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ABSTRACT

This study investigates factors leading to the "go/no go" decision on organizational innovations, with particular reference to Electronic Commerce (E-Commerce). The goal is to explore important antecedents promoting the adoption of technological innovations, and to extend the frontiers of knowledge in this area, by integrating two major research paradigms - basic and applied. Randomly selected organizations in the IT area participated in the study. Variables pertaining to organizations, Information Technology, and users of the technology were assessed and analyzed using an omnibus instrument and probit analysis respectively. This study provides a tentative elucidation of contemporary unresolved issues, and also broadens understanding in the assimilation of emerging technologies into organizations.

BACKGROUND AND OBJECTIVE

In this information age, interest in the Internet and in its ancillary Electronic Commerce (E-Commerce) is profound, pervasive and booming. E-Commerce is defined as "the exchange of data, information, goods, ser-vices, and payments, by electronic means, over the World Wide Web (Wigand, R.; 2000). There is no question that the emerging National Information Infrastructure (NII) or Information Highway is giving increased access to a vast selection of goods and services. As these electronic markets unfold, and thousands and thousands more businesses join the Internet continuously, the study of the actual antecedents of electronic commerce adoption warrants the serious attention it deserves. The emergence of the NII or Information Highway offers dramatic new business opportunities, as well as new ways to run existing businesses. Electronic transactions are now commonplace in the business and government environments in the industrialized world, as well as in developing countries.

With the phenomenal growth of the Internet, a unique and new electronic marketplace is evolving. Various estimates project tens of billion dollars transactions have been advanced in terms of purchases by the number of people who will be connected to computer networks as they expand to include telephones, televisions, computers, as well as a range of computer-sensible devices such as the "market-choice-box". When one overlays and projects many of the future electronic commerce activities on the envisioned NII and Global Information Infrastructure, it is indeed astonishing to fathom the future potential of joining the on-line commerce community.

The objective of this research is to explore an approach to benchmark Information Technology (IT) adoption by organizations. Innovation adoption research has a long and rich tradition. Apart from the fact that most of the studies focused on industrial-age type technologies, more often than not, their analyses and results have tended to be qualitative in nature. While suggestive of policy implications, they do not provide a basis for an assessment of the quantitative impact of various policy instruments. This research focuses on an Information Technology —E-commerce— and seeks to extend the conventional analysis of factors driving innovation through the use of a quantitative technique: multivariate probit analysis. Since the study of factors promoting the adoption of innovations to date remains purely speculative, the thrust of this research is in its use. Probit analysis will make it possible to analytically identify the factors likely to influence the adoption of E-Commerce among organizations, and to determine the possible effects of different policy instruments designed to stimulate or encourage adoption.

The plan of the paper is as follows: an outline of probit theory and the model formulated for the study are highlighted in section 2. Section 3 reviews the relevant literature. The research plan, sources of the data, limitations of the study, as well as the definition of variables are discussed in section 4. The empirical results of the probit analyses are presented in section 5. This is followed in section 6 by an evaluation of the results. The application of the results and the quantitative effects of policy changes are presented in section 7. Section 8 evaluates the effects of different possible policy changes, while section 9 provides a summary of the results and conclusions drawn from the study.

THE PROBIT ANALYSIS MODEL

In the standard linear regression model, a particular dependent variable is related to a near combination of explanatory variables. The dependent variable is generally some measured quantity such as a respondent's answer to a given "outcome" question. Explanatory variables may include quantitative as well as qualitative variables. A qualitative factor can be incorporated into a regression model through the use of a "dummy" variable which takes on the values of 0 or 1. Generally, the value 1 indicates that an observation possesses a particular characteristic while 0 represents otherwise.

There are research instances, however, where relationships are formulated with a dependent variable that is dichotomous (i.e. with only two possible values, yes or no). For example,

the dependent variable might be based on whether an organization is aware of a particular technology, or whether an organization has adopted a specific innovation. It is also possible to view the dependent variable as the probability of occurrence of either of the events. Even though it is possible to compute ordinary least squares estimates with these types of dependent variables, certain assumptions of the classical regression model are violated, and ordinary least Squares estimates of some standard statistics such as t-ratios are incorrect. It has long been pointed out, that the specifications for the expected value of the dependent variable are violated when ordinary least squares regression is employed with a limited dependent variable.

