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Exogenous factors related to the adoption of an innovation: Domain Name Registration in the Swiss hospitality industry

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Abstract
Based on diffusion models by Bass and Rogers, Scaglione et al (2004a, 2004b, 2005) studied the evolution of domain name registrations (DNR) by Swiss accommodation enterprises. This research extends these studies by analysing the relationship of exogenous variables with the adoption of domain names. A better understanding of the adoption of innovations by tourism organisations can shed light on better use of these innovations and subsequently better value for customers. The results of this study show that the adoption of an innovation, i.e. domain names, relates to three exogenous socio-economic trends. Information technology variables were most relevant followed by macroeconomic national variables such as the Swiss Market Index (SMI), Consumer Confidence Index (CCI) and Appropriate Moment for Important Acquisition (AMIA) but not the Gross Domestic Product (GDP). The least important set of variables related to the tourism economy.

Introduction

Internet use varies among small- to medium-sized enterprises, or SMEs (Sadowski, Maitland, & Dongen, 2002), and offers tourism SMEs the opportunity to develop their business and gain a competitive advantage (Buhalis & Main, 1998; Morrison & Rhodri, 1999). This competitive advantage, however, depends on if and how well SMEs integrate the Internet into their business.

Diffusion of innovations research has shown that organisations adopt technologies over a continuum, from having a technology to using it effectively throughout the organisation (Raho, Belohlav, & Fiedler, 1987; Rogers, 1995; Zmud & Apple, 1992). Similarly, organisations evolve in their use of the Internet (Beatty, Hsim, & Jones, 2001; Daniel, Wilson, & Myers, 2002; Gosain & Faraj, 2001; Hanson, 2000; Lennon & Harris, 2002), such as beginning with a domain name and email address, having a simple website, and then adding advanced website and customer service features.

Domain names, such as *hotel.com* or *hotel.ch*, serve as an online brand and facilitate finding the company's website (Hanson, 2000; Murphy, Raffa & Mizerski, 2003). As a rule, global domain names such as .com are available on a first come, first serve basis and cost as little as $10 US annually. Regulations and costs for country domains such as .ch for Switzerland vary depending on the country. A .ch domain name costs over $60 US for the first year and almost $30 US for subsequent years. The cost to register a .ch domain name is small and the procedure is simple, but some hotels adopted this innovation faster than other hotels did.

Earlier studies shed insights on structural factors related to this adoption process in the Swiss accommodation industry (Scaglione et al. 2004a, 2004b, 2005). Affiliated hotels adopted Internet technology – represented by domain names – faster than their smaller and family-run competitors did. Furthermore, all hotels adopted domain names faster than auberges did. The results suggested that domain name adoption by *auberges* is driven exclusively by imitation (i.e. internal communication) and not by innovation (i.e. external communication). External influences seemed to push hotels to re-engineer their business process or adopt an innovation more than *auberges*.

The previous results are in line with an analysis by Buhalis & Main (1998) who stated that external influences such as strategic partners, i.e. other members in the supply chain such as intermediaries and suppliers, force small and medium-sized hospitality organisations to re-engineer their business processes and utilise information technologies. Hotels through affiliations or contracts with tour operator generally have tighter links to business networks and are therefore subject to stronger external influences than *auberges.*

These conclusions, however, investigated just one of five factors – product or innovation, organisational (or structural), environmental, task and individual characteristics – related to organisational adoption (Kwon & Zmud, 1987). The present paper extends these previous studies. In addition to organisational variables, this research investigates a second important factor – environmental characteristics.

Modelling the Diffusion of Innovations

Diffusion of innovations has explained technology adoption for over half a century (Rogers, 1995) and shown remarkable similarities in the adoption of innovations such as the telephone, radio, and television (Fidler, 1997). This theory classifies adopters into five categories: pioneers, early adopters, early majority, late majority and laggards (Rogers, 1995). Businesses use adopter categories for target marketing, market size, and gauging the diffusion of a new technology.

Originally used to explain individuals' first purchase of new consumer goods (Bass, 1969; Mahajan, Muller, & Bass, 1990), Rogers (1995) and others have extended this model to organisations, albeit with difficulties (Damanpour, 1991; Wolfe, 1994). While individuals usually make innovation decisions, organisations decide collectively based on factors such as leader characteristics and influenced by the company's internal/external structure (Abrahamson & Rosenkopf, 1993; Damanpour & Evan, 1984; Fichman, 2000). Regardless of the unit of analysis, individual or organisational, Bass and other models are excellent tools to predict market size and adoption rates of new technologies (Mahajan, Muller, & Wind, 2000).

Bass suggests that two factors fuel adoption. Internal influence (e.g. word of mouth) drives *imitation* and external influence (e.g. mass-media) drives *innovation*. Equation 1 shows the Bass function (1969). *N(t)* is the cumulative number of adopters at time *t*, and *m* is the total market potential for new products. The parameters *p* and *q* are the coefficients of *innovation* and *imitation,* respectively. The former (*p*) represents adoption for the innovation itself and the latter (*q*) represents adoption owing to others already having the innovation.

$$\frac{dN(t)}{dt} = p(m - N(t)) + q\frac{N(t)}{m}(m - N(t)) \quad (1)$$

One way to capture the relationship of external variables with the adoption process is the survival analysis model by Cox (1972). For this study, the function λ(t , Z) represents the conditional probability that a hotel owner will adopt a domain name in the time interval (t, t+*d*t) given no adoption at time t. In addition, the decision should co-vary with an exogenous variable Z in the marketplace at time t. Equation (2) show the *hazard function* in survival analysis, λ.

$$\lambda(t, Z) = \frac{f(t, Z)}{[1 - F(t, Z)]} \quad (2)$$

Combining the discrete proportional hazard model proposed in Bass et al. (2000, p.111-115) with Cox' survival analysis model the Domain Name Registration (DNR) process $S(t_i)$ is:

$$S(t_i) = [m - X(t_{i-1})]J(t_{i-1,}t_i) + u(t_i) \quad (3a)$$

where

$$J(t_{i-1}, t_i) = 1 - \left[\exp(-a)\left\{\frac{1 + b\exp(-at_{i-1})}{1 + b\exp(-at_i)}\right\}\right]^{\exp(p(z(t_i\beta)))} \quad (3b)$$

where m is the total market potential, $X(t_i)$ is the observed cumulative numbers of adopters before t_i, $a=p+q$ and $b=q/p$, p and q respectively are the innovation and imitation coefficients of Bass and finally, $u(t_i)$ is a random error.

Eq (3) is obtained once f and F are replaced in (2) by the density and cumulative Bass' functions.

The data

To investigate domain registration by Swiss accommodation enterprises, the research relied upon the database of Switch (www.switch.ch), the Swiss domain name registrar. The set of data - the time series of more than 2100 names registered by Swiss accommodation enterprises in the Swiss .ch domain - is the same as in Scaglione et al (2004b).

Table 1 shows the exogenous variables tested in the present study:

Table 1 : Exogenous variables and sources

Type of variables	Variables	Frequency	Number of observations
Macroeconomic (M)	Swiss Market Index (ii)	Monthly	95 (SMI)
	Consumer confidence index (i)	Quarterly	31 (CCI)
	Appropriate moment for important acquisition (i)	Quarterly	31 (AMIA)
	Gross domestic product (ii)	Quarterly	30 (GDP)
Tourist's (T)	Foreigns overnights in Switzerland (iii)	Monthly	96 (FO)
	Domestic overnights in Switzerland (iii)	Monthly	96 (DO)
	Total overnights in Switzerland (iii)	Monthly	96 (TO)
IT	Proportion (%) of Internet users in Switzerland (iii)	Semestrial	11 (PMIU)
	Percentage of the overall adoption of DNR .ch (iv)	Quarterly	31 (POCH)
	www growth (v)	Monthly	97 (WWW)

(i) SECO State Secretariat for Economic Affairs

(ii) BNS Swiss National Bank

(iii) BFS Swiss federal statistical office

(iv) SWITCH The Swiss education and network research

(v) http://www.zakon.org/robert/internet/timeline/#Growth

The macroeconomic variables fall into two categories. GDP and SMI are quantitative and objective whereas latter indexes (i.e. *CCI, AMIA*) are based on stated behaviour. The former, GDP and SMI rely upon actual behaviour. The Swiss State Secretariat for Economic Affairs conducts regular consumer surveys to measure consumer expectations such as the *Consumer Confidence Index (CCI)* and the *Appropriate Moment for Important Acquisition (AMIA)*. The latter asks "Would you say that it is the appropriate moment for important acquisitions (i.e. important domestic appliance, furniture, cars, etc)?" measured on a five-item Likert scale. The results of both survey indexes can be either negative or positive. For example, the AMIA sample for this study showed negative results for the first and the third quarters. The final variable, www growth (Hobbes, 2005), gives the monthly number of web servers from December 1990 – December 2004.

Methodology

The formulas (1) to (3) developed earlier unify examining covariate exogenous factors in diffusion models. We applied the SAS routine PROC MODEL using nonlinear methods to estimate the parameters of the equation (3).

The analysis follows three viewpoints: the level of influence (i.e. covariance) for each exogenous variable with DNR adoptions; the shape of the utility function; and whether the predictive power of each exogenous variable changed over time.

In order to study the shape of the covariance the authors used three forms of equation (3) based on the polynomial $p(x)=ax^2+bx+c$ (see equation 3b). If a=0 it is a linear function; b=0 represents an incomplete quadratic function and both $a\neq0$ and $b\neq0$, represent the complete quadratic form (a concave or convex U-shape, depending on a positive or negative value of *a* respectively).

The choice of the best model for each exogenous variable follows these criteria (by decreasing order): all estimated parameters are significant, minimum of the mean absolute percentage error (MAPE) of the estimates, and maximum of the square correlation coefficient (R^2) adjusted to the number of parameters in the model.

To see if the coefficients of explanatory variables remain the same within the sample, the authors applied the Chow test (Koopman, S J et al. 1995, p. 136 & 184). Roughly speaking, a significant test at time t_w, suggests that the coefficients (βs) of the exogenous variables for $t< t_w$ differ from the coefficients for $t> t_w$. Therefore, at t_w , the explanatory power of the exogenous variable changes, in our cases, dismisses. From hereafter, when this happens the authors refer to this situation as the model's "structural break" at time t_w.

A final point about the parameter estimation process for equation 3 is that coefficients of exogenous variables (βs) and final number of adopters (*m*) have robust estimates; whereas the contrary happens with parameters *a* and *b*. In order to solve this problem, two techniques, generalised method of moments (GMM) for parameters estimation and scale exogenous data, were applied.

Results

The results of these DNR adoption models shed light on innovation decision processes in the tourism industry. Table 2 shows a synthesis of the main features.

Table 2 : Models, estimated parameters , goodness of fit figures and time of structural breaks

Type	Variables	Frequency	N	Model	Covar. shape	R2 (adj)	MAPE	Time structural break	Imitators/ innovator s rate	Estimated final number of adopters
M	SMI	Monthly	95	Linear	+	0.85	1.24	Aug-02	68.49	3033
M	CCI	Quarterly	31	Linear	+	0.84	0.42	IQ-2002	8.21	2532
M	AMIA	Quarterly	31	SQRT	∩	0.87	0.57	IQ-2002	8.47	2904
M	GDP	Quarterly	30				none			
T	FO	Monthly	96	Linear	+	0.65	1.68	Jul-02	27.78	3040
T	DO	Monthly	96	Linear	+	0.65	1.52	Jul-02	30.30	2954
T	TO	Monthly	96	Linear	+	0.65	1.56	Sep-02	28.74	3009
IT	PMIU	Semestrial	11	Linear	+	0.98	0.10	nil	6.91	2290
IT	POCH	Quarterly	31	Linear	+	0.91	0.27	nil	7.63	2570
IT	WWW	Monthly	97	Full SQRT	∩	0.83	0.8	nil	30.10	2688

The exogenous variables that show the best fit relate to IT. These models show no evidence of structural breaks, have the highest correlation coefficients (R^2) and the lowest MAPE, but the estimated final numbers of adopters is too low with respect to the total number of hotel in Switzerland. Nevertheless, the results are in line with Van den Bulten and Lilien (1997 page 348), who argue the Bass model "seriously underestimates … potential market".

However, these results merit caution. On one hand, the variable "Avg % of Internet users" has only 11 observations in the model (there are no other available data). On the other hand, the hotel's DNR is part of the variable "% of the overall adoption of DNR" and the high correlation coefficient could be, in part, due to the variable being partially exogenous.

In order to account for these limitations, the authors used another IT exogenous variable, a more *global* one, namely www growth. The model that adjusts the best is a full square, having a negative *a* value (-1.3E-7) and *b* coefficient close to zero (72E-4). The shape of the covariance function, an inverted U, centred almost at the origin, shows that the relationship between the exogenous variable and DNR is increasing/decreasing. There is no evidence of a structural break, which helps reduce doubts about the results with the other IT variables. Finally, that the relationship with www variables increases/decreases can be explained by the maturity of DNR for Swiss hotels versus the international evolution www servers that is still increasing as shown in figure 1.

The second best set of explanatory variables (with correlation coefficients between 0.84 and 0.86) are three macro econometric variables (SMI, CCI, AMIA), but not GDP. The SMI has a too high level for the ratio of imitators to innovators (*q/p*), certainly due to stability problems in the parameter estimates. In Scaglione et al (2004a), the *q/p* ratios for all three macro variables using univariate estimations i.e. without exogenous variables, ranged from 26.6 for affiliated hotels to 49.6 for non-affiliated hotels. This result is similar to the *q/p* ratio in Table 2 for all other variables having monthly frequency except for SMI. Exogenous factors with quarterly or bi-annual frequencies seem to underestimate the *q/p* ratio – suggesting limitations of the parameter estimation approach – although all are around eight, which shows consistency of those figures.

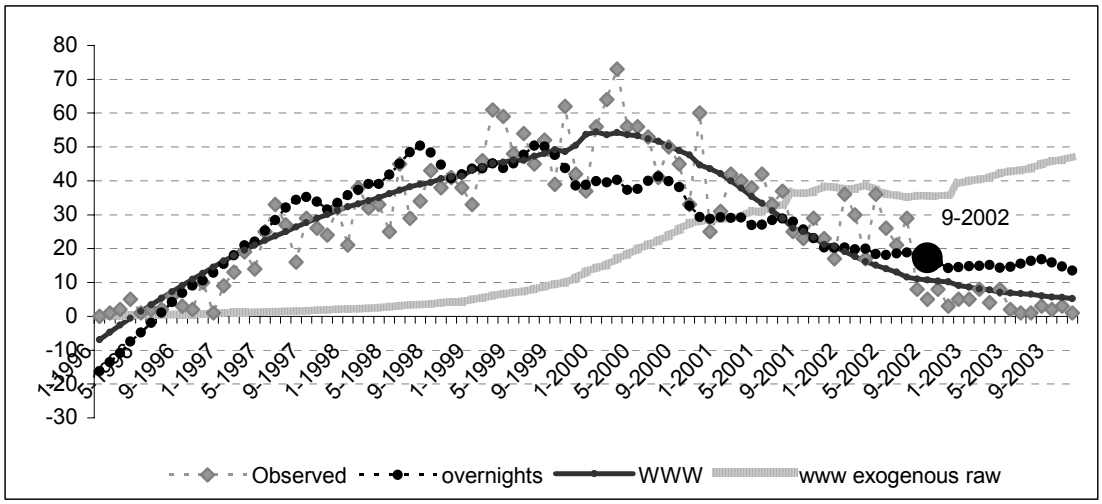
A final remark about models using exogenous macroeconomic variables is that the AMIA model is the only one with an inverted "U" shape, but AMIA's values are almost

negative. Therefore, given that the coefficient of the quadratic model is negative without a linear term, the relationship here is an increasing/increasing one. Yet as Table 2 shows, the two other macroeconomic variables converged with linear models with positive coefficient. Hence, for modeling three of the macroeconomic variables, their relationship with DNR is increasing/increasing

The tourist variables (T), which correlate moderately with DNR, show similar results except that "Foreign overnight in Switzerland" has the highest estimation of final numbers of adopters (*m*) of all the models.

The set of macroeconomic and tourism variables all show structural break during the first nine months of 2002. The predictive power of these variables overestimates the number DNR in the tail of the series as shown in Figure 1.

Figure 1: Observed and estimated DNR absolute frequency using foreign overnights (FO) as exogenous factor and WWW overlap with the raw series of WWW in millions



Conclusion

Although subject to limitations such as observation frequencies differing across the models due to available exogenous variables, the results show strong relationships between exogenous factors and domain registrations. The results also answer calls for studying relationships between management fashions and external macroeconomic indicators (Abrahamson, 1996; Carson, Lanier, Carson, & Guidry, 2000) by showing both the exogenous variables related to technology adoption as well as the strength of these variables. Bailey (2001) attributes part of the stock market's rise in the late 1990s to the same forces of IT and globalisation that drove the economy. The market and the new economy of the 1990s seem inevitably and strongly linked.

Drawing upon the Bass-Rogers categorisation of adopters, the laggards began registering domain names in November 2000 (cf. Scaglione et al (2004b)). In these

results, however, some exogenous variables (tourist and SMI) lose their predictive power in the first quarter of 2002, suggesting the presence of a new adopter category that we label *bandwagoners*, driven more by the influence of IT adoptions than by others macroeconomic factors.

That the IT variables show no structural break may be because the process under study is a part of them; the purchase of a domain name by a hotel counts in the variable "Percentage of the overall adoption of DNR .ch". Nevertheless, this is less straightforward for the variable "percentage of Internet users" and even less for the "global growth of servers".
Another explanation that does not exclude the previous one could be that the return of investment of adopting domain names was faster for the hotels in the last part of the diffusion process, given that tourism has matured in e-commerce relative to when the earlier adopter categories bought domain names. Whether this proposition is a cause or just supervenes is beyond the scope of this paper.

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