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Moderating effect of national attributes and the role of cultural dimensions in technology adoption takeoff

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ABSTRACT

Purpose: Due to the globalization of business, a better understanding of companies' international multi-cultural market environment is needed in the search for competitive advantage. This study focuses on the influence of national cultural dimensions on the evolution of national innovation adoption over time. The paper considers the moderating effects of national wealth, population density, and illiteracy rate on the role of cultural dimensions in the timing of innovation takeoff in national markets.

Methodology and approach: The empirical study investigates 137 national innovation adoption time series; the dependent variable being the time it takes for innovation adoption to take off. The independent variables are Hofstede's five cultural dimensions and the moderating variables are GDP, population density, and illiteracy rate.

Findings: The outcome of the study shows that cultural dimensions have a greater influence on takeoff time in countries with highly developed economies, dense populations, and low illiteracy rates. The study also shows that especially the cultural dimension of individualism has a significant context independent influence on takeoff dynamics whereas masculinity has no such effect.

Research limitations and implications: The paper provides evidence that the influence of cultural dimensions may be more complex than previously believed. Contribution of the research to the academic community especially lies in results regarding moderation effect of GDP, population density and illiteracy. Other independent and moderating variables could provide useful subjects for further research.

Practical implications: The results of this study could assist companies conducting business in cross-national settings in planning their international operations in such areas as designing marketing promotions and deciding the entry order into national markets. Especially useful the results are in pre-takeoff phase of the evolution of innovation adoption.

Originality and value of paper: The paper extends our understanding of the relationship between the national cultural dimensions and the early evolution of innovation adoption. Especially, incomplete understanding of the cross-national dynamics of the innovation adoption takeoff is scrutinized and the findings support earlier research that cultural dimensions affect adoption dynamics. Additionally, the study demonstrates that the influence of cultural dimensions may be dependent on and moderated by other national attributes.

Keywords: takeoff point, adoption of innovations, moderation effect, Hofstede's cultural dimensions, empirical research

Introduction

The study investigates the dynamics of the cross-national adoption of innovations. The focus is on the influence of cultural dimensions on the evolution of national innovation adoption over time. Foresight and an understanding of the dynamics of adoption are needed in most managerial decisions and could significantly help improving the process. Earlier empirical studies have shown that not only the dynamics of national adoption, but also the start of the adoption (i.e., national launch timing), depends on various national level attributes (Ganesh et al., 1997, Takada and Jain, 1991). Further, the attributes have varying degrees of influence on the adoption dynamics at the national level (Golder and Tellis, 2004, Ganesh and Kumar, 1996, Tellis et al., 2003, e.g. Andonova, 2006, de Mooij, 2000).

Adoption of innovations, i.e. purchase or acquisition of innovations traverses various customer segments, which differ dramatically in their characteristics along the adoption life cycle (e.g. Moore, 1999, Rogers, 1995). Because of differing customer segments and motives to adopt innovations, adoption has been divided into separate phases, from initial slow growth to accelerating growth and, finally, to maturity and decline (Rogers, 1995). Adopters in slow growth phase are distinctive in that they have a high degree of technological sophistication and knowledge. Marketing communications, product designs, and advertising message should, therefore, differ for the adopters in a slow growth phase compared with markets later in adoption (e.g. Mohr, 2001).

The transition points between the phases have also recently attracted attention, especially the intermediate point between the introductory and growth phases (e.g. Agarwal and Bayus, 2002). This takeoff point marks a dramatic change in customer requirements and preferences, from technical functionality to usability and reliability (Moore, 1999, Rogers, 1995). In an international setting, the change can be particularly challenging for marketing operations due to the heterogeneous nature of the markets. As a result, companies developing innovations and products must change the focus of their approach from technical functionality to market oriented factors such as reliability and usability (Christensen, 1997).

Previous research into international innovation adoption has focused on comparing estimates of diffusion parameters between countries (e.g. Gatignon and Robertson, 1985, Heeler and Hustad, 1980, Helsen et al., 1993, Mahajan and Muller, 1994, Talukdar et al., 2002). To explain the differences in diffusion parameters between countries, these studies have reported that the adoption process is both product and country specific and that cross-national characteristics also affect adoption (Kumar et al., 1998, Takada and Jain, 1991, Tellefsen and Takada, 1999, e.g. Gatignon et al., 1989, Stremersch and Tellis, 2004, Golder and Tellis, 2004).

Diffusion models, however, have been criticized in an applied international setting from a number of standpoints. Heeler and Hustad (1980) report difficulties in adapting diffusion models to in international setting. In their research review of diffusion, Mahajan, Muller and

Bass (1990a) note that parameter estimation for diffusion models is primarily of historical research interest rather than guiding managerial actions. Reliable estimation also requires that data span the inflection point to the growth phase of technology or product life cycle (Schmittlein and Mahajan, 1982). In addition, Dekimpe et al. (1998) provide evidence to show that estimation of diffusion parameters can be risky and misleading in an international setting.

The current research does not deal in a comprehensive way with the dynamics of the phenomenon of innovation adoption in a cross-national setting. Among the few earlier studies are Haapaniemi (2006) and Mäkinen et al. (2005), but these do not consider such moderation either. To redress the situation, the present paper examines the relationship between cultural dimensions and the length of takeoff time. It also considers the moderating effects of GDP per capita, population density, and illiteracy rate on this relationship. The practical implications of the findings are also discussed.

Theoretical Foundations

Generally, innovations are first adopted gradually after a product's commercial launch (Bass, 1969, Gort and Klepper, 1982, Rogers, 1995) and then, later, after takeoff at a sharply increasing rate. Innovators make up the customer segment in the early phases of innovation adoption (Rogers, 1995). Innovators differ from subsequent customer segments in their lower price sensitivity. They also tolerate unreliable products and prefer functionality over ease of use to a greater extent than later customer segments in adoption dynamics (Rogers, 1995). Therefore, the shift from the introductory phase of innovation adoption to the growth phase represents a major challenge for companies selling new products in the business sector (Moore, 1999).

For most innovations, the takeoff point is clear because typically they penetrate the market rapidly upon reaching mass markets (Tellis et al., 2003). Agarwal and Bayus (2002) report that takeoff can be seen as "hockey-stick" or "elbow shape" pattern in sales histories. Takeoff point is critical because the shift from the pre-takeoff to post-takeoff phase in innovation adoption represents a major hurdle for companies selling new products in their business sector (Moore, 1999, Rogers, 1995). Takeoff point is the juncture in innovation dynamics where dominant designs are adopted (Utterback, 1994).

Studies on takeoff has been largely ignored in marketing literature (Mahajan et al., 1990a, Kalish et al., 1995, Agarwal and Bayus, 2002). Golder and Tellis (1997) and Tellis (1994) were the first to conduct an empirical study of product takeoff. They examined totally new household consumer durables and identified a takeoff point for them. They found that price and market penetration seemed to be strongly associated with takeoff point. Agarwal and Bayus (2002) studied consumer and industrial product innovations and explored the evolution of innovation adoption in relation to industry structure. They found that demand shifts during the early evolution of a new market due to non-price factors are the key driver of a sales takeoff. Montaguti et al. (2002) have also provided a discussion and a conceptual framework of takeoff in technology industries. However, these studies were conducted with no international or cross-national focus, and consider only a single country.

In multi-country terms, different countries launch new innovations in a sequence rather than all at the same time (e.g. Tellis et al., 2003). Additionally, differing customer segments are reached at different times in adoption. In the current literature, the time that has elapsed after the first global launch of a new innovation is often referred to as launch-lag and it has been showed to quicken adoption dynamics on a national level. (Takada and Jain, 1991, Ganesh and Kumar, 1996, Ganesh et al., 1997, Kumar et al., 1998). According to these studies, the phenomenon is referred to as a "lead-lag effect" or "cross-national learning effect", where decision-makers gather and communicate information across national borders, not solely within a national context.

Culture is a relatively unified set of shared symbolic ideas associated with societal patterns of cultural environment (Gudykunst and Kim, 1984). Culture and national level attributes have been shown to have impacts on technology and innovation adoption in a cross-national setting (e.g. de Mooij, 2000). For example, Tellis et al. (2003) report that innovations are adopted more rapidly in wealthy and educated countries and in more open and internationally focused economies than in poor or less open economies. They also observe that a greater need for achievement, lower uncertainty, and industriousness are factors that affect adoption dynamics. Economic conditions were also found to affect adoption in a study by Golder and Tellis (2004). Moreover, it has been shown that cultural value differences persist, even if markets continue to globalize and national incomes converge (Watson et al., 2002, de Mooij, 2000). 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.

Hofstede (1980), among other researchers, has reduced the multidimensional cultural attributes affecting individual behavior into researchable constructs. His cultural dimensions are based on analyses of IBM Corporation employees' values in 1960s and 1970s. The dimensions have been used in earlier research seeking explanatory factors for national level behaviors and cross-cultural variations (e.g. Dawar et al., 1996). There is considerable research that supports the existence of the dimensions and their role in classifying national cultures (e.g. Watson et al., 2002). Dwyer et al. (2005) have linked Hofstede's cultural dimensions to cross-national product diffusion. Though Hofstede's dimensions are not without their critics, they can still be considered as a coherent theory to explain variation between national cultures (Sivakumar and Nakata, 2001, Søndergaard, 1994, McSweeney, 2002b, Hofstede, 2002, McSweeney, 2002a, Yeniyurt and Townsend, 2003, Hofstede, 2006, Javidan et al., 2006, Earley, 2006, Smith, 2006). Despite the criticism, researchers have favored this framework because of its clarity, parsimony and resonance with managers (Kirkman et al., 2006). On the basis of previous work it can, therefore, be concluded that the validity and the reliability of the dimension are well established in the current literature.

Hofstede's original four cultural dimensions power distance (PDI), individualism (IDV), masculinity (MAS), and uncertainty avoidance (UAI) indices represent cultural variability and different value systems between cultures (Hofstede, 1980). Hofstede's is a broad concept of culture, comprising everyday practices, symbols, and rituals shared by members of a society (Schwartz, 1997). Confucian work dynamism was later added to the original four dimensions; this is often labeled as long-term orientation (LTO) (Hofstede and Bond, 1988). The values form the core of culture and define tendencies to prefer certain states of affairs over others (Hofstede, 1997).

Power distance is "the extent to which the less powerful members of [a culture] expect and accept that power is distributed unequally" (Hofstede, 2001). In high PDI cultures hierarchy and its pervasiveness inhibits individual decision-making (Hofstede, 1997). More broadly, PDI captures how sensitive people are to status differences and how much they are motivated by the need to conform with those in their status group or in status groups to which they aspire (Roth, 1995). High PDI also leads to a general distrust of others, which further inhibits fast and decisive decision-making (Dawar et al., 1996). High PDI cultures tend to have calculative trust formation, while low PDI cultures form trust through a benevolent intentionality process (Doney et al., 1998).

The extent to which status differences are accepted affects how important it is to adopt the "right" innovations at the "right" time. In these conditions decisions as to whether to adopt an innovation are highly dependent on the agents of change at the society level. On the one hand, one must not adopt too early to avoid appearing presumptuous about one's place in society. On the other hand, people will seek to emulate the consumption behavior of their superiors (Tarde, 1903) and aspiration groups (Simmel, 1971) and will also quickly pick up innovations adopted by others of similar status if they fear that such adoptions might undo the present status ordering (Burt, 1987).

High power distance has been found to hinder the adoption of new products (Sivakumar and Nakata, 2001). Further, Steenkamp et al. (1999) report that PDI cannot be related to consumer innovativeness. Tellis et al. (2003) found neither theoretical arguments nor empirical support linking it to takeoff time of new products. However, in earlier research, high PDI has also been found to have positive effects on adoption dynamics (Dwyer et al., 2005). Therefore, we hypothesize the following:

> *Hypothesis 1*: The higher PDI is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts.

Need for achievement and industriousness can be closely associated with individualism index (Tellis et al., 2003, Peapody, 1985). Independent decision making, pleasure, personal time, and the need for personal reward are the preferred values in individual cultures with high IDV (Triandis, 1995, Schwartz, 1992). Individualism is the opposite of collectivism, which is the extent to which “people from birth onwards are integrated into strong, cohesive in-groups” (Hofstede, 2001). Collectivism denotes an emphasis on group welfare. Members of collectivistic cultures with low IDV do not follow purely individualistic behaviors, while well-being is attained by more individualistic driven motives and behaviors in high IDV cultures.

Individualism becomes operationalized through audacious experimentation and curiosity in the sense of seeking new knowledge (Hofstede, 1997, Tellis et al., 2003). In collectivist cultures people work more for the community and spend greater time in group settings. “We”-identity, duty, and loyalty come first (Hofstede, 1997). People have a tendency to take care of their social networks and relationships. The need for personal reward and initiative are preferred values in individual cultures. In collective cultures members of the society seek acceptance of the group they belong to and express needs for maintaining harmony and traditions (Schneider and Barsoux, 1997). Steenkamp et al. (1999) find a positive correlation between a country’s individualism and its citizens’ consumer innovativeness. Further, high IDV is linked to earlier adoption of new products (Sivakumar and Nakata, 2001). Previous studies indicate that a high IDV results in faster adoption of new products. We, therefore, hypothesize the following:

> *Hypothesis 2*: The higher IDV is in a country, the shorter the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts.

Masculinity is the extent to which “social gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success; women are supposed to be more modest, tender, and concerned with quality of life” (Hofstede, 2001). Important for consumer behavior, masculine cultures place more emphasis on wealth, material success, and achievement (Steenkamp et al., 1999, de Mooij, 1998). As a result, the display of status in general and the display of material possessions in particular are both more prevalent in masculine than in feminine cultures. More feminine cultures attach greater importance to social goals, such as relationships and more masculine cultures attach more importance to ego goals, such as careers and status (Hofstede, 2001). Femininity is associated more with taking care of people, equality in relationships, and a concern for work life and the environment. Generally the gender roles are more equal in feminine cultures than in masculine cultures (Hofstede, 1997).

Steenkamp et al. (1999) report a positive correlation between masculinity and consumer innovativeness. However, certain studies suggest that MAS has no significant effect on product acceptance or innovation adoption (Tellis et al., 2003, Yeniyurt and Townsend, 2003). In the earlier literature it has also been found that the degree of masculinity is linked to ownership of luxury articles, for example, which reflects greater success and attracts more members of masculine cultures than members of feminine cultures (de Mooij and Hofstede, 2002). The adoption of new products might be a significant aspect of exhibiting wealth and success, which in turn may be more compatible with masculine societies and an influence on takeoff time. However, so far this lacks empirical support (Tellis et al., 2003). On the basis of the above discussion we hypothesize the following:

> *Hypothesis 3*: The higher MAS is in a country, the shorter the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts.

Uncertainty avoidance is "the extent to which the members of a culture feel threatened by uncertain or unknown situations". Uncertainty creates anxiety in individuals and this anxiety is managed with the aid of technology (artifacts), laws (rules), and religion (knowledge of unknown) at the society level, as well as at the individual level (Hofstede, 1997). A lower intrinsic tendency to adopt innovations would be expected because consumers in such countries are more averse to what is different and new. (Hofstede, 2001) Higher UAI creates group pressure and fosters avoidance of being different from the social group that individuals belong to. High UAI is associated with a strong identification with one's own group and its rules (Dawar et al., 1996). This identification fosters the belief that threats to existing structures are to be avoided. In those cultures that strive to avoid uncertainty, the individual's behavior must be perceived as positive, desirable, and loyal to maintain group membership (Vitell et al., 1993).

Tellis et al. (2003) report that low uncertainty avoidance results in faster overall adoption. A study by Steenkamp et al. (1999) provide additional support for this by finding a negative correlation between the country's UAI and its citizens' innovativeness. Research by Rallapalli et al. (1994) reports that a propensity for taking risks is highly correlated with unethical actions in a consumer setting. Further, it has been found that cultures with high UAI are intolerant of ambiguity and distrustful of new ideas or behaviors (Dawar et al., 1996). Further, high UAI hinders adoption of new products (Sivakumar and Nakata, 2001, Tellis et al., 2003). Therefore, we hypothesize the following:

> *Hypothesis 4*: The higher UAI is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts.

Long-term orientation is related to a culture's orientation to the future. The LTO dimension relates to the temporal emphasis of a society, whether goal seeking behavior is directed to long-term goals or short-term results are sought. A high LTO value indicates an emphasis on building relationships, perseverance in gaining slow results and concentration on future prosperity, rather than short-term fulfillment (Hofstede, 2001). Short-term orientations focus on respect for tradition, personal steadiness and stability, fulfilling social obligations, and a reciprocation of favors and gifts. However, there is no consensus as to whether LTO has an effect on behavior at the organizational or group level (e.g. Peterson et al., 2002). Short-term values are oriented toward the past and the present. (Bond et al., 1987, Hofstede, 2001, Hofstede and Bond, 1988, Kirkman et al., 2006)

In earlier studies of product adoption dynamics, a high long-term orientation value has been found to positively influence the adoption of information systems at a company level (Waarts and van Everdingen, 2005), possibly due to the large investment decisions involved. However, at the societal level, in countries with a low LTO individual behavior is directed to achieving quick results. There are also social pressures on spending and social status is considered an obligation (Hofstede and Hofstede, 2005). Therefore, we hypothesize as follows:

> *Hypothesis 5*: The higher LTO is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts.

In addition to the above, earlier studies suggest that some moderation variables temper the effect of cultural dimensions. Our first moderation variable is a measure for national level of wealth and economic development. We measured national economic wealth in terms of gross domestic product (GDP) per capita in thousands of U.S dollars, at rates for 1995. The national economic variables, especially GDP, have been shown in previous studies to affect national level innovation adoption (e.g. Tellis et al., 2003, van den Bulte, 2000, Yeniyurt and Townsend, 2003). Therefore, we expect GDP to have a moderating effect on the role of cultural dimensions:

> *Hypothesis 6*: The level of economic development moderates the effects of cultural dimensions on takeoff time.

Besides the level of economic development, it is reasonable to assume that in densely populated countries people have more numerous contacts with other members of society. (Klasen and Nestmann, 2004). In densely populated countries more information sharing takes place and innovations can be expected to diffuse more rapidly (Fell et al., 2003). Population density also influences the adoption of innovation indirectly by creating higher returns on investment in public goods, such as electricity networks or other infrastructure (Frederiksen, 1981). To some degree this can be expected to lead to faster innovation adoption. In addition, the traditional diffusion literature postulates that population density would increase the imitation coefficient of diffusion (Rogers, 1995) even though the innovation coefficient negatively correlates with the imitation coefficient, and the resulting adoption influence is ambiguous. Therefore, we expect population density to have a moderating effect on the influence of cultural dimensions:

> *Hypothesis 7*: Population density moderates the effects of cultural dimensions on takeoff time.

Literacy rate is defined as the percentage of adults (over the age of 15) that can read, write, and understand short simple statements. This is a widely used measure of educational systems and their development (e.g. Glenn and Gordon, 2001). Education facilitates the development of individuals' understanding of the world around them and also promotes an understanding of different cultures. In addition, lower levels of literacy somewhat inhibit formal communication channels and their effectiveness in a country. In earlier studies the illiteracy rate has been found to correlate negatively with technology diffusion (Andonova, 2006). Furthermore, the literacy rate has been found to moderate product adoption at the national level (Yeniyurt and Townsend, 2003). Therefore, we hypothesize the following:

Hypothesis 8: Illiteracy rates moderate the effects of cultural dimensions on takeoff time.

The following Table 1 summarizes the hypotheses.

Table 1 about here

Data and methodology

The empirical data set covered 49 national markets throughout the world (see Appendix). The data set consisted of the annual level adoption data of three category: cellular telephone, personal computer, and internet hosts. These three time series consisted of the same 49 national markets for each innovation. The cellular telephone category covered the years 1978 through 2004, the PC category 1979 through 2004, and the internet hosts category 1974 through 2004. The source of the time series was International Telecommunication Union's (ITU) World Telecommunication Indicators database.

The dependent variable in the study was the time (in years) taken for a national innovation adoption to take off. This is the time needed from national commercial launch to reach the point where "elbow" shape (i.e., takeoff point) exists. It is followed by the first dramatic and sustained increase in innovation category adoption (Golder and Tellis, 2004). In order to reliably and consistently determine takeoff points in a time series, the study used a content analysis method. Other ways of determining takeoff point include discrimination analysis procedure (Agarwal and Bayus, 2002, Gort and Klepper, 1982, Mahajan et al., 1990b). However, these methods have been shown to give a less reliable estimates of takeoff point than the content analysis method using expert judges (Haapaniemi and Mäkinen, 2007)

Content analysis involved two expert researchers making subjective classifications of research objects i.e. finding the takeoff point from the time series data. The classifications were based on a handbook that outline guidelines for an analyst to identify, extract and classify research objects i.e. separating the takeoff point from the time series. Data from countries where experts' determinations showed marked differences between each other or where the adoption dynamics was distorted were eliminated from the data set. This is because with a smooth or linear pattern of adoption, the takeoff point in these outliers cannot be precisely determined.

The independent variables were Hofstede's five cultural dimensions, which – as mentioned earlier – are widely considered as reliable measures of culture. In the dimensions, scores (indices) are preferred to rankings. The reason for choosing scores over rankings is that the scores contain more accurate information. The rankings are derived from the statistically calculated scores, and the mathematical indices also describe the relative difference between the national cultures. For the purposes of the study, scores represent the 'distance' between the cultures more precisely than rankings. Further, culture and nation are used synonymously. This is considered to be a generally accepted principle in cultural discussion (Ganesh and Kumar, 1996). In addition, we studied the moderating effect of three national attributes, namely wealth measure (GDP per capita in thousands of U.S dollars in 1995), population measure (population density), and education measure (illiteracy rate). The source of these three data sets was the World Bank Group's World Development Indicators (WDI) database.

Hofstede's dimensions had to have been measured and identified for a particular country for it to be included in the study. Hofstede's cultural dimensions have been identified for 50 countries (Hofstede, 2001). The data set consisted of the adoption data for 49 countries, thus one country from the Hofstede's original data set (El Salvador) was rejected due to a lack of data. Therefore, the total data set of time series for the present study – after the elimination of outliers – included innovation adoption data on mobile telephone for 49, PC for 41 and internet hosts for 47 countries.

The relationship between dependent and independent variables was studied by using a nested univariate regression analysis instead of multivariate regression analysis (e.g. Newbold, 1995). The independent variables were considered separately in the study in order to discover and understand the influence of single independent variables on the extent of takeoff in each innovation category.

Following Yeniyurt et al. (2003), we also studied the effect of moderation variables on the influence of cultural dimensions. In order to test the moderating effects of GDP, population density, and illiteracy, a median split was employed. That is, the data set was split according to median of each moderating variable. This resulted in groups having significantly different means from original time series.

Results

Table 2 below presents the descriptive statistics and correlation matrix for the variables used in the study.

Table 2 about here

We observed a number of substantial correlations, but the strongest pairwise correlation among the variables in Table 2 is that between IDV – GDP (r = 0.688, $p < 0.01$) and PDI – IDV (r = 0.678, $p < 0.01$). However, the variables are mainly measuring different aspects and the independent variables are used separately, therefore the multicollinearity does not pose a problem.

The estimation results of the nested univariate regression models for each innovation including all countries are presented in Table 3.

Table 3 about here

According to Table 3, the coefficient of PDI is statistically significant for mobile telephone (*b(PDI)* = 0.469, $p < 0.001$) and in internet host (*b(PDI)* = 0.484, $p < 0.001$) innovations. The coefficients are positive and thus support Hypothesis 1, namely that the higher PDI is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts. Two out of three innovations are, therefore, statistically significant, and support Hypothesis 1.

The coefficient of IDV is statistically significant and negative for mobile telephone (*b(IDV)* = -0.577, $p < 0.001$), in PC (*b(IDV)* = -0.350, $p < 0.05$), and for internet host (*b(IDV)* = -0.655, $p < 0.001$) innovations. Therefore, in more individualistic cultures, people are likely to adopt innovation more rapidly. Hypothesis 2, (the higher IDV is in a country, the shorter the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts) is thus supported by three out of three innovations.

The result shows that the coefficient of MAS is not statistically significant for any of the three innovations. Therefore, Hypothesis 3 (the higher MAS is in a country, the shorter the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts) remains unresolved.

The coefficient of UAI is statistically significant and positive in mobile telephone (*b(UAI)* = 0.245, $p < 0.10$) innovation. Therefore, Hypothesis 4 (the higher UAI is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts), is supported by one out of three innovations.

The coefficient of LTO is not statistically significant in any of the cases. As a result, Hypothesis 5 (the higher LTO is in a country, the longer the takeoff time will be for the country in the adoption of mobile telephone and PC, and the number of internet hosts), remains unresolved.

Tables 4–6 below show the results of the study for the effect of moderation variables on the influence of cultural dimensions on takeoff timing. Table 4 presents the results of the nested univariate regression models for each three innovations after median split of GDP.

Table 4 about here

As Table 4 shows, for mobile telephone innovation, there are no statistically significant variables in low GDP countries. In high GDP countries, statistically significant is UAI (*b(UAI)* = 0.366, $p < 0.10$).

In the case of PC innovation, there are no statistically significant variables for either low or high GDP countries.

In internet hosts innovation, there are no statistically significant variables in low GDP countries. However, in high GDP countries, statistically significant are PDI (*b(PDI)* = 0.508, $p < 0.01$), IDV (*b(IDV)* = -0.662, $p < 0.001$), UAI (*b(UAI)* = 0.486, $p < 0.05$), and LTO (*b(LTO)* = 0.586, $p < 0.01$).

Therefore, Hypothesis 6 (the level of economic development moderates the effects of cultural dimensions on takeoff time) is partially supported. In the case of mobile telephone innovation, there is one more statistically significant variable in countries with high GDP. In the case of internet hosts innovation, there are four statistically significant variables more in countries with high GDP. In other words, the result of internet hosts innovation strongly supports this hypothesis. Therefore, two out of three innovations support Hypothesis 6.

Table 5 presents the results of the nested univariate regression models for each three innovations after median split of population density.

Table 5 about here

Table 5 shows that for mobile telephone innovation, the statistically significant variables in low population density countries are PDI (*b(PDI)* = 0.521, $p < 0.01$), IDV (*b(IDV)* = -0.658, $p < 0.001$), UAI (*b(UAI)* = 0.538, $p < 0.01$), and LTO (*b(LTO)* = 0.659, $p < 0.05$). In high population density countries, statistically significant are PDI (*b(PDI)* = 0.445, $p < 0.05$) and IDV (*b(IDV)* = 0.018, $p < 0.01$).

In PC innovation, statistically significant variables for low population density countries are IDV (*b(IDV)* = -0.612, $p < 0.01$) and UAI (*b(UAI)* = 0.400, $p < 0.10$). For high population density countries, there are no statistically significant variables.

In Table 5, for the results of internet hosts innovation, statistically significant variables for low population density countries are PDI (*b(PDI)* = 0.480, $p < 0.05$), IDV (*b(IDV)* = -0.624, $p < 0.01$), UAI (*b(UAI)* = 0.602, $p < 0.01$), and LTO (*b(LTO)* = 0.934, $p < 0.001$). For high population density countries, statistically significant are PDI (*b(PDI)* = 0.492, $p < 0.05$) and IDV (*b(IDV)* = -0.701, $p < 0.001$).

The results presented in Table 5 show that Hypothesis 7 (population density moderates the effects of cultural dimensions on takeoff time), is supported. Each of the three innovations lends support to the Hypothesis 7. In all the cases, there are two more statistically significant variables in countries with low population density than in countries with high population density. Therefore, three out of three innovations support Hypothesis 7.

Table 6 presents the results of the nested univariate regression models for each three innovations after median split of illiteracy rate.

Table 6 about here

Table 6 shows that for mobile telephone innovation, the statistically significant variables in low illiteracy rate countries are PDI (*b(PDI)* = 0.545, $p < 0.01$) and IDV (*b(IDV)* = -0.490, $p < 0.05$). For high illiteracy rate countries, there are no statistically significant variables.

In the results for PC innovation, statistically significant variables for low illiteracy rate countries are IDV (*b(IDV)* = -0.456, $p < 0.05$) and UAI (*b(UAI)* = 0.385, $p < 0.10$). For high illiteracy rate countries, there are no statistically significant variables.

In the results for internet hosts innovation, statistically significant variables for low illiteracy rate countries are PDI (*b(PDI)* = 0.581, $p < 0.01$), IDV (*b(IDV)* = -0.813, $p < 0.001$), UAI (*b(UAI)* = 0.472, $p < 0.05$), and LTO (*b(LTO)* = 0.752, $p < 0.001$). For high illiteracy rate countries, there are no statistically significant variables.

The results presented in Table 6 support Hypothesis 8 (illiteracy rate moderates the effects of cultural dimensions on takeoff time). In the case of mobile telephone and PC innovations, there are two more statistically significant variables for countries with low illiteracy rates than for those with high illiteracy rates. In the case of internet hosts innovation, there are four statistically significant variables more for countries with low illiteracy rates than for those with high illiteracy rates. Therefore, three out of three innovations support Hypothesis 8.

Discussion

Our study outlines five main results: Firstly, only individualism has context independent influence on takeoff dynamics on all studied time series. The result for individualism conforms to the findings of the existing literature in that high IDV suggests faster adoption of innovations. Also power distance index has influence on mobile telephones and internet hosts adoption dynamics but we fail to find statistical significance in the relationship between PDI and PC adoption dynamics. The result for the power distance index runs counter to the findings of the earlier literature, that customers in high power distance index countries are expected to adopt innovations more quickly.

Secondly, the moderating role of GDP demonstrates that the influence of cultural dimensions may be industry dependent and partially that only in high GDP countries cultural variables have influence on adoption dynamics. However, this needs to be further studied especially from the point of view of the reasons behind this moderating effect. Does the GDP represent a purchasing hurdle and therefore cultural dimensions do not influence adoption? Or do the expensive innovations, like internet hosts, represent special class of innovations and in this class adoption is influenced by cultural variables? Moderating role of the GDP suggests that future research should study the influence of the culture for low and high GDP countries separately. The minor influence of cultural variables in low GDP countries may also be explained by the reason that the consumers' needs usually changes as GDP increases. In low GDP countries, people might lack the opportunity to acquire these kinds of sophisticated product. For future research a number of questions arise from this result that is also against earlier findings reporting that cultural dimensions have more influence on high-GDP countries.

Thirdly, population density strongly moderates influence of the cultural variables on the adoption dynamics. Multiple cultural variables have influence on adoption dynamics, and individuality and uncertainty avoidance have context independent, influence on adoption dynamics in low population density countries. The relatively limited social networks among individuals in low population density countries may partly explain the moderating effect of this variable since sparser social networks inhibit the diffusion of new ideas (following e.g. Fell et al., 2003) resulting in more stable patterns of purchasing behavior, which are based on existing cultural values. In contrast, in high population density countries, cultural dimensions are much less important in explaining the takeoff time of the innovation adoption. This lends further support to the claim that a high population density has a moderating effect on takeoff since people have wider and more numerous communication contacts (Klasen and Nestmann, 2004), resulting in the likelihood of modifying and updating their purchasing behavior continually.

Fourthly, similarly to the moderating effect of population density also illiteracy rate moderates influence of cultural dimensions on the dynamics of the takeoff. Number of cultural explanatory variables has influence on the takeoff dynamics in low illiteracy countries. Individuality index specifically has context independent influence on the adoption dynamics in log illiteracy rate countries. The low influence of cultural variables in high illiteracy countries may be explained in terms of the nature of the innovation since people may have little need for a technological innovations because literacy is either a prerequisite or condition for its use.

Fifthly, masculinity has no effect on adoption dynamics in any of our models, moderated or not. Therefore, our results confirm earlier findings that masculinity has no influence on takeoff.

Overall, the results of the study confirm the earlier empirical findings that cultural values do have an effect on national level innovation adoption dynamics. Contribution of the research to the academic community especially lies in results regarding moderation effect of GDP, population density and illiteracy. The results show that influence of culture is depending on national attributes and, thus, open several avenues for further research. Moreover, the research on the influence of cultural variables complements the finding reported in existing literature. However, the results of the study contain certain limitations. The study focused only on a restricted set of innovations or independent variables. Change over time might also partly explain the results and this provides a fruitful avenue for future studies. Further, the research does not consider changes in marketing mix variables. Therefore, there remain numerous avenues for future research. To corroborate the findings of the study, further research is needed with other innovations.

Furthermore, research could also be conducted with other independent variables. Our result that the influence of cultural dimensions is more marked in countries with low GDP and high illiteracy needs further investigation. Although this is partially in line with the existing literature (e.g. Rouvinen, 2006, Yeniyurt and Townsend, 2003), the actual reasons explaining this kind of moderating effects need further investigation. However, our findings for the moderating effect of population density on takeoff are quite likely to be result of some hidden variables, such as the competitive environment, behavioral differences, social conditions or similar. This would be another fruitful avenue for future research.

The practical implications of the study suggest that companies launching new innovations should consider cultural dimensions in their international operations, such as designing marketing promotions, deciding market entry order, etc. In particular, they should consider the influence of cultural dimensions in countries having a highly developed economy, a low population density, and a low rate of illiteracy. Specifically, the results suggest that PDI and IDV have an impact on the extent of takeoff time, whereas MAS seems to play a very minor role in the occurrence and timing of takeoff. Regarding the launch before takeoff, the results suggest that an innovation should be commercialized first in countries with low PDI and high IDV indices. After the occurrence of takeoff, companies should especially focus on equality and individuality related matters in their product and production development, such as customers' personal reward and pleasure. The recommendations should especially be considered in countries with high GDP and literacy rate, and low population density.

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Tables

Table 1. The hypotheses.

Hypothesis no.	Hypothesis
1	The higher PDI, the shorter the takeoff time.
2	The higher the IDV, the shorter the takeoff time.
3	The higher the MAS, the shorter the takeoff time.
4	The higher the UAI, the longer the takeoff time.
5	The higher the LTO, the longer the takeoff time.
6	The level of economic development moderates the effects of cultural dimensions on takeoff time.
7	Population density moderates the effects of cultural dimensions on takeoff time.
8	Illiteracy rates moderate the effects of cultural dimensions on takeoff time.

Table 2. The descriptive statistics and correlation matrix for the variables used in the study.

Independent variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1. Mobile Takeoff Time	14.59	2.75	1.000										
2. PC Takeoff Time	13.71	4.12		1.000									
3. Int. hosts Takeoff Time	5.06	1.88			1.000								
4. PDI	55.61	22.17	0.469 **	0.223	0.484 **	1.000							
5. IDV	44.45	25.86	-0.577 **	-0.350 *	-0.655 **	-0.678 **	1.000						
6. MAS	49.04	18.98	0.077	-0.193	-0.011	0.064	0.062	1.000					
7. UAI	65.33	24.84	0.245	0.273	0.240	0.238	-0.335 *	-0.021	1.000				
8. LTO	42.69	21.61	0.034	0.157	0.287	0.263	-0.402 *	0.019	0.000	1.000			
9. GDP	11851.70	10247.49	-0.653 **	-0.316	-0.624 **	-0.590 **	0.688 **	0.025	-0.264	0.156	1.000		
10. Population Density	298.53	943.41	-0.139	-0.087	-0.044	0.137	-0.165	0.051	-0.377 **	0.501 **	0.220	1.000	
11. Illiteracy	6.75	10.24	0.545 **	0.094	0.408 **	0.396 *	-0.509 **	0.015	0.121	-0.276	-0.527 **	-0.011	1.000

* p < 0.05
** p < 0.01

Table 3. The results for the nested univariate regression models for the cellular mobile, PC, and internet hosts innovations including all countries.

Independent variable	All Countries					
	Mobile Telephone		PC		Internet Hosts	
	Std. b	**R Square**	***Std. b***	**R Square**	***Std. b***	**R Square**
PDI	0.469 ***	0.220	0.233	0.050	0.484 ***	0.234
IDV	-0.577 ***	0.333	-0.350 *	0.123	-0.655 ***	0.429
MAS	0.077	0.006	-0.193	0.037	0.011	0.000
UAI	0.245 †	0.060	0.273	0.074	0.240	0.058
LTO	0.034	0.001	0.157	0.025	0.287	0.082

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

Table 4. The results for the nested univariate regression models for the cellular mobile, PC, and internet hosts innovations with the moderation effect of GDP per capita.

Independent variable	Low GDP						High GDP					
	Mobile Telephone		PC		Internet Hosts		Mobile Telephone		PC		Internet Hosts	
	Std. b	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square
PDI	-0.012	0.000	-0.109	0.012	-0.020	0.000	0.168	0.028	0.169	0.029	0.508 **	0.258
IDV	-0.178	0.032	-0.224	0.050	-0.231	0.053	-0.207	0.043	-0.224	0.050	-0.662 ***	0.465
MAS	0.007	0.000	-0.360	0.129	-0.092	0.008	0.184	0.034	-0.143	0.020	0.018	0.000
UAI	-0.134	0.018	0.138	0.019	-0.037	0.001	0.366 †	0.134	0.345	0.119	0.486 *	0.236
LTO	-0.556	0.309	0.504	0.254	-0.467	0.218	0.068	0.005	0.102	0.010	0.586 **	0.344

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

Table 5. The results for the nested univariate regression models for the cellular mobile, PC, and internet hosts innovations with the moderation effect of population density.

Independent variable	Low Population Density						High Population Density					
	Mobile Telephone		PC		Internet Hosts		Mobile Telephone		PC		Internet Hosts	
	Std. b	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square
PDI	0.521 **	0.272	0.376	0.142	0.480 *	0.231	0.445 *	0.198	0.008	0.000	0.492 *	0.242
IDV	-0.658 ***	0.433	-0.612 **	0.374	-0.624 **	0.390	0.018 **	0.273	0.173	0.030	-0.701 ***	0.492
MAS	0.154	0.024	-0.274	0.075	0.045	0.002	-0.073	0.005	-0.063	0.004	-0.097	0.009
UAI	0.538 **	0.289	0.400 †	0.160	0.602 **	0.363	0.047	0.002	0.255	0.065	-0.012	0.000
LTO	0.659 *	0.434	0.545	0.297	0.934 ***	0.872	-0.310	0.096	-0.246	0.060	0.132	0.017

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

Table 6. The results for the nested univariate regression models for the cellular mobile, PC, and internet hosts innovations with the moderation effect of illiteracy.

Independent variable	Low Illiteracy Rate						High Illiteracy Rate					
	Mobile Telephone		PC		Internet Hosts		Mobile Telephone		PC		Internet Hosts	
	Std. b	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square	*Std. b*	R Square
PDI	0.545 **	0.297	0.346	0.119	0.581 **	0.338	0.049	0.002	0.019	0.000	0.145	0.021
IDV	-0.490 *	0.241	-0.456 *	0.208	-0.813 ***	0.660	-0.238	0.057	-0.306	0.094	-0.300	0.090
MAS	0.091	0.008	-0.219	0.048	-0.015	0.000	0.068	0.005	-0.138	0.019	0.029	0.001
UAI	0.300	0.090	0.385 †	0.148	0.472 *	0.223	0.117	0.014	0.136	0.019	0.004	0.000
LTO	0.294	0.086	0.246	0.060	0.752 ***	0.565	-0.362	0.131	-0.099	0.010	-0.177	0.031

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

APPENDIX

The list of the countries examined

Country	Country
Argentina	Malaysia
Australia	Mexico
Austria	Netherlands
Belgium	New Zealand
Brazil	Norway
Canada	Pakistan
Chile	Panama
Colombia	Peru
Costa Rica	Philippines
Denmark	Portugal
Equador	Singapore
Finland	South Africa
France	South Korea
Germany (R.R.)	Spain
Greece	Sweden
Guatemala	Switzerland
Hong Kong	Taiwan
India	Thailand
Indonesia	Turkey
Iran	United Kingdom
Ireland	United States
Israel	Uruguay
Italy	Venezuela
Jamaica	Yugoslavia
Japan	