One of the reasons for the inadequacy of the classical model is that the disturbances exhibit heteroscedasticity, and in addition, the variances of these disturbances depend on the unknown expected values of the dependent variable. Hence, there is no simple way to "correct" for the heteroscedastic residuals (Ben-Haim; 1985). Another problem with the classical model is that predicted values of the dependent are not necessarily 0 or 1. Even if the values between 0 and 1 are viewed as probabilities, negative values or values greater than 1 cannot be interpreted. There is nothing in the model to restrict prediction to values between 0 and 1.

Probit analysis is a procedure that takes account of heteroscedasticity of the disturbances as well as restricting predictions to values between 0 and 1. Alternative models such as logit analysis have also been developed (Ashton; 1972; Kolajo, E. F. & Martin, N. R; 1997).

In the prototype probit model, developed for the present study, the probability of observing a response (an organization adopted E-Commerce) is defined in terms of a single unobserved index or stimulus, and the standard cumulative normal distribution with mean 0 and variance 1 is used to transform the index to the probability value. The basic statistical problem is to estimate values for unknown B_n parameters. An iterative procedure making use of the maximum likelihood estimation technique is employed in estimating the unknown B_n parameters.

The probit model is most appropriate for this study for a number of reasons. First, an adoption of innovation decision is dichotomous in nature. A method that restricts the value of the predictor variable to 0 and 1, as the case with the probit model should be the method of choice. Moreover, Probit analysis outperforms most of the other competing approaches in terms of efficiency and effectiveness in minimizing heteroscedasticity.

LITERATURE REVIEW

The theoretical framework underlying research on adoption of technology draws upon a variety of major topical areas namely: organizational theory and development; management science; theories of organizational change; and technological innovation/transfer process. Accordingly, this research derives from previous works in these various domains. Literature on innovation diffusion theory (Tornatzky and Klein, 1982; Zmud, 1982; 1983; Rogers, 1983; Johnson and Rice, 1987; Brancheau and Wetherbe, 1990) has identified broad classes of factors promoting assimilation and institutionalization of technology (i.e. economic conceptions of task demands, specifiable social features of an organization, and the characteristics of a particular technology). In consonance with this foundation therefore, this study attempts to evaluate cat-

egories of variables namely – individual characteristics, organizational characteristics and technological characteristics.

While previous literature gave us some insight into the organizational and related factors surrounding Information Technology adoption, and generated different profiles of the consumer innovator in general, few investigated these factors as they relate to an emerging technology. Among the few, Brancheau and Wetherbe (1990) tested the innovation diffusion theory, using the adoption of Spreadsheet Software in the context of End-user Computing. Market (1993) and Pursell (1993) did a fairly exhaustive analysis on the adoption of contemporary and appropriate technologies. In a recent study, Van Vliet and Pota (2001) did a fairly comprehensive analysis of the classification of online retailers. They concluded that online retailers with origins in catalog retail, either as their sole business, or in combination with traditional storefront retail seem to have the strongest infrastructure and skill set on which to build an effective online retail presence. Mirchandani and Motwani (2001) in their paper titled "Understanding Small Business Electronic Commerce Adoption: An Empirical Analysis" tried to shed light on the critical factors leading to Electronic Commerce adoption in small businesses. In general, a sizeable number of authors have made a passionate plea for continuous research in this area as the results of research efforts to date, have been mixed and inconclusive.

Despite a strong research tradition of innovation adoption and diffusion, understanding how to adopt and implement IT successfully, however, is still one of the challenging issues facing the Information Systems (IS) field (Swanson, 1988; Brancheau and Wetherbe, 1990). The lack of a robust theoretical base and use of a wide array of measures by implementation researchers without adequate theoretical and psychometric justification, have been identified as major causes of this incomplete state of knowledge in IS adoption and implementation (Davis et al. 1989; Kwon and Zmud, 1987). The research proposed here presents a unique opportunity to address some of the problems plaguing innovation research, to the extent that, it could extend the frontiers of knowledge in the IT adoption and implementation research domain. The study used a standardized measurement instrument and Electronic Commerce as a basis (Brancheau and Wetherbe, 1990). It is conceivable that the results of the study should be of interest for what they would reveal about the nature and issues concerning adoption of an emerging technology in the corporate world, as well as, their general implications for implementation research.

RESEARCH PLAN

The data gathering method used in the study is a cross-sectional field survey. The main data gathering tools were questionnaires, the advantage being, the ability to administer them economically. Personal interviews were used to supplement the data gathering effort. More than anything else, the personal interview approach enabled the researchers to converse with numerous individuals pertinent to the study. It helped to assess their attitudes, roles as well as clarifying and validating data from the survey; that is, it primarily served as a diagnostic and illustrative aid.

