Cross-country differences in ICT adoption

A consequence of Culture?

Abdul Azeez Erumban[#]

Simon B. de Jong*

SOM theme C Coordination and growth in economies

Abstract

The diffusion of information and communication technology (ICT) has witnessed a surge in the recent years; nevertheless, the rate of adoption across countries diverges considerably. This divergence is observed regardless of the income levels of countries. In this paper, we attempt to explain the differences in ICT adoption rates across countries using Hofstede's cultural framework. The results suggest that national culture does influence the ICT adoption rate of a country. The results are robust even after controlling for levels of education and income.

(also downloadable) in electronic version: http://som.rug.nl/

Groningen Growth and Development Centre, Faculty of Economics, University of Groningen. Email: a.azeez.erumban@eco.rug.nl, * Faculty of Management and Organization, University of Groningen, Email: s.de.jong@bdk.rug.nl. Both are affiliated with the research

1. Introduction

The rate at which new technologies are adopted and incorporated into the productive process i.e. the diffusion or adoption of a new technology[1] is considered to be a major factor in driving the pace of economic growth (see among others, Rogers, 1995; Rosenberg, 1972). However, this diffusion does not follow a common pattern in terms of rates or timing across countries. While some countries are receptive to changes, others are not. Hence, some countries lag while others lead. This divergence is due to both economic and non-economic factors. The economic factors behind diffusion have been subjected to considerable research (Griliches, 1992, 1957; Mansfield, 1963; Rosenberg, 1972)[2]. From an economic viewpoint, adoption of any (new) technology involves certain costs and benefits to the users. Therefore, the decision to adopt is largely the result of a series of individual decisions, resultant of a comparison of uncertain costs and benefits associated with the adoption, regarding the use of the new technology. Hence, one may expect different economic agents, having diverse preferences as well as abilities, to adopt the new technology at different times and stages.

Previous studies have highlighted, *inter alia*, the roles of adoption costs (prices), degree of openness to trade, human capital endowment, post introduction improvements, growth of the economy, and level of income as the major economic factors determining the adoption decisions (Comin and Hobijn, 2003; Hall and Khan, 2003; Pohjola, 2003; Caselli and Coleman, 2001; Rosenberg, 1972). This line of research rests on the premise that the creation of technology and its diffusion are essentially economic phenomena. Nevertheless, it may be noted that the meaning

---

school SOM. The authors are thankful to Jakob de Haan, Bart Los, and Marcel Timmer for their comments.

[1] Adoption and diffusion may be seen as used synonymously in this paper, as they are closely related; diffusion occurs when a user adopts an external technology.

[2] Note that there are many theories in economics that explain the technology diffusion. There is no intention to discuss them here. For a review of the technology adoption theories, see, Geroski (2000). Also see Rogers (1995), who presents four different diffusion theories.

attributed to technologies might differ among regions and people, depending on their socio-cultural attitudes. Hence, the socio-cultural ambience, perceived values, institutions and political atmosphere might influence the perception of the individuals within a society in a certain way and hence will impact the adoption decisions, along with the generally perceived economic factors. Rosenberg (1972) himself acknowledges that, "…in fact, the number of variables—social, legal and institutional as well as economic and technological—which might retard the diffusion process is virtually limitless" (Rosenberg, 1972 p. 29). Hence, it may be argued that the cross-country variation in technology adoption is not only due to economic conditions but is also due to the prevailing social conditions.

This paper looks into the factors affecting the decision to adopt a new technology. For this purpose, we consider the Information and Communication Technologies (ICT). ICT is the latest in the series of continuing technological revolutions, and is argued to have significant influence on economic growth in many industrialized countries (van Ark et al, 2003). Given the amazing speed at which this technology have been pushing around in the market it is interesting to look into factors that may play a determining role in its diffusion across countries. The present study, however, does not intend to examine the whole range of factors influencing ICT adoption.[3] Instead, taking a deviation from most earlier studies, we argue that apart from the generally considered economic factors the cultural setting of a society plays an important role in ICT adoption. So far, this issue has not received much attention in the literature. Most studies that look into the impact of culture concerned with economic growth in general (e.g. Jonson and Lenartowicz, 1998). Hence, we examine the role of cultural factors in determining ICT adoption across countries and our results suggest a strong relation between the two.

---

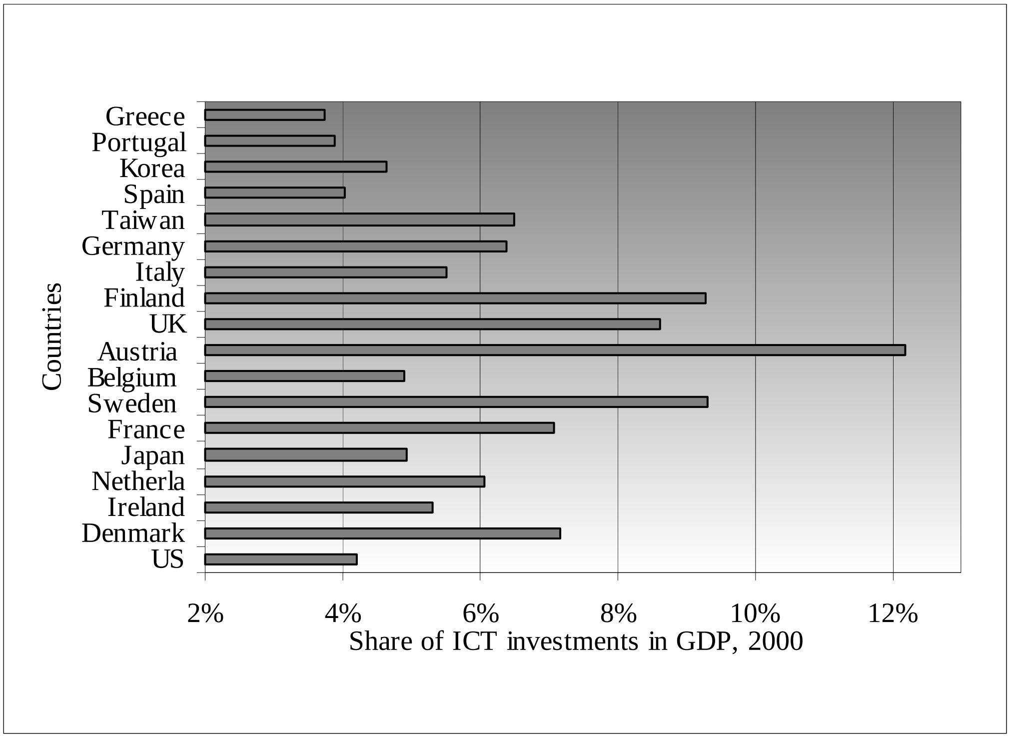
[3] See Casseli and Coleman (2001) for a study on determinants of computer adoption and Pohjola (2003) for determinants of ICT adoption in general. We depart from both these studies in that we concentrate more on cultural factors in determining the adoption of ICT in general.

2. ICT Adoption across Countries

The information and communication technologies have been spreading amazingly fast, making researchers contemplate whether we are facing a new economy phase. The proliferation of ICT has in fact created a revolution by making the world seemingly smaller and improving the potential for economic growth. It is observed that ICT has produced a fundamental change in the U.S economy (Jorgenson, 2001). The same is true with the European countries as well. In contrast to earlier scepticism[4], recent studies have shown that ICT has contributed significantly to economic growth in the US and the EU, by improving labour productivity (Van Ark et al, 2002).

This remarkable spread of ICT created an interest among researchers to unearth the factors behind this phenomenon; this was done largely in terms of variables identified in the literature in the context of any other technology. For instance, the rapid spread of ICT has been often attributed to the incredible price declines (Jorgenson 2001), which is one of the major economic factors behind the decision to adopt a new technology. Other major economic factors behind ICT adoption which have been highlighted are the human capital, the level of income and openness to trade (Pohjola, 2003; Caseli and Coleman, 2001). While the level of income explains the economic capacity of a nation to acquire new technology, the importance of human capital explains, to a large extent, the skill component in the technology. Openness to trade assumes importance, as the access to the new technology depends on the exposure of technology-using countries to technology-producing countries, which is largely reflected in their openness to trade (see Caseli and Coleman, 2001). However, even across countries with similar income levels and human capital endowments differences in ICT diffusion exist- for example, it has been shown that even though the European Union has a similar industry pattern as the US, the proliferation of ICT in the EU has been slower than the US (Van Ark et al, 2002).

Figure1: ICT investments as a percent of GDP across countries, 2000



Note: Countries are ordered according to GDP per capita
Source:GGDC Total Economy Growth Accounting Database, Timmer et al.(2003)

In Figure 1 we have plotted ICT investment as a percentage of GDP across countries. The countries are ordered according to GDP per capita measured by current

[4] In 1987 Robert Solow remarked, "we see computers everywhere but in the productivity statistics," an observation that became referred to as the "productivity paradox."

price GDP in own currencies divided by population. We observe considerable divergence across countries (even with similar economic conditions) in adoption rates.[5] This divergence in adoption rates assumes importance as most developed countries, apart from high levels of income, share similar structural and institutional characteristics like qualified workforce, and modern infrastructure.

It is, at this juncture, important to resume to the previous discussion regarding the decisions to adopt a technology. Adoption decisions are highly subjective to the attitudes of the people in an organization/country and may be influenced by the organization/country's social and cultural characteristics. This is because, as we stated earlier, adoptions are largely individual decisions aggregated into group decisions, and such individual decisions are largely affected by many non- economic factors, