Author(s)	Haapaniemi, Tomi; Mäkinen, Saku
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The Extent of the Takeoff Time in the Technology Adoption: An International Study of the Effects of National Attributes

Tomi Haapaniemi & Saku J. Mäkinen

ABSTRACT

The earlier research has attested that the dynamics of the national technology adoption is dependent on various national attributes like economic and political conditions, and cultural attributes. However, the influence of these attributes on the dynamics of the adoption is still under debate and the takeoff point, i.e. the start of the rapid growth phase in the dynamics has only recently received attention in the literature.

This paper investigates the effects of cultural, population, and wealth attributes on the extent of the takeoff time. Our research studies five different technologies involving 214 national time series. Practical results from the study suggest that companies can expect the takeoff to occur faster in countries that are more equal, individualistic, future oriented, and wealthy. Future research implications and possible avenues are also discussed.

Keywords: takeoff point, technology adoption, cultural dimensions, content analysis

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INTRODUCTION

The globalization is proceeding at an increasing pace creating more and more competitive international business arena for companies to deal with (Wolf, 2000). From business perspective in this globalizing environment, one of the decisions that companies face is the task of selecting geographic scope of their operations, operational planning of their offering, and foreseeing the growth of aggregate global markets consisting of national markets (e.g. Douglas and Craig, 1995). In this decision making companies need to analyze, among other aspects, dynamics of the demand for their offering. In this respect variation between countries has especially critical meaning since national attributes have been found to affect many aspects of technology and product adoption dynamics on a national and international level (e.g. Tellefsen and Takada, 1999, Tellis et al., 2003) and operations companies need to engage into in national markets (e.g. Triandis, 1989).

The national technology adoption dynamics is dependent on various aspects and attributes like national economic and political conditions and cultural attributes such as similar religious beliefs, language, and lifestyles (Ganesh et al., 1997). These attributes influence the whole adoption dynamics of new technologies and products (Ganesh and Kumar, 1996). In addition to national attributes also time that has passed after the first global launch of a new technology affects the technology adoption dynamics at national level (Ganesh et al., 1997, Takada and Jain, 1991).

Traditionally international heterogeneity of national technology adoption has been studied with economic indicators like national wealth and prosperity derived from GDP. These measures have been used to anticipate and predict the adoption dynamics of new technologies (Gort and Klepper, 1982). However, adopting and accepting any new product or technology is not only an issue of wealth and prosperity in a culture which is highlighted in studies that have found that wealth as a predictor is not any more as important as earlier (de Mooij and Hofstede, 2002). They argue that economic variables loose even further their explanatory power as countries become more similar to each other in an economic sense as globalization proceeds. Converging incomes do not automatically imply converging consumption patterns. On the contrary, people are able to spend more money on products corresponding their value patterns, thus rendering cultural value differences more apparent (de Mooij, 2004). Therefore, the cultural attributes and other national characteristics such as culture, modernity, political system and other socioeconomic factors explain national technology adoption dynamics in addition to the economic variables (Sivakumar and Nakata, 2001).

Technology and innovation adoption in the international setting has mostly been traditionally studied with diffusion models (Helsen et al., 1993, Gatignon and Robertson, 1985, e.g. Dekimpe et al., 1998, Gatignon et al., 1989, Mahajan and Muller, 1994, Putsis et al., 1997, Talukdar et al., 2002, Heeler and Hustad, 1980). The earlier research on international technology adoption has mainly concentrated on comparing diffusion parameter estimates between countries. In order to explain differences in diffusion parameters between countries these studies have reported findings that adoption process is both product and country specific and cross-national influences are having effect on adoption as well (Gatignon et al., 1989, Kumar et al., 1998, Takada and Jain, 1991, Tellefsen and Takada, 1999). However, the cross-national patterns of the national technology takeoff timing remain unexplored to a great extent in current literature. The only existing research explicitly considering this phenomenon in international setting is Tellis, Stremersch and Yin (2003) and their study is limited to 16 European countries.

Therefore, there exists contradicting evidence in current literature on the influence of globalization on national attributes and their homogenization. The dynamics of technology adoption must be analyzed not only as a technological phenomenon but research should take into account as well the socio-cultural features (Daghfous et al., 1999). Therefore, this paper reports results from a global study on influence that social and cultural dimensions have on the national takeoff timing.

THEORETICAL BACKGROUND

Culture can be regarded as “the collective programming of the mind which distinguishes the members of one group or category of people from another” (Hofstede, 1997). Hofstede’s view is a broad concept of culture comprising of the many everyday practices, symbols, rituals, and values shared by the individuals in a society (Schwartz, 1997). Hofstede, among other researchers, has reduced the multidimensional cultural attributes affecting individual behaviour into researchable constructs (Hofstede, 1980). Values as a part of culture can be defined to be expressing a person’s beliefs about ideal modes of conduct and ideal terminal goals (Kluckhohn, 1951, Rokeach, 1970). Cultural-level values partly guide and determine individual behaviour and decision making in the limits of the respective culture. Hofstede states that values form the core of culture and define tendencies to prefer certain states of affairs over others (Hofstede, 1997).