A random sample of participating organizations was drawn from the Internet, trade directories and registers that collectively, constituted the sample frame. The organizations span five (5) industries, covering - financial, automobile, publishing, transportation as well as the insurance industry. Since most trade databases are established by law, one would expect the entries to be fairly exhaustive and up-to-date. An initial administrative phase involving establishing contact with key individuals within the firms was carried out. The purpose was to encourage high response rate, which in turn, was to guarantee a high degree of variability among organizations.

SOURCES OF DATA AND VARIABLES' DEFINITION

Three hundred and twenty three (323) questionnaires were mailed out originally. One hundred and one (101) organizations, representing 31% completed and returned their questionnaires. As it turned out, some questionnaires, and indeed, their data were unusable, hence, the primary data for the study derived from ninety-seven (97) organizations, a substantial percentage (61%) of which is made up of progressive Fortune 500 technology-champion companies. The rest are the not-so-progressive, technology-laggard companies. The focus was the information processing units or work-groups in the organizations. Structured questionnaires, supplemented with personal interviews, were used to collect the required data. The main data gathering tool is an adapted form of a standard instrument developed by Brancheau and Wetherbe (1990). There variables, were grouped into three (3) classes - Individual, Organizational, and Technological. Their operationalizations were clearly spelt out in the instrument to aid easy comprehension and completion by respondents (see Figure 1). Some aspects of the data used in this study were obtained from respondents who depended on their memory. Difficulties with "memory recall" approach are well documented in literature. Measurement of some of the variables had not been standardized, hence, all these could have acted jointly to diminish the validity of the measurements. By and large, adequate precautions were taken to ensure that subjects' responses were as candid as possible.

FIGURE 1

Dependent Variable

Y = 1 If the organization adopted electronic commerce; Y = 0 otherwise.

Explanatory Variables	**Operational Measure**
Individual Characteristics	
1. Age (x_1)	Fill-in item: Recalculated as age at time of adoption
2. Education (x_2).	Fill-in item: Years of education
3. Media exposure (x3).	Check-off and fill-in items: count of media sources used in last six months
4. External Participation (x4)	Count of affiliations with professional associa tions and attendance at meetings over past five years
5. Change Agent contact (x_5)	Multi-item scale: one scaled item for each change agency
6. Internal Communication (x_6)	Sociometric choice items: % of people in network regularly contacted for advice (at least once per month).
7. External Communication (x_7)	Fill-in items: count of interpersonal contacts outside individual's own department.
8. Opinion Leadership (x_8)	Sociometric choice items % of network regularly coming for advice (at least once per month). Measured for computer and business related advice.
9. Advice Seeking (x_9)	Sociometric choice items: % of network regularly sought out by respondent for advice
10. Job Level (x_{10})	Multiple-choice item: (1) professional/technical; (2) managerial
11. Channel Type (x_{11})	Mass media, TV ads, magazines, vendor litera ture etc
12. Channel Source (x_{12})	Multi-choice item: as in 11 above
Organizational characteristics	
1. Centralization (x_{13})	Sum of responses indicating location of IS staff decision responsibility for system-related activities
2. Formalization (x_{14})	Number of IS-related tasks for which standards already existed in the organization
3. Size (x_{15})	Natural logarithm of number of employees in the organization
4. Degree of Professionalism (x_{16})	Members of the IS department that have college degrees and are active in professional bodies

5.	Industry Sector (x_{17})	1 = IT; 2 = non-IT
6.	Management Support for Innovation (x_{18})	Perception of the extent CEO supported technology and exerted influence during adoption
Technological Characteristics		
1.	Compatibility (x_{19})	Perceived fit between EC and existing established organizational practices.
2.	Relative Advantage (x_{20})	Perceived performance-edge over preceding practices and identified alternatives
3.	Divisibility (x_{21})	Perceived level of modularization and individualization

DATA ANALYSIS

Empirical analysis, for the most part, involved estimating the coefficients of the Probit regression model, including all the explanatory variables using the maximum likelihood estimation technique. The full model was subjected to statistical parametric analysis, and after several iterations of the likelihood ratio test, gave rise to the restricted model. Therefore, the coefficients of the prototype model including all the explanatory variables were first estimated using maximum likelihood estimation technique (Table 1). The full model was successively refined by checking on the signs of the coefficients, the level of significance and by testing that the coefficients of the excluded variables are zero using the likelihood ratio test. The estimated final or restricted probit model of Electronic Commerce adoption by organizations is presented in Table 2.

