRADENET SYSTEM

TradeNet originated as an initiative from the Singapore government in 1986. Two major driving forces motivated the implementation of TradeNet: the government's vision of Singapore as a leader in the creation and use of information technologies and the government's desire to improve Singapore's competitive advantage in external trading activities after the rude awakening of the 1985 recession.

One area which posed tremendous potential for the use of IT was the information exchange required in trade documentation. In modern trade transactions, large amounts of information must be exchanged between the trading community and government agencies to ensure compliance with a myriad of trade regulations and international trade agreements. This documentation process was tedious and time consuming. Traders had to produce invoices and other documents to support their applications. The process typically involved despatch clerks delivering required documentation to TDB and returning two days later to collect the documents. Where the goods required payment of customs duties, or where they were governed by special trade regulations, the same process was repeated with several other government departments before goods could be imported or exported.

As port activities in Singapore increased in number and as international legal agreements increased in complexity,[1] the traditional trade documentation process became a paperwork bottleneck in trading. Before TradeNet, traders had to complete one to three of twenty government documents per incoming or outgoing shipment. TDB was loaded with the paperwork for about 10,000 declarations every day.

To streamline trade processing, TDB and the National Computer Board (NCB) jointly developed TradeNet. With TradeNet, traders submit structured electronic trade permit applications to TDB and other government departments. In December, 1986, TDB announced its decision to implement TradeNet and to make the system mandatory by early 1993. To facilitate the design of the TradeNet system, TDB developed an on-line prototype, Trade-Dial-Up. Traders could utilize the prototype on a voluntary basis. The significance of Trade-Dial-Up went beyond a testing ground for the authorities. It also gave the users or traders a chance to test out the innovative concept of on-line trade documentation.

TradeNet was open to a pilot group on January 1, 1989. In April of the same year, TradeNet became fully operational. Although TradeNet was supposed to be mandatory only in early 1993, the mandatory date was brought forward to early 1991 because 40% of trade documentation was submitted via TradeNet eight months after implementation.

As of mid-1991, TradeNet had captured 95% of trade documentation volume and had 1,800 subscribers. The remaining 5% of trade documents pertained to disparate elements such as personal effects of ship/airline crews and diplomatic staff and commodities such as rice that were subject to sensitive regulations.

Compared to other innovations, TradeNet was unconventional because it is a mandatory innovation; the trading community had no option about adopting the new trade-supporting EDI system. However, individual firms in the trading community were given a two-year period to adopt the system. Thus, TradeNet presents a unique case where research on innovation diffusion can be examined in the midst of coercive institutional pressures.

3. RESEARCH MODEL

One fundamental question underlying this research is, what were the factors that affected a firm's timing of adoption of TradeNet, given that the use of TradeNet would eventually be mandatory? EDI, of which Tradenet is an archetypal, represents one of the most significant IT innovations for transmitting documents and facilitating the flow of a product or service. For example, in 1988, 75% of Fortune 100 and 39% of Fortune 500 companies were reported to be using some form of EDI to perform traditional business communications (Canright 1988). The Gartner Group further estimated in 1989 that one-third of all business documents would be sent using EDI by 1995 (*I/S Analyzer* 1989). Research to date on EDI has focused primarily on the strategic implications of interorganizational systems (e.g., Venkatraman and Zaheer 1990) and on the sociopolitical impact of the technology on channel relationships (see Stern and Kaufmann 1985). However, with the exception of O'Callaghan, Kaufmann and Konsynski (1992) and Bouchard (1993) which offered sustained inquiries into the voluntary adoption of EDI, relatively little is known about the adoption decision process itself.

Drawing on Roger's (1983) theory of innovation and the DiMaggio and Powell (1983) theory of institutional pressures, we postulate that the timing of adoption of TradeNet is influenced by three broad classes of environmental pressures: pressures related to the attributes of the innovation (i.e., TradeNet), pressures arising from competitors, and pressures from coercive influence.