Hofstede’s cultural dimensions (power distance, individualism, masculinity, and uncertainty avoidance) represent cultural variability and different value systems in cultures (Hofstede, 1980). Later the Confucian work dynamism was added, often labelled as long term orientation. Hofstede’s research included 53 cultures. Each culture consists of identifiable characteristics, values, attitudes, behaviours, habits, and world view, even though there exists individual and sub-cultural variation inside each respective culture.

Hofstede’s dimensions have been used in the earlier research seeking explanatory factors for national level behaviours and cross-cultural variations (Dawar et al., 1996). Further there exists earlier research findings that support the existence of dimensions and their power of classifying national cultures (e.g. Watson et al., 2002). Even though Hofstede’s dimensions have not been left without critique, “they were based on a rigorous design, a systematic data collection and a coherent theory to explain national variations” (Søndergaard, 1994). Therefore, based on previous work it can be concluded that the validity and the reliability of the measures are established in the current literature.

National level attributes have been found to have impacts on technology and product adoption in a cross-national setting. For example, Tellis, Stremersch, & Yin (2003) found that products are adopted faster in wealthy countries and in more open economies than in poor or less open economies. They further report that higher need for achievement; lower uncertainty and industriousness are factors that affect the adoption dynamics. Further, it has been found that cultural value differences persist, even if markets continue to globalize and national incomes are converging (de Mooij, 2004, Watson et al., 2002). This implies that people are able to spend more money on products that correspond to their value patterns, thus rendering cultural value differences more apparent.

HYPOTHESES DEVELOPMENT

Power distance dimension of national culture is human inequality between individuals. Areas where power distance manifests itself are like social status, prestige, wealth, power and laws, rights and rules. There exists contradicting forces that at the same time maintain and diminish inequality. In high power distance cultures respect to hierarchy inhibits individual decision-making, maintains inequality between members of the society and results in internal inertia at the national level (Hofstede, 1997). Power distance also affects the formation of trust between its members in a society. High power distance leads to a general distrust of others which further inhibits fast and decisive decision-making (Dawar et al., 1996). High power distance cultures tend to have calculative trust formation while low power distance cultures form trust through an benevolent intentionality process (Doney et al., 1998). In earlier research power index has been found to have effects on adoption dynamics. For example, high power index have been found to hinder adoption of new products (Sivakumar and Nakata, 2001) while at the same time the high power index has also been found to positively affect adoption of new products (Dwyer et al., 2005). Therefore, we hypothesize the following:

Hypothesis 1: The higher the power distance index, the shorter the takeoff time.

Uncertainty about future is a basic fact of human life. Time passes on and the future is always more or less uncertain. Extreme uncertainty necessarily creates anxiety and human societies and individuals cope with anxiety and uncertainty with technology (artefacts), laws (rules), and religion (knowledge of unknown) (Hofstede, 1997). Higher uncertainty avoidance creates group pressure and fosters avoidance of being different from the social group that individuals belong to. High uncertainty avoidance index is attached to a strong identification with one's own group and its rules (Dawar et al., 1996). This identification fosters a belief that threats to existing structures are to be avoided. It has been found that low uncertainty avoidance index results in faster overall adoption (Tellis et al., 2003). Further, it has been found that cultures with high uncertainty avoidance index are intolerant of ambiguity and distrustful of new ideas or behaviours (Dawar et al., 1996). Further, high uncertainty index hinders adoption of new products (Sivakumar and Nakata, 2001) and products take off faster in countries with low uncertainty avoidance index (Tellis et al., 2003). Therefore, based on above discussion, we hypothesize:

Hypothesis 2: The higher the uncertainty avoidance index, the longer the takeoff time.

Individualistic orientation is opposed with collectivistic orientation. Societies with high individuality index tend to consider individualistic behaviours as sources of well-being. In contrast members of collectivistic cultures with low individuality index have more interdependent self-constructs and they do not follow purely individualistic behaviours.

Individualism including personal achievements becomes operationalised through self-confidence, task-orientation, and courageous and curiosity in the sense of new knowledge and experiments (Tellis et al., 2003, Hofstede, 1997). In collectivist cultures people work more for the community and in-group. "We"-identity, duty and loyalty come first (Hofstede, 1997). People have tendency to take care of their social networks and relationships. Independent decision making and need for personal rewards and initiativeness are preferred values in individual cultures. In collective cultures they look more for sense and acceptance of the group and they express needs for maintaining harmony and traditions (Schneider and Barsoux, 1997). Further, earlier studies indicate that a high individuality index results in faster adoption of new products (Sivakumar and Nakata, 2001). Therefore, we hypothesize:

Hypothesis 3: The higher the individuality index, the shorter the takeoff time.