In the latter model, six (6) of the variables included in original full model were omitted namely: Age (x_1), Internal Communication (x_6), Advice Seeking (x_9), Job Level (x_{10}), Formalization (x_{14}), and Size (x_{15}); all variables with logically inconsistent signs and non-significant coefficients in the full model. It is interesting to note, that an important variable, Formalization (X_{14}), which on an "a priori theoretical grounds" would be thought of as influencing E-Commerce adoption did not enter the final probit equation i.e. it did not seem to matter. The restricted model performed as well as the full model, which included all the variables previously defined, based on the likelihood ratio test.

The estimated coefficients of the restricted model have the expected signs and most were significantly different from zero at the 0.05 level of significance. The coefficients exhibit asymptotic statistical properties. For example, the negative coefficient associated with size could be explained as being due to the substitution of additional personnel for managing web related computing.

TABLE 1

Full Model: Probit Regression Coefficients for the Determinants of Electronic Commerce Adoption Among Organizations.

Dependent Variable: Whether Organizations adopted Electronic Commerce: Yes = 52; No= 45.

Explanatory Variables	Coefficient	Standard Error	Coefficient /Std Error
Age (x_1)	-0.0628	0.0487	-1.2886
Education (x_2)	0.0164	0.0074	2.1990
Media Exposure (x_3)	0.2820	0.1150	2.4518
External Participation (x_4)	1.2249	0.2474	4.9506
Change Agent (x_5)	0.9335	0.3009	3.1017
Internal Communication (x_6)	-0.1552	0.1952	-0.7951
External Communication (x_7)	0.6101	0.2538	2.4053
Opinion Leadership (x_8)	0.1660	0.2940	0.5645
Advice Seeking (x_9)	-0.0002	0.0011	-0.1780
Job Level (x_{10})	-0.3813	0.2631	-1.4564
Channel Type (x_{11})	0.1888	0.1204	1.5682
Channel Source (x_{12})	0.1683	0.2425	0.6942
Centralization (x_{13})	0.2466	0.1956	1.2610
Formalization (x_{14})	-2.8851	1.1661	-2.4740
Size (x_{15})	-0.0687	0.0917	-0.7487
Degree of Professionalism (x_{16})	0.4158	0.3050	1.3631
Industry Sector (x_{17})	1.2833	0.4381	4.4772
Management Support for Innovation (x_{18})	1.8845	0.7991	3.5221
Compatibility (x_{19})	0.929	0.4499	1.1304

Relative Advantage (x_{20})	1.1002	0.7372	1.7951
Divisibility (x_{21})	0.7773	0.3361	1.3141
Constant	-2.7792	1.5334	-2.6622
Log. Of likelihood	Fn -152.0600		

TABLE 2

Restricted Model: Probit Regression Coefficients for the Determinants of Electronic Commerce Adoption Among Organizations.

Dependent Variable: Whether Organizations adopted Electronic Commerce:

Yes = 52; No = 45

Explanatory Variables	Coefficient	Standard Error	Coefficient/ Standard Error
Education (x_2)	0.0135	0.0108	1.2480
Media Exposure (x_3)	1.0525	0.0434	2.2084
External Participation (x_4)	0.3136	0.1819	1.7326
Change Agent (x_5)	2.6122	0.1922	3.1855
External Communication (x_7)	0.4690	0.2921	1.6162
Opinion Leadership (x_8)	0.0950	0.3690	0.2578
Channel Type (x_{11})	0.3010	0.2086	1.4430
Channel Source (x_{12})	0.1230	0.2505	0.4910
Centralization (x_{13})	0.1274	0.0953	1.3366
Deg. of Professionalism (x_{16})	0.1548	0.2731	0.5667
Industry Sector (x_{17})	3.0651	0.1727	0.3771
Management Support (x_{18})	3.1393	0.6391	3.7980
Compatibility (x_{19})	0.7472	0.9421	1.1315
Relative advantage (x_{20})	2.2110	0.6614	1.2484
Divisibility (x_{21})	0.4552	0.3318	1.1415
Constant	-0.5195	0.9424	-3.7343
Log. Of Likelihood	Fn -152.06		

EVALUATION AND APPLICATION OF RESULTS

As pointed out earlier, most of the coefficients in the final model were significant at the 0.05 level of significance, and had the expected sign. A few of the coefficients were however not significant at this level but were included in the model. Their inclusion was justified by pragmatic, logical and a priori theoretical rather than statistical considerations. The restricted model which included only variables whose coefficients were statistically significant at the 0.05 level and which had the right sign was found to perform less well than the full model.