3.1 Relative Advantage

Rogers postulated that attributes of the innovation as perceived by potential adopters significantly affect innovation adoption. Of the attributes, *relative advantage* of the innovation compared to the existing system is regarded as the most significant factor (Tornatsky and Klein 1982; Rogers 1983). Generally, EDI systems have three immediate effects on the quality of interorganizational communications: (1) faster transmission, (2) greater accuracy, and (3) more complete information about the transactions (Stern and Kaufmann 1985). In the case of TradeNet, the speed of transmission shortens lead times. Direct computer-to-computer linkages eliminate despatch clerks, thus reducing the labor costs incurred by traders. Furthermore, TradeNet offers greater accuracy as checking and the approval process are performed automatically. With TradeNet, the same electronic document is used consistently across all trade controlling agencies instead of separate manual documents. The reduction of the number of manual copies of documentation means fewer transcription errors and retyping errors. Thus, we expect

> *H1: The greater the perceived relative advantage of TradeNet over the transactions of business without TradeNet, the more likely a firm will adopt TradeNet earlier.*

3.2 Trialability

According to Rogers, trialability is defined as the "degree to which an innovation may be experimented on a limited basis" (1983, p. 15). An innovation that is trialable is less uncertain and more valuable to the adopter because it offers the adopter the opportunity to learn by using (Rosenburg 1982). Through experimentation, potential adopters learn to adapt existing business processes to fit the innovation into the organization's culture and practices. In the case of TradeNet, potential users were given the opportunity to experiment with the TradeNet innovation on a limited basis. An on-line prototype of TradeNet, known as Trade Dial-Up, was made available to traders for experimentation and trial runs six months before TradeNet became operational. Trial users experimenting with Trade Dial-Up were not required to adopt TradeNet when the system came into operation. Accordingly, the use of Trade Dial-Up did not constitute an "early adoption" practice. Because hands-on experimentation reduces uncertainty about the features and processes inherent in the innovation, we expect trialability to have a positive impact on the timing of adoption.

> *H2: Firms that had experimented with Trade Dial-Up would be more likely to adopt TradeNet earlier. Conversely, firms that did not experiment with Trade Dial-Up would be less likely to adopt TradeNet earlier.*

3.3 Peer Influence

Attributes of innovation such as relative advantage and trialability are critical determinants on the timing of adoption. However, focusing solely on such factors overly atomizes the decision making process. As argued by Granovetter (1985) and others (Davis, Bagozzi, and Warshaw 1989), organizational decisions are not made in a vacuum. Rather, they are embedded in a network of social relations. Particularly in the case of TradeNet, external influences in the form of peer influences from competitors can have potentially significant impacts on a firm's decision on the timing of adoption of TradeNet. In fact, as elaborated by DiMaggio and Powell, in situations of high uncertainty, such as the diffusion of an innovation, "the ubiquity of certain kinds of structural arrangements can more likely be credited to the universality of mimetic processes than to any concrete evidence that the adopted models enhance efficiency" (pp. 151-152).

In this context, target firms may adopt TradeNet because they observed how peer firms utilize and gain from TradeNet. Especially when prevailing managerial practice may be perceived to approximate optimal behavior (Anderson 1988), adoption decisions of peer firms foster vicarious learning on the part of target firms and, hence, encourage imitative behavior of target firms (Huber 1991), Thus, we would expect that

> *H3: A firm will be more likely to adopt TradeNet earlier if its competitors have already adopted TradeNet. Conversely, a firm will be less likely to adopt TradeNet earlier if its competitors have not adopted TradeNet.*

3.4 Coercive Influence

Finally, timing of adoption may be influenced by the coercive institutional influence of government regulators.

According to DiMaggio (1988), the role of coercive influence is particularly powerful in explaining organizational phenomena in highly regulated industries such as banks or high government regulated societies where well laid-out rules, structures, regulation and practices govern the operations of firms. Under these conditions, institutional pressures lead organizations to be guided more by legitimacy concerns than task performance or efficiency considerations. A legitimate organization is one that is perceived to be pursuing socially acceptable goals in a socially acceptable manner and not necessarily in an economically efficient manner. Thus, when legitimacy concerns are high, efficiency and performance alone are not sufficient in explaining organizational actions (Epstein and Votaw 1978).

Given that TradeNet is a government initiative and a mandatory EDI system, we would expect that firms, guided by legitimacy considerations, would adopt TradeNet earlier if the perceived coercive influence from the government regulators with regards to the use of TradeNet is high. Thus,

H4: The greater the perceived influence of the government regulators, the more likely a firm will adopt TradeNet earlier.

4. POST-ADOPTION EFFECTS OF TRADENET

Research on the impacts of EDI systems is relatively sparse. In a literature review, O'Callaghan, Kaufmann, and Konsynski found that the focus on EDI effects has been the sociological impacts of the technology rather than direct productivity, efficiency, or performance effects of technology. EDI was found to formalize the communication processes and procedures that enhance speed, accuracy, and completeness of interorganizational communications (Stern and Kaufmann 1985).

In one of the few studies that focused on competitive or performance effects, Morris and Holman (1988) observed that simplification of the buyer's tasks as a result of EDI significantly affected buyer's loyalty to a supplier. In another study, Monczka and Carter (1989) showed that EDI enabled suppliers to gain considerable competitive advantage by being more responsive to buyers' needs. Finally, Venkatraman and Zaheer (1990) found that EDI-linked insurance agents increased the number of policies written with the focal carrier at a significantly greater rate than the nonlinked agents, thus supporting the case that firms that adopt EDI linkages with their suppliers increased the percentage of business they do with that supplier.

In this study, we examined the impact of TradeNet on two performance measures: (1) overall business performance of the firm as measured by business market share, overall profitability, and revenue growth, and (2) internal planning efficiency. Based on concepts of process redesign (Hammer and Champy 1993; Davenport 1993) and process simplification, we postulate that TradeNet simplifies the trade clearance process for the trading community, which in turn translates to significant overall business performance and internal planning efficiencies. Three determinants of post-adoption effects were postulated. First, we hypothesized that positive effects of TradeNet will be felt more strongly by early adopters of TradeNet because they reap the benefits of prime mover advantage of the simplification process. Especially when time represents the most powerful new source of competitive advantage (Stalk and Hout 1990), early adopters can capitalize on the prime mover advantage of reorganizing their organizations to cut lead times and offer customers quicker delivery. Thus,

H5: The earlier the adoption of TradeNet, the better the post-adoption performance of the firm.

Second, we hypothesized that the benefits of TradeNet will be felt most strongly in firms who were able to take advantage of TradeNet in redesigning and streamlining their internal trade documentation workflow and processes. This is in line with the concept of business process reengineering (Davenport 1993; Hammer and Champy 1993) and the evidence from Morris and Holman (1988). IT and, in particular, EDI simplified existing internal processes which can lead to significant firm efficiencies and productivity. Thus,

H6: The more TradeNet is integrated to the firm's internal processes and procedures, the better the post-adoption performance of the firm.

Third, as a control variable, we hypothesized that the degree of business computerization will not, in itself, affect firm performance. On the surface, this seems to run contrary to the implicit belief that IT has an impact on the organizational performance (Crowston and Treacy 1986, p. 226; Raymond, Pare, and Bergeron 1993). However, as demonstrated by Weill and Olson (1989), Raymond, Pare and Bergeron (1993), and Chan and Huff (1993), IT has impacts on firm performance only when contingency factors such as strategic fit, IS-business alignment, structure, and uncertainty are factored into the IT-firm performance relationship. Similarly, in this case, we suspect that business computerization or the level of IT usage will not, in itself, significantly improve firm performance. As argued by Hammer (1990), merely automating fundamentally archaic or flawed processes will not yield substantial gains. Thus, controlling for all other factors,

H7: The extent of business computerization has no significant effect on the post-adoption performance of the firm.

5. RESEARCH METHOD

5.1 Sampling

The sample for this study was drawn from a population of TradeNet users in Singapore provided by the Singapore Network Services (SNS), a private company that was established to design and implement TradeNet. As of October, 1992, there were 1,535 active TradeNet users grouped by number of permit declarations submitted via TradeNet. A stratified random sample of 504 was selected to allow representations across all groups. Heavier users of TradeNet were consciously over sampled because impacts, if any, are likely to be more discernible among these users.

A questionnaire was sent to the General Manager or Managing Director of each user firm. There were 504 questionnaires sent but four were undelivered and returned, thereby reducing the sampling base to 500 questionnaires. Of these 500 questionnaires, 158 completed and usable questionnaires were returned, yielding a response rate of 31.6%. Fourteen responses were removed from the 158 questionnaires because they represented firms that began operations in Singapore after January 1989, the date TradeNet was first implemented. This was done to remove distortion to the data, which otherwise would have skewed the data toward later adoption. Thus, subsequent analysis was performed on a sample of 144 firms.

To determine the representativeness of the sample, respondent profiles were compared with the profiles of all TradeNet users on record. A chi square test revealed that a disproportionate number of firms with a higher number of declarations (at least 75 per month) responded ($\chi^2 = 15.66$, $p < .05$). This is consistent with our original sampling strategy where we oversampled large users because returns on IT investment are likely to be more discernible among heavier users of the technology (Stevens 1990).