Social roles of genders are partly determined by the biological differences between the sexes. According to earlier research women attach more importance to social goals such as relationships and men attach more importance to ego goals such as careers and status (Hofstede, 2001). Masculinity means assertiveness, high competition, ambition and forms of materialism like money and earnings. Femininity is attributed more to taking care of people, equality in relationships, and concern for work life and environment. The gender roles are more equal in feminine cultures than in masculine cultures (Hofstede, 1997). In earlier literature it has been found that the degree of masculinity has effects on, for example, ownership of different (luxury) articles which manifests greater success and attracts more members of masculine cultures than members of feminine cultures (de Mooij and Hofstede, 2002). In addition, the adoption of new products or technologies might be important aspect in exhibiting wealth and success, which may be more compatible with masculine societies (Tellis et al., 2003). Further, it has been found that consumer innovativeness is higher in countries whose national culture is characterized by higher levels of masculinity (Steenkamp et al., 1999). Based on above discussion we hypothesize:

Hypothesis 4: The higher the masculinity index, the shorter the takeoff time.

Long-term orientation (LTO) dimension considers the temporal emphasis of a society, whether the goal seeking behaviour is directed to the future or short-term results are sought. High long-term orientation index value indicates emphasis on building relationships and concentrating on future prosperity rather than short-term fulfilment. In earlier studies long-term orientation has been found to, e.g., positively influence information systems adoption in a firm level (Waarts and van Everdingen, 2005). In low LTO index countries behaviour is directed to quick results, and there exists social pressures towards spending (Hofstede and Hofstede, 2005). Therefore, based on above, we can hypothesize:

Hypothesis 5: The higher the long-term orientation index, the longer the takeoff time.

In addition to cultural dimensions also three other national level attributes were included in the study, namely time variable indicating the national launch timing and its effect and population figures to indicate population characteristics and their effect on national technology adoption dynamics.

The measure of urban population reflects two distinct features of national social structure. Firstly, urban and metropolitan areas are heavier users of communications services than rural customers and the level of metropolitan population has positive effect on usage (Majumdar and Venkataraman, 1998). Secondly, larger share of urban population suggests that customers are more easily accessible to operators providing services based on a new technology. Thirdly, marketing messages can be delivered faster, efficiently and effectively in urban areas (e.g. Fell et al., 2003) Therefore we hypothesize:

Hypothesis 6: The higher the level of urban population, the shorter the takeoff time.

Also related to the urban population level is the national population density. It can be expected that people are more inclined to have numerous contacts with other members of society in a more densely populated countries and therefore more information sharing takes place (Klasen and Nestmann, 2004). They also conclude that new ideas can faster be used in relation to a new technology and this would increase the growth rate. In traditional diffusion literature population density would increase the imitation coefficient and result in faster adoption (Rogers, 1995). Further, also reaching possible users of a new technology with marketing efforts is easier. Therefore, we hypothesize:

Hypothesis 7: The more dense the country the shorter the takeoff time.

We measured national economic wealth by average GDP per capita in thousands of U.S dollars through the national adoption time. The national economic variables, especially GDP, has been showed in previous studies to have effects on national level technology adoption (e.g. Tellis et al., 2003, van den Bulte, 2000, Yeniyurt and Townsend, 2003). The earlier studies suggest with some confidence that the level of wealth positively affects the rate of adoption of new technologies. Therefore, we hypothesize:

Hypothesis 8: The higher the level of GDP the shorter the takeoff time.

METHODOLOGY AND DATA

In this research, we study the adoption of analog and digital wireless telephone, CD, personal computer and video camera technology globally. Analog radiotelephone services with manually operated exchanges have been neglected and only fully automatic analog mobile telephone systems are included. Data used in the study was the yearly penetration levels of wireless telecommunications subscribers and the yearly possessions of CD, PC and video camera in each national market. Therefore, the study concentrates on the category level of the technologies.

The main source for telecommunication data has been International Telecommunication Union (ITU), UN (United Nations), and OECD (Organisation for Economic Co-operation and Development). Other sources include International Engineering

Consortium (IEC), equipment vendors, telecommunication operators and trade journals and magazines like Telecommunications, Communications International, and Cellular Business etc. Multiple data sources were used to build sound establishment of the actual national launch year of the cellular telephone service. The source for CD, PC and video camera data has been Euromonitor's global marketing information database (GMID).