In order to demonstrate the effect of the explanatory variables on E-Commerce adoption, the predicted change on the stimulus level, **I**, have been computed for selected changes of the explanatory variables.

The results are presented in Table 3. It should be noted that the change in the probability corresponding to a specified change in the stimulus level is not always the same. This is because the transformation from stimulus to probability is non-linear; hence the effect of a change in the stimulus level depends on the initial location on the curve (i.e. the initial value of I). For example, the effect is largest when the total stimulus level is close to zero.

Based on the magnitude of the coefficients and the predicted changes in the stimulus level ($\blacktriangle$I), the important variables that influence E-Commerce adoption are: exposure to the media, presence of a change agent, the sector of the industry an organization belongs, management support for innovation, and a reasonable level of perceived relative advantage.

TABLE 3

The Stimulus Level For Selected Factors Affecting Adoption Of Electronic Commerce

Variables	**Change ($\blacktriangle$I) in Stimulus Level**
10% in increase in Media exposure (X_3)	0.1470
Availability of Change Agent (X_5)	0.3140
Private Sector (X_{17})	0.4700
Management Support for Innovation (X_{18})	0.6120
10% perceived level of Relative Advantage (X_{20})	0.3010

ESTIMATING THE EFFECT OF POLICY CHANGES

The effect of different policy alternatives on E-Commerce adoption could be analyzed using the probit regression results. The mechanics are as follows:

The predicted probability of an organization adopting electronic commerce may be written as:

$$P_t = f(I_t),$$

$$I_t = \Sigma B_n X_{nt},$$

where t = 1, 2, ...n represents t^{th} organization;

P_t is the predicted probability of employing E-Commerce in the t^{th} organization. It is the predicted stimulus for the t^{th} organization, while B_n is the estimated coefficient; n = 0, 1, ... N; X_{nt} is the observed level of the n^{th} explanatory variable for the t^{th} organization.

The sum of the predicted probabilities (ΣP_t) corresponds to the estimated number of organizations that have adopted E-Commerce. The same procedure could then be repeated for a particular policy situation (i.e., change in any or combination of the explanatory variables) to get a new estimate of the number of adopters. The difference between these two estimated numbers would represent the effect of the policy.

The technological champion or change agent variable (x_5) will be used to illustrate the mechanics. Given the current online age wave in which it is fashionable to join the online electronic commutiny, what would be the effect on E-Commerce adoption if all organizations in the sample were to belong in the IT sector? (i.e., x_{17} =1).

This could be estimated by making a comparison between the sum of predicted probabilities using the observed values for the creation of a change agent (x_5) and all other variables, and the sum after specifying the same variable as 1 for all observations; leaving all other variables the same. The result shows an almost 23% increase in adoption from the original estimated number of adopter organizations. The effects of other policy alternatives could be analyzed in the same way (see Table 4).

TABLE 4

The Effect of Different Policy Alternatives on Electronic Commerce (E-Commerce) Adoption Among Organizations.

Policy Set	Sum Of Probability	Estimated Number Of Adopters	% Change from Original Situation	% Change Of Organizations Adopting
1. No Change	51.83	52	-	53.60
2. Improved (X_3) Media Exposure	58.39	59	13.46	60.82
3. Creation Of a Change (X_5) Agent	67.44	67	22.76	79.69
4. All are in IT Industry (X_{15})	73.14	73	40.38	85.56
5. Management Support for (X_{18}) Innovation	78.02	78	50.00	87.78
6. Combination Of Policies 2, 3, 4, and 5.	87.92	88	69.23	92.11

SUMMARY AND CONCLUSIONS

This study has provided a somewhat simplified illustration of a method that may be used to measure the effect of personal, technological and organizational factors on the rate of adoption of technological innovations. The multivariate probit regression technique is a useful addition to the tools of analysis, which might be employed by those responsible for advising on policy decisions.

The results of the probit analysis imply that the stimulus index of E-Commerce adoption is influenced more by institutional and personal considerations than by technological factors. The

availability of technology is a necessary but clearly not a sufficient condition for E-commerce adoption. To the extent that inferences could be drawn about the whole population of online commerce community from the sample used in this study, it becomes apparent that the presence of a technological champion and management support among other things could encourage a wider adoption of Electronic Commerce in organizations.

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