5.2 Measures

5.2.1 Dependent Variables

Timing of adoption was operationalized as the lag, in terms of number of months, between the first Tradenet adopter and the date the respondents first used TradeNet. *Post-adoption performance* was operationalized as the impact of TradeNet on (1) overall business performance measured by perceived market share, revenue growth and profitability and (2) planning efficiency measured by the impact of TradeNet on staff, logistics, and inventory scheduling.

5.2.2 Independent Variables

Relative advantage, the degree to which an innovation is perceived as being better than the idea it supersedes, was operationalized as the extent to which TradeNet reduces paperwork costs and supports business objectives of the firm. *Trialability*, the degree to which an innovation may be experimented, was operationalized as the extent to which a firm had used Trade Dial-up, the prototype to TradeNet. *Peer influence* refers to the influence from mimetic isomorphic pressures to adopt TradeNet. It was operationalized as the extent to which a firm adopted TradeNet because competitors were using it. *Coercive influence* refers to the influence from coercive isomorphic pressures to adopt TradeNet. It was operationalized as the extent to which a firm adopted TradeNet because it perceived strong government pressures to use it.

Degree of process integration refers to the extent of integration between TradeNet and the user firm's internal systems in three areas: data, approval, and application. First, the required data for TradeNet permits may be entered manually or retrieved automatically from other systems. Second, approvals from TDB to traders may be monitored manually by the trader or monitored automatically by the trader's internal computer systems which would then trigger necessary actions and transactions upon approval. Finally, traders may operate TradeNet as a standalone system or as an integrated system with other application systems in the firms. *Degree of business computerization* refers to the extent to which an organization has automated its functional activities. It is operationalized as a composite index formed from individual indicators which assess the extent to which computers are used to support order processing, marketing and sales, operations, warehousing and inventory, accounting, administration, and personnel. Measures for each of the constructs are provided in the appendix.

5.3 Construct Validation

A combination of single and multiple item measures were used in this study. Discriminant and convergent validity among the measures were examined by using Campbell and Fiske's (1959) MTMM matrix. From Table 1, we observe that within-measure item correlations are consistently greater than between-measure correlations, indicating acceptable discriminatory validity.

For multiple item constructs, items in each construct were subjected to factor analysis to ensure a single factor structure for that construct. All items for each construct have

Table 1. Multitrait-Multimethod Matrix of Measures

Measures	RA1	RA2	RA3	RA4	RA5	TRIAL	PEER	COERCIVE	ADOPTN	INTEG1	INTEG2	INTEG3
RA1	1.0000											
RA2	0.4633	1.0000										
RA3	0.5872	0.5747	1.0000									
RA4	0.2858	0.6136	0.3444	1.0000								
RA5	0.4475	0.3861	0.2855	0.4469	1.0000							
TRIAL	0.1212	0.0585	0.1978	0.0251	0.0672	1.0000						
PEER	0.2222	0.2679	0.2358	0.1696	0.2729	0.0674	1.0000					
COERCIVE	0.0251	0.0830	-0.0132	-0.0257	-0.0331	-0.1643	-0.0825	1.0000				
ADOPTN	0.0240	-0.0045	-0.0979	0.1243	-0.0739	-0.2956	-0.1801	0.0157	1.0000			
INTEG1	-0.0269	-0.0271	0.1636	0.1064	0.1008	0.2724	0.1216	-0.0715	-0.0011	1.0000		
INTEG2	0.0578	0.0413	0.1304	0.2082	0.2638	0.2622	0.2129	-0.1781	-0.0291	0.5306	1.0000	
INTEG3	0.0844	0.0506	0.1539	0.1631	0.2461	0.2125	0.1080	-0.1029	-0.0496	0.3438	0.6368	1.0000
COMP1	0.1268	0.1200	0.1483	0.0816	0.1841	0.1825	-0.0572	-0.1518	-0.3093	0.1663	0.1116	0.1968
COMP2	0.2689	0.0873	0.2492	0.0725	0.2775	0.1958	-0.0657	0.0392	-0.3101	0.0844	0.1861	0.2405
COMP3	0.2636	0.1937	0.2452	0.1925	0.2737	0.1391	0.1846	-0.0674	-0.1890	0.1420	0.1785	0.1832
COMP4	0.1931	0.2024	0.1236	0.0797	0.1645	0.1193	0.0653	-0.0394	-0.2349	-0.1357	0.0558	0.1535
COMP5	0.2125	0.1582	0.1202	0.0235	0.2318	0.0105	0.0186	0.0989	-0.2146	-0.0174	-0.0219	0.0141
COMP6	0.1999	0.0607	0.1621	0.0077	0.1583	0.2718	-0.0157	-0.1728	-0.3935	0.0591	0.0853	0.1095
COMP7	0.1192	0.1064	0.0867	0.0301	0.1701	0.1130	-0.0943	0.0363	-0.2109	0.0432	0.0529	0.1369
BUS1	-2.3380	-0.3145	-0.1399	-0.4162	-0.4676	-0.1597	-0.3041	-0.0189	0.1409	-0.1452	-0.2398	-0.0823
BUS2	-0.2395	-0.3449	-0.1652	-0.3974	-0.3505	-0.0950	-0.2433	-0.0313	0.2045	-0.0601	-0.2096	-0.0947
BUS3	-0.2517	-0.3269	-0.2032	-0.3504	-0.3702	-0.1274	-0.3721	-0.0729	0.1926	-0.1249	-0.1921	-0.1061
PLAN1	-0.2027	-0.2614	-0.2002	-0.2915	-0.2923	-0.1040	-0.1759	0.0413	0.0382	-0.1050	-0.2451	-0.1333
PLAN2	-0.2475	-0.3425	-0.3074	-0.3321	-0.3386	-0.0248	-0.1905	0.0302	0.0378	-0.0744	-0.2506	-0.2976
PLAN3	-0.1924	-0.2438	-0.2394	-0.3220	-0.3764	-0.0371	-0.2877	0.0690	0.1116	-0.1487	-0.3124	-0.3518