The total data set of telecommunication adoption time series for the present study included technology adoption of analog cellular telecommunications for 142 countries and digital cellular telecommunications for 169 countries[1]. The data set of CD, PC and video camera technologies included technology adoption of 42 countries in each technology. The analog cellular telecommunications category covered the years 1979 through 2000 and the digital cellular telecommunications category 1992 through 2000. The CD category covered the years 1981 through 2000, the PC category 1980 through 2000, and the video camera category 1976 through 2000.

Explanatory factors in our study included population variables, national wealth, and Hofstede's cultural dimensions. Hofstede's dimensions of culture and the scores (indices) are preferred to the rankings. The reason for the usage of scores rather than the indices is that the scores contain more accurate information. The rankings are derived from the statistically calculated scores. Mathematical indices describe the relative difference between the national cultures. For the purposes of the study scores represent more precisely the 'distance' between the cultures than the rankings. Further, culture and nation are used as synonyms. This is considered to be a generally accepted principle in the cultural discussion (Ganesh and Kumar, 1996).

Hofstede's dimensions had to be measured and identified for a country to be included in the study. Originally these have been identified for 50 countries. These countries were further screened to whether they had national launches of all the technologies to be studied. In addition also urban population, population density and GDP per capita had to be reported for the countries.

Once all the possible variables above were identified we had 214 data sets to be analyzed. From this dataset we determined the national takeoff points. In order to reliably and consistently determine the takeoff points in time series the study used a content analysis method. Other possibilities to determine the takeoff point would have been discrimination analysis procedure (Agarwal and Bayus, 2002, Gort and Klepper, 1982, Mahajan et al., 1990). However, these methods have been shown to produce less reliable estimates for the takeoff point than content analysis method with expert judges (Haapaniemi and Mäkinen, 2006).

The procedure for the determination of the takeoff point consisted of four steps. Firstly, we showed the training document (one figure) and gave instructions how to determine the takeoff point. Training document was an adoption figure which follows typical pattern of adoption and involves clear takeoff point. We gave instructions how to find "hockey-stick" pattern and the "elbow" point from the adoption figure. To find that point they had to figure out when the slope of the line drawn between two data points next to each other increased radically. We showed that this previous point is the year of takeoff.

[1] 'Country' is a UN and ITU classification that loosely treats some regions as countries.

Secondly, the researchers got training sample, a couple of typical figures, from which they determined the takeoff year. This involved figures where the takeoff point is self-evident, figures where it is not self-evident but can be found and figures where the penetration percentage increases smoothly. In addition to this the sample involved figures where the takeoff point does not exist. After this trial-determination, we checked the results and gave more instructions, if needed.

Thirdly, the researchers identified the takeoff points from the whole data set. We studied three different technologies, i.e., they had three similar sets of countries involving adoption figures of three different technologies.

Fourthly, we discussed the discrepancies emerged in the determination of the takeoff points. We asked the arguments for differing results in order to make sure that there were no mistakes or misinterpretation in the timing of the takeoff year.

This resulted in determination of whether there is a takeoff point in time series and if so which point it is. To test the hypotheses, we defined the relationship between dependent and independent variables by using a multivariable regression analysis with OLS estimation procedure (e.g. Newbold, 1995). The standard regression model is presented in Eq. 1.

$$y_i = \alpha_i + \beta_{ij} x_{ij} + \mu_i \qquad (1)$$

where y_i is the dependent variable (time it takes to reach the takeoff point of technology adoption) and x_{ij} is the independent variable j (Hofstede's dimensions, urban population, population density or GDP), α_i and β_{ij} are regression parameters, and μ_i is a random disturbance term with the mean of 0 for a country i. We tested the hypotheses by analyzing both the full model with all the variables in a multivariable regression and by identifying the model that is the best fit to the data. The best fitting model was identified by step-backward multivariable regression. From these alternative models, we identified the best F-statistics in conjunction with the significance and adjusted R square and in combination with the maximum amount of variables in the model.

RESULTS

Table 1 presents descriptive statistics and correlation matrix for all variables.

Table 1. Descriptive statistics and correlations for the different technologies.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Analog Takeoff Time	11.767	3.108	1.000												
2. Digital Takeoff Time	4.644	1.334		1.000											
3. CD Takeoff Time	5.703	3.943			1.000										
4. PC Takeoff Time	8.588	2.840				1.000									
5. Video Camera Takeoff Time	8.839	3.698					1.000								
6. Power Distance	55.188	22.201	0.346 *	0.313 *	-0.146	0.284	-0.199	1.000							
7. Individuality	44.813	26.010	-0.488 **	-0.423 **	-0.128	-0.415 *	0.168	-0.675 **	1.000						
8. Masculinity	49.625	18.733	0.153	0.180	-0.142	-0.319	-0.084	0.096	0.042	1.000					
9. Uncertainty Avoidance	64.854	24.877	0.359 *	0.373 *	-0.110	-0.247	-0.312	0.224	-0.326 *	0.008	1.000				
10. Long-term Orientation	42.690	21.609	-0.276	0.149	-0.206	-0.060	-0.624 **	0.263	-0.402 *	0.019	0.000	1.000			
11. Urban Population	67.788	19.242	-0.180	-0.052	-0.205	-0.127	-0.358 *	-0.323 *	0.417 **	0.009	-0.071	0.123	1.000		
12. Population Density	340.383	1084.353	-0.199	-0.195	0.104	0.420 *	-0.164	0.142	-0.175	0.045	-0.385 **	0.442 *	0.323 *	1.000	
13. GDP	13923.112	12252.087	-0.696 **	-0.589 **	-0.193	-0.282	0.018	-0.584 **	0.667 **	0.025	-0.237	0.066	0.521 **	0.214	1.000

* p < 0.05
** p < 0.01

We observed some substantial correlations but the strongest "pairwise" correlation among the independent variables indicated in Table 1 is that between power distance index –

individuality index (r = 0.675, p < 0.01) and individuality index – GDP (r = 0.667, p < 0.01). This finding suggests that multicollinearity was not a problem, especially in the latter case as the variables are theoretically derived from differing bases.

The estimation results of the multivariable regression analysis are presented in Tables 2 and 3. Table 2 shows the model with all independent variables.

Table 2. The multivariable regression models with all the variables for the different technologies.

	Analog		Digital		CD		PC		Video Camera	
Independent variable	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**
Power Distance	0.118	2.492	-0.002	0.994	-0.286	2.576	0.013	2.476	-0.367	2.942
Individuality	-0.319	4.911	-0.281	0.347	0.042	4.776	-0.140	4.001	0.244	5.546
Masculinity	0.366 *	1.128	0.379 *	0.023	-0.234	1.075	-0.290	1.266	-0.129	1.198
Uncertainty Avoidance	-0.165	2.233	-0.181	0.406	0.305	2.335	-0.144	2.421	0.431	2.449
Long-term Orientation	-0.279	1.721	0.265	0.148	-0.389	1.449	-0.208	1.528	-0.522 †	1.976
Urban Population	0.214	2.938	0.335	0.171	-0.217	2.806	-0.086	2.603	-0.566 †	3.363
Population Density	-0.292	4.243	-0.527 †	0.094	0.306	4.774	0.429	4.968	0.658 †	4.343
GDP	-0.494 *	2.319	-0.664 **	0.010	-0.123	2.682	-0.181	2.468	-0.010	2.601
R Square	0.551		0.577		0.295		0.409		0.494	
F	2.91 *		3.41 *		0.89		1.56		1.96	

† p < 0.10
* p < 0.05
** p < 0.01
*** p < 0.001

As seen from Table 2, there are no statistically significant variables in the models with CD and PC technology. Further, only the models for the analog and the digital telecommunication technologies are statistically significant. According to the results, power distance, individuality and uncertainty avoidance indices do not have statistically significant independent variables in any of the models. Therefore, we further analyzed the possible relationship between independent variables and dependent variables with searching the best fitting models. The justification for studying further the best possible models is that 1) the most of the models in the Table 2 are not significant 2) only few of the independent variables are significant, although earlier research has shown their significance 3) and significance level of independent variables that are significant is low. The Table 3 demonstrates the best models achieved with the independent variables.

Table 3. The best multivariable regression models for the different technologies.

	Analog		Digital		CD		PC		Video Camera	
Independent variable	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**	**Standardized Coefficient**	**VIF**
Power Distance			-0.133	2.082	-0.597 **	1.900			-0.510 †	2.358
Individuality	-0.250	2.557	-0.338 †	2.643					-0.666 *	2.476
Masculinity	0.196 †	1.009	0.227 †	1.051			-0.481 **	1.174	-0.724 ***	1.420
Uncertainty Avoidance							0.206	1.824		
Long-term Orientation							-0.391 *	1.512		
Urban Population	0.296 *	1.566	0.439 **	1.541	-0.229	1.411	-0.355 †	1.297		
Population Density	-0.230 †	1.573	-0.265 †	1.537	0.401 *	1.345	0.936 ***	2.183		
GDP	-0.633 ***	2.299	-0.619 ***	2.529	-0.528 *	2.122				
R Square	0.585		0.535		0.278		0.588		0.573	
F	10.41 ***		7.30 ***		3.09 *		5.14 **		7.61 **	

† p < 0.10
* p < 0.05
** p < 0.01
*** p < 0.001

According to the Table 3, all models exhibit significant F statistics (*F(analog)* = 10.41, p < 0.001; *F(digital)* = 7.30, p < 0.001; *F(CD)* = 3.09, p < 0.05; *F(PC)* = 5.14, p < 0.01; *F(video* *camera)* = 7.61, $p < 0.01$). The model of the analog cellular technology explained 58.5 % in the variation of takeoff time, and the model of digital cellular technology explained 53.5 % in the variation of takeoff time. In addition, the values of R square in CD, PC and video camera category are 0.278, 0.588, and 0.573, respectively. Since tolerance coefficients (VIF) are in the range of 1.009 – 2.643 and the acceptable level would be under 10, multicollinearity analysis shows that none of the independent variables have strong, disturbing linear relationship between each other.

The Table 3 shows that masculinity index, urban population and population density have differing signs of the coefficients for the technologies and therefore the hypotheses considering these independent variables remain unresolved. Further, this indicates that there exists a difference in the adoption dynamics between the technologies, e.g., the independent variables have inconsistent, category specific influences on the technology adoption dynamics.

According to the best models presented in the Table 3, the coefficient of power distance index is negative (*b(digital)* = -0.133, $p > 0.41$; *b(CD)* = -0.597, $p < 0.01$; (*b(video camera)* = -0.510, $p < 0.10$). The Hypothesis 1 suggests that the higher the power distance index is likely shorten the takeoff time. The result of digital telecommunication technology is not statistically significant, but the results of CD and video camera technologies are statistically significant, and the support the Hypothesis 1. Therefore, two out of five cases support the Hypothesis 1.

The coefficient of uncertainty avoidance index is positive in the model of PC technology (*b(PC)* = 0.206, $p > 0.33$). However, the result is not statistically significant and therefore the Hypothesis 2 remains unresolved.

The coefficient of individualism index has negative sign in the models of the analog (*b(analog)* = -0.250, $p > 0.15$), the digital (*b(digital)* = -0.338, $p < 0.10$) and the video camera (*b(video camera)* = -0.666, $p < 0.05$) technologies. However, only the results of digital telecommunication and the video camera technology are statistically significant. Therefore, two out of five cases support the Hypothesis 3, i.e., the higher the individuality index, the shorter the takeoff time.

The coefficient of long-term orientation is negative in PC technology (*b(PC)* = -0.391, $p < 0.05$). This supports the Hypothesis 5 that the higher the long-term orientation the longer the takeoff time. However, long-term orientation is statistically insignificant in all other technologies and therefore, the long-term orientation is not included in other models in Table 3. Therefore, only one out of five cases supports the Hypothesis 5.

The coefficient of GDP is negative in the best models for all the technologies where the independent variable is statistically significant (*b(analog)* = -0.633, $p < 0.001$; *b(digital)* = -0.619, $p < 0.001$; *b(CD)* = -0.528, $p < 0.05$). Therefore, the results suggest that a higher GDP makes the takeoff time shorter. The Hypothesis 8 – the higher the level of the GDP the shorter the takeoff time – is then supported by three cases out of five.

DISCUSSION

Generally the results with all the independent variables produce disappointing results as compared with previous studies. The statistical significance is poor, both for the models and for the most variables as well. This can be attributed either to the lack of coherent measurement of the takeoff time, or that the independent variables are not significant for the phenomenon under study or that the independent variables are not coherently measuring the cultural dimensions as the length of the takeoff time is considered.

Nevertheless, the search for significance and explanatory power in the best possible models including the subset of the independent variables, i.e., nested models, produces statistically significant models and also some of the independent variables become statistically significant. This way we were able to test our initial hypotheses in a meaningful way.

As can be observed from the Table 3 results models are statistically significant with different technologies. These results support partially the Hypothesis 1 (higher power distance index, longer takeoff time), the Hypothesis 3 (higher individualism index, shorter takeoff time), the Hypothesis 4 (higher masculinity index, shorter takeoff time), the Hypothesis 5 (higher long-term orientation index, shorter takeoff time), the Hypothesis 6 (higher urbanization, shorter takeoff time), the Hypothesis 7 (higher population density, shorter takeoff time), and the Hypothesis 8 (higher GDP, shorter takeoff time) are at least partially supported. Therefore, none of the Hypothesis attached to the independent variables are unequivocally supported.

In addition to the above, there are contradictory evidence for the Hypothesis 4 (higher masculinity index, shorter takeoff time), the Hypothesis 6 (higher urbanization, shorter takeoff time), and the Hypothesis 7 (higher population density, shorter takeoff time). For these Hypotheses the results are mixed demonstrating statistically significant supporting and contradicting evidence. Further, the Hypothesis 2 remains unresolved without statistically significant evidence.

These findings clearly suggest that further studies are needed to further study the relationship between the cultural attributes and the dynamics of the length of the takeoff time in a cross-national setting. For academic community the results present some intriguing contradictions to existing literature while providing additional backup for existing results. First of all, the fact that only partial support for the Hypotheses is found in this study raises need for additional queries on the topical area. What is causing the partiality of the support; the industry, category, temporal or some other factors? These might prove to be worthwhile future research avenues. Fruitful research avenues for future research include exploring other cultural and national attributes and their possible relationships with the takeoff timing. Also studies considering other industries and technologies would advance our understanding on the attributes and variables influencing the takeoff timing. These other industries could be differing from consumer electronics used in this study, for example fast moving goods.

This raises some serious questions on the generalisability of technology adoption modelling across technologies. The questions fall into two basic categories; have the national attributes changed in time or are the technologies and their launches differing from one another so significantly that generalizations cannot be made. Cultural dimensions have been found to be stable in time, i.e., they do not change frequently. Further, changes in other national level attributes can be measured and these change based measures might shed light further on the effects of national level attributes on the differing results on technologies found in the results of this study. Other results were not statistically significant and also this needs further analysis. Additional research also on the actions and events taken place in the national technology launches of subsequent technological generations is also called for to find out how the launches have differed and whether these changes would explain the differing results found in this study.

The practical results of the study suggest that masculine, urbanization and population density have mixed influences on the technology adoption. The results show that these variables both inhibit and promote the technology adoption, depending on the technology. Therefore, these variables can be used but industry-specificity needs to be accounted for when considering their influences. Practical results from the study further suggest that companies can expect a faster takeoff of technology life cycle from more equal (low power distance), individualistic (high individualism), more future oriented (high long-term orientation) and wealthy countries (high GDP). Especially these results are important in practicing community when investigating and planning international operations and market entry order. The results suggest that directing the marketing effort in the launch to these countries results in faster adoption of new technologies.

REFERENCES

Agarwal, R. & Bayus, B. L. (2002) The market evolution and sales takeoff of product innovations. *Management Science,* 48**,** 1024-1041.

Daghfous, N., Petrof, J. V. & Pons, F. (1999) Values and adoption of innovations: a cross-cultural study. *Journal of Consumer Marketing,* 16**,** 314-331.

Dawar, N., Parker, P. M. & Price, L. J. (1996) A Cross-cultural study of Interpersonal Information Exchange. *Journal of International Business Studies,* 27**,** 497-516.

De Mooij, M. (2004) *Consumer Behavior and Culture. Consequences for Global Marketing and Advertising,* Thousand Oaks, CA, Sage Publications.

De Mooij, M. & Hofstede, G. (2002) Convergence and divergence in consumer behavior: implications for international retailing. *Journal of Retailing,* 78**,** 61-99.

Dekimpe, M. G., Parker, P. M. & Sarvary, M. (1998) Staged estimation of international diffusion models: An application to global cellular telephone adoption. *Technological Forecasting and Social Change,* 57**,** 105-132.

Doney, P. M., Cannon, J. P. & Mullen, M. R. (1998) Understanding the influence of national culture on the development of trust. *Academy of Management Review,* 23**,** 601-620.

Douglas, S. & Craig, S. C. (1995) *Global marketing strategy,* New York, USA, McGraw-Hill.

Dwyer, S., Mesak, H. & Hsu, M. (2005) An exploratory examination of the influence of national culture on cross-national product diffusion. *Journal of International Marketing,* 13**,** 1-27.

Fell, D. R., Hansen, E. N. & Becker, B. W. (2003) Measuring innovativeness for the adoption of industrial products. *Industrial Marketing Management,* 32**,** 347-353.

Ganesh, J. & Kumar, V. (1996) Capturing the cross-national learning effect: An analysis of an industrial technology diffusion. *Journal of the Academy of Marketing Science,* 24**,** 328-337.

Ganesh, J., Kumar, V. & Subramaniam, V. (1997) Learning effect in multinational diffusion of consumer durables: An exploratory investigation. *Journal of the Academy of Marketing Science,* 25**,** 214-228.

Gatignon, H., Eliashberg, J. & Robertson, T. S. (1989) Modeling multinational diffusion patterns: An efficient methodology. *Marketing Science,* 8**,** 231-247.

Gatignon, H. & Robertson, T. S. (1985) A propositional inventory for new diffusion research. *Journal of Consumer Research,* 11**,** 849-867.

Gort, M. & Klepper, S. (1982) Time paths in the diffusion of product innovations. *The Economic Journal,* 92**,** 630-653.

Haapaniemi, T. & Mäkinen, S. (2006) Determining Takeoff Point of Innovation Adoption in International Setting: An Analysis of Three Methods. *IAMOT 2006.* Beijing, China.

Heeler, R. M. & Hustad, T. P. (1980) Problems in predicting new product growth for consumer durables. *Management Science,* 26**,** 1007-1020.

Helsen, K., Jedidi, K. & Desarbo, W. S. (1993) A new approach to country segmentation utilizing multinational diffusion patterns. *Journal of Marketing,* 57**,** 60-71.

Hofstede, G. (1980) *Culture's Consequences: International Differences in Work-related Values,* Beverly Hills, CA, Sage Publications.

Hofstede, G. (1997) *Cultures and Organizations. Software of the Mind,* New York, USA, McGraw-Hill.

Hofstede, G. (2001) *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations,* Thousand Oaks, California, Sage Publications.

Hofstede, G. & Hofstede, G. J. (2005) *Cultures and Organizations: Software of the mind,* New York, USA, McGraw-Hill.

Klasen, S. & Nestmann, T. (2004) Population, population density and technological change. *CESifo Working Paper Series*.

Kluckhohn, C. (1951) Values and Value-Orientations in the Theory of Action: An Exploration in Definition and Classification. IN Parsons, T. & Shils, E. A. (Eds.) *Toward a General Theory of Action.* Cambridge Massachusetts, Harvard University Press.

Kumar, V., Ganesh, J. & Echambadi, R. (1998) Cross-national diffusion research: What do we know and how certain are we? *Journal of Product Innovation Management,* 15**,** 255-268.

Mahajan, V. & Muller, E. (1994) Innovation diffusion in a borderless global market: Will the 1992 unification of the European Community accelerate diffusion of new ideas, products, and technologies? *Technological Forecasting and Social Change,* 45**,** 221-235.

Mahajan, V., Muller, E. & Srivastava, R. K. (1990) Determination of adopter categories by using innovation diffusion models. *Journal of Marketing Research,* 27**,** 37-50.

Majumdar, S. K. & Venkataraman, S. (1998) Network effects and the adoption of new technology: Evidence from the U.S. telecommunications industry. *Strategic Management Journal*, 19**,** 1045-1062.

Newbold, P. (1995) *Statistics for business & economics,* Englewood-Cliffs, New Jersey, Prentice-Hall.

Putsis, W. P. J., Balasubramanian, S., Kaplan, E. H. & Sen, S. K. (1997) Mixing behavior in cross-country diffusion. *Marketing Science,* 16**,** 354-369.

Rogers, E. M. (1995) *Diffusion of innovations, 4th Ed.,* New York, USA, The Free Press.

Rokeach, M. (1970) *Beliefs, Attitudes, and Values: A Theory of Organization and Change,* San Francisco, Cal., Jossey-Bass Inc.

Schneider, S. C. & Barsoux, J.-L. (1997) *Managing across Cultures*, London, UK, FT Prentice Hall.

Schwartz, S. H. (1997) Values and Culture. IN Munro, D., Carr, S. C. & Schumaker, J. F. (Eds.) *Motivation and Culture.* New York, USA, Routledge.

Sivakumar, K. & Nakata, C. (2001) The Stampede Toward Hofstede's Framework: Avoiding the Sample Pit in Cross-Cultural Research. *Journal of International Business Studies,* 32**,** 555-574.

Steenkamp, J.-B. E. M., Hofstede, F. & Wedel, M. (1999) A Cross-National Investigation into the Individual and National Cultural Antecedents of Consumer Innovativeness. *Journal of Marketing,* 63**,** 55-69.

Søndergaard, M. (1994) Hofstede's Consequences: A Study of Reviews, Citations and Replications. *Organization Studies,* 15**,** 447-456.

Takada, H. & Jain, D. (1991) Cross-national analysis of diffusion of consumer durables in Pacific Rim countries. *Journal of Marketing,* 55**,** 48-54.

Talukdar, D., Sudhir, K. & Ainslie, A. (2002) Investigating new product diffusion across products and countries. *Marketing Science,* 21**,** 97-114.

Tellefsen, T. & Takada, H. (1999) The relationship between mass media availability and the multicountry diffusion of consumer products. *Journal of International Marketing,* 7**,** 77-96.

Tellis, G. J., Stremersch, S. & Yin, E. (2003) The International Takeoff of New Products: The Role of Economics, Culture and Country Innovativeness. *Marketing Science,* 22**,** 188-208.

Triandis, H. C. (1989) The self and social beravior in differing cultural contexts. *Psychological Review,* 96**,** 506-520.

Waarts, E. & Van Everdingen, Y. (2005) The influence of national culture on the adoption status of innovations: An empirical study of firms across Europe. *European Management Journal,* 23**,** 601-610.

Van Den Bulte, C. (2000) New product diffusion acceleration: Measurement and analysis. *Marketing Science,* 19**,** 366-380.

Watson, J., Lysonski, S., Gillan, T. & Raymore, L. (2002) Cultural values and important possessions: a cross-cultural analysis. *Journal of Business Research,* 55**,** 923-931.

Wolf, C. J. (2000) Globalization: Meaning and measurement. *Critical Review,* 14**,** 1-10.

Yeniyurt, S. & Townsend, J. D. (2003) Does culture explain acceptance of new products in a country? An empirical inverstigation. *International Marketing Review,* 20**,** 377-396.