Note: Definition of measures is provided in the appendix.

Table 1. Multitrait-Multimethod Matrix of Measures (Continued)

Measures	COMP1	COMP2	COMP3	COMP4	COMP5	COMP6	COMP7	BUS1	BUS2	BUS3	PLAN1	PLAN2	PLAN3
RA1													
RA2													
RA3													
RA4													
RA5													
TRIAL													
PEER													
COERCIVE													
ADOPTN													
INTEG1													
INTEG2													
INTEG3													
COMP1	1.0000												
COMP2	0.6014	1.0000											
COMP3	0.5087	0.5965	1.0000										
COMP4	0.5645	0.6152	0.5266	1.0000									
COMP5	0.5759	0.5576	0.5372	0.5810	1.0000								
COMP6	0.5332	0.5216	0.6184	0.3562	0.3730	1.0000							
COMP7	0.4448	0.4960	0.3448	0.4679	0.3259	0.6698	1.0000						
BUS1	-0.0926	-0.2049	-0.2639	-0.2076	-0.1792	-0.1017	-0.0855	1.0000					
BUS2	-0.1246	-0.2506	-0.2701	-0.2460	-0.2233	-0.1989	-0.1441	0.8172	1.0000				
BUS3	-0.1182	-0.2952	-0.2912	-0.1878	-0.2295	-0.1429	-0.0696	0.7088	0.7606	1.0000			
PLAN1	-0.0237	-0.1111	-0.1055	-0.0991	-0.1726	-0.1195	-0.0543	0.4305	0.4129	0.5010	1.0000		
PLAN2	0.0343	-0.1570	-0.2058	-0.1593	-0.1923	-0.1452	-0.1322	0.4548	0.5208	0.5093	0.6382	1.0000	
PLAN3	-0.0129	-0.1896	-0.2346	-0.1081	-0.1314	-0.1117	-0.0655	0.4900	0.5075	0.5831	0.5604	0.8477	1.0000

Note: Definition of measures is provided in the appendix.

Table 2. Means, Standard Deviations, Coefficient of Variation and Intercorrelations Among Constructs

Constructs	Mean	Standard Deviation	Coefficient of Variation	1	2	3	4	5	6	7	8	9
1. Relative Advantage	25.26	6.19	4.08	1.00								
2. Trialability	2.84	2.08	1.37	0.14	1.00							
3. Peer Pressure	3.37	1.98	1.70	0.32	0.07	1.00						
4. Coercive Influence	6.00	1.57	3.82	0.02	-0.16	-0.08	1.00					
5. Timing of Adoption	18.53	10.90	1.70	-0.04	-0.30	-0.18	0.02	1.00				
6. Degree of Process Integration	8.93	4.93	1.81	0.18	0.33	0.17	-0.15	-0.03	1.00			
7. Degree of Business Computerization	33.4	9.63	3.47	0.19	0.29	-0.02	-0.16	-0.42	0.22	1.00		
8. Business Performance	9.92	3.04	3.26	-0.44	-0.15	-0.03	-0.04	0.19	-0.17	-0.28	1.00	
9. Planning Efficiency	9.84	2.99	3.29	-0.43	-0.08	-0.03	0.07	0.08	-0.28	-0.26	0.57	1.00

Note: Defintion of constructs is provided in the appendix.

substantial loadings onto single factor structures and items were summed into a composite measure for each construct. Next, each construct with its corresponding items was subjected to Cronbach's alpha reliability testing to assess its internal consistency. Based on the item-to-total correlation statistic, items were culled to produce the most reliable multiple-item measures (Nunnally 1978). The final reliability coefficients for multi-item constructs range between .75 and .90 (see the appendix). The means, standard deviations, coefficients of variation, intercorrelations among the constructs are given in Table 2.

5.4 Statistical Analysis

Two multiple regression models were formulated to test the above hypotheses. First, a model was formulated to examine the four hypothesized determinants of the timing of adoption (H1 to H4). Then, a second regression model was formulated to examine the determinants of post-adoption performance (H5 to H7). The results of each of these two models are discussed separately in the following section.

6. RESULTS

6.1 Timing of Adoption

The regression model to test for the timing of adoption is formulated as

$$Y_i = a_i + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

where Y_i = timing of adoption

X_1 = relative advantage

X_2 = trialability

X_3 = peer influence

X_4 = coercive influence

Table 3 shows the results of the multiple regression analysis. The results indicate that trialability was an important element in the decision to adopt TradeNet earlier than later (t_{TRIAL} = - 2.8; $p < .01$), and the hypothesized relationship between peer influence and timing of adoption was significant at $p < .10$ level (t_{PEER} = 1.8; p =.06). No statistically significant relationship was found between expected relative advantage (t_{RA} = .301; $p > .7$) or coercive influence on the timing of adoption ($t_{COERCIVE}$ = .29; $p > .7$).

6.2 Post-Adoption Effects

The regression model to test for post-adoption effects is formulated as

$$Y_j = a_j + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8$$

where Y_j = Business Performance; Planning Efficiency

X_5 = Timing of Adoption

X_6 = Degree of Process Integration

X_7 = Degree of Business Computerization

The second set of multiple regression analyses examines the relationships among the hypothesized determinants of the performance of firms that adopted TradeNet. Given that there are two separate dependent measures of post-adoption effects — business performance and planning efficiency — an overall multivariate analysis of variance (MANOVA) was conducted, and was found to be significant (Hotelling's T^2 = .708; $p < 01$). Subsequent follow-up univariate analysis of variance were conducted to assess the significance of each hypothesized determinant on each of the two post-adoption effects.

6.3 Business Performance

Table 4 shows the results of the follow-up univariate analysis on business performance. The results indicate that the degree of process integration was a significant determinant of business performance (t_{INTEG} = 1.99; $p < .05$). However, the hypothesized relationship between timing of adoption and business performance was not (t_{ADOPT} = -1.54; $p > .10$). Furthermore, as hypothesized, no significant relationship was found between degree of business computerization and business performance (t_{COMP} = 1.04; $p > 30$).

6.4 Planning Efficiency

Table 5 shows the results of the follow-up univariate analysis on planning efficiency. The results indicate that the degree of process integration was a significant determinant of planning efficiency (t_{INTEG} = 3.87; $p < .00$). Also, the hypothesized relationship between timing of adoption and planning efficiency was significant at the $p < .10$ level (t_{COMP} = 1.88; p =.06). As with business performance, no statistically significant relationship was found between timing of adoption and planning efficiency (t_{ADOPT} = -0.99; $p > 30$).

Table 3. Results of Regression Model of Timing of TradeNet Adoption

Dependent Variable: Timing of Adoption

Independent Variables	Hypothesis	Estimate	Standard Error	T - Statistic	Prob.
Relative Advantage	1	.048	.16	.301	.764
Trialability	2	-1.352	.482	-2.805	.006
Peer Influence	3	-.982	.527	1.864	.065
Coercive Influence	4	.192	.641	.299	.765
R Square	.102				
Adjusted R	.069				

Table 4. Results of Regression Model of Post-Adoption Performance

Dependent Variable: Business Performance

Independent Variables	Hypothesis	Estimate	Standard Error	T - Statistic	Prob.
Timing of Adoption	5	-.060	.038	-1.54	.13
Degree of Process Integration	6	.149	.075	1.99	.05
Degree of Business Computerization	7	-.046	.044	1.04	.30
R Square	.21				
Adjusted R	.16				

Table 5. Results of Regression Model of Post - Adoption Performance

Dependent Variable: Planning Efficiency

Independent Variables	Hypothesis	Estimate	Standard Error	T - Statistic	Prob.
Timing of Adoption	5	0.036	0.04	0.99	0.32
Degree of Process Integration	6	0.268	0.07	3.87	0.00
Degree of Business Computerization	7	0.076	0.04	1.88	0.06
R Square	.29				
Adjusted R	.24				

7. DISCUSSION

7.1 Timing of Adoption

The study found that trialability and peer influence were important factors affecting the timing of adoption of TradeNet, thus supporting hypotheses 2 and 3. Voluntary users of Trade Dial-Up were the earliest and most enthusiastic adopters of TradeNet, implying that experimentation reinforced the benefits of the innovation. These users in turn became industry pace-setters for other traders who became aware of the benefits of TradeNet vicariously through these early adopters. Subsequently, firms competing directly with these early adopters were influenced to follow quickly in adopting TradeNet.

Effects of relative advantage and coercive influence were not significant, and thus hypotheses 1 and 4 were not supported. The lack of variance in the measurement of the two variables accounted for the insignificant findings. In terms of relative advantage, the coefficient of variation was 4.08, suggesting that the benefits of using TradeNet were so obvious that it was not difficult for traders to have consensus on its utility regardless of their timing of adoption. The savings in turnaround time and labor utilization were uniformly enjoyed by all adopters and visible to the entire trading community.

The same argument holds for the perceived degree of government pressure to use TradeNet. The coefficient of variation was 3.82. All traders were continuously asked to use TradeNet and the fees for manual processing were raised to give the message greater persuasive power. Furthermore, eight months after TradeNet's launch in August, 1989, TDB announced that TradeNet would be made mandatory in 1991 instead of the previous deadline of 1993. In addition, TDB counters for manual trade permit applications would be closed by 1991. Thus, there were no doubts in the traders' mind that TDB was exercising increasing pressures for TradeNet's adoption.

7.2 Post-Adoption Effects

The timing of adoption did not have a significant relationship to both post-adoption effects measured. Hypothesis 5 was therefore not supported. The lack of support may be due to the rapid adoption of TradeNet by the trading community. TradeNet was handling 60% of all trade documentation by the end of the first year and 90% by the end of the second year. The rapid diffusion of TradeNet meant that differential performance due to the presence or absence of TradeNet was experienced only very temporarily. It also appears that the short time lag between early and late adopters averted any potential erosion of late-adopters' customer base who may be tempted to switch to other competitors who were earlier adopters of TradeNet.

The degree of process integration was significantly associated with both business performance and planning efficiency. Therefore, hypothesis 6 was supported. It appears that firms which had re-engineered their trade documentation processes in tandem with TradeNet adoption experienced the most benefits. The integration of TradeNet into internal organizational processes provided traders with significant time compression in their trade cycle. In contrast, firms that adopted TradeNet only as a standalone system found that the trade processing cycle remained lengthy. In some cases, the processing cycle with a standalone TradeNet became even more arduous because of newly discovered bottlenecks in their internal paperwork flows.

Finally, the degree of business computerization was marginally associated with planning efficiency but not with business performance. Hypothesis 7 is therefore partially supported. The lack of impact of the degree of business computerization on business performance was expected. It supports the current view that investments in IT without a corresponding fundamental change to business processes offer no substantive benefits at the business level. On the other hand, the significant relationship between computerization and planning efficiency suggests that planning efficiency may be a more direct measure than business performance for the impact of computerization. Thus, planning efficiency is an intermediate measure that may be enhanced because of computerization.

8. CONCLUSION

Lessons about implementing a nationwide IT system may be drawn from the above results. To ensure and facilitate rapid adoption, users must be given the opportunity to experiment and learn by using. Also, adoption behaviors of peers and competitors provide added impetus for the rapid diffusion of adoption. Because of the lack of variance in the coercive influence variable, we did not find a statistical relationship between coercive influence and timing of adoption. Nevertheless, we believe that a high coercive influence is in fact vital for ensuring adoption of a nationwide innovation. This point is reinforced by Hong Kong's experience with their version of TradeLink where the perceived lack of government support was the Achilles' heel of the project (*Asian Finance* 1987).

In terms of the effectiveness of IT systems, the study underscores the need for individual firms to reengineer

existing organizational processes to order to reap significant benefits from an innovative technology. Thus, it appears that promoting IT *in tandem* with process simplification is the challenge facing IT champions and change agents to ensure that firms achieve long-term strategic benefits resulting from an IT innovation.

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10. ENDNOTES

1. In 1989, Singapore was the largest port in the world in terms of gross tonnage.

APPENDIX

Measures of Hypothesized Determinants of the Timing of TradeNet Adoption

Constructs	Measure	Reliability
Respondents were asked to indicate on a scale of "1" to "7" (where "1" represents "Strongly Disagree," "4" represents "Neutral" and "7" represents "Strongly Agree"), the extent to which they agree or disagree with the following reasons as the basis for their respective organization's decision to use TradeNet		
Relative Advantage		Cronbach a =.7903
(RA1)	"Reasons for Using TradeNet — We wanted to reduce our costs of trade processing"	
(RA2)	"Reasons for TradeNet Use — We wanted to improve our service to our customers"	
(RA3)	"Reasons for TradeNet Use — We wanted to reduce paperwork in our organization"	
(RA4)	"Reasons for TradeNet Use — TradeNet was crucial for us to achieve our strategic business objectives"	
(RA5)	"Reasons for TradeNet Use — We wanted to move into Electronic Data Interchange technology for other uses"	
Peer Influence		N.A.
(PEER)	"Reasons for TradeNet Use — Our competitors were using TradeNet and we could not afford not to use it"	
Coercive Influence		N.A.
(COERCIVE)	"Reasons for TradeNet Use — The government requires all trade declarations to be sent through TradeNet"	
Respondents were asked to indicate on a scale of "1" to "7" (where "1" represents "Strongly Agree," "4" represents "Neutral" and "7" represents "Strongly Disagree"),the extent to which the following statement represents how TradeNet is actually used by their respective organizations:		
Trialability		N.A.
(TRIAL)	"TradeNet Use Characteristics — We used Trade Dial-Up before TradeNet"	

Measures of Hypothesized Determinants of Performance

Constructs	Measure	Reliability
Timing of Adoption	Computed from respondents' replies to "When did your organization first used TradeNet? (Month/Year)"	N.A.
Degree of Process Integration	Respondents were asked to indicate on a scale of "1" to "7" (where "1" represents "Strongly Disagree," "4" represents "Neutral" and "7" represents "Strongly Agree"), the extent to which the following statements represent how TradeNet is actually used by their respective organizations:	Cronbach a = .7571
(INTEG1)	"Characteristics of Tradenet Use — Data required for TradeNet are retrieved automatically from other systems"	
(INTEG2)	"Characteristics of Tradenet Use — Approval of trade declarations automatically triggers other transactions in our computer system"	
(INTEG3)	"Characteristics of Tradenet Use — TradeNet is integrated with our other computer/communications systems"	
Degree of Business Computerization	Respondents were asked to indicate the percentage of computerization on a scale of "0," "10," "30," "50," "70," "90," "100," NA (if no corresponding listed function) for each of the various functional areas in their respective organizations:	Cronbach a =.8887
(COMP1)	"Functional Areas — Order Processing"	
(COMP2)	"Functional Areas — Marketing/Sales"	
(COMP3)	"Functional Areas — Operations"	
(COMP4)	"Functional Areas — Warehousing/Inventory"	
(COMP5)	"Functional Areas — Accounting"	
(COMP6)	"Functional Areas — Administration"	
(COMP7)	"Functional Areas — Personnel"	

"Performance" Measures

Constructs	Measure	Reliability
Respondents were asked to indicate on a scale of "1" to "7" (where "1" represents "Much Worse Off," "4" represents "No Change" and "7" represents "Much Better Off"), the extent to which TradeNet has affected their respective operations in the following areas:		
Business Performance		Cronbach a =.9033
(BUS1)	"Characteristics of Business Operations — Market share"	
(BUS2)	"Characteristics of Business Operations — Revenue growth"	
(BUS3)	"Characteristics of Business Operations — Overall profitability"	
Planning Efficiency		Cronbach a =.8600
(PLAN1)	"Characteristics of Business Operations — Customer service"	
(PLAN2)	"Characteristics of Business Operations — Ability to plan/schedule staff"	
(PLAN3)	"Characteristics of Business Operations — Ability to plan/schedule delivery vehicles"	
(PLAN4)	"Characteristics of Business Operations — Ability to plan/schedule use of warehouse space"	
(PLAN5)	"Characteristics of Business Operations — Ability to commit on turn-around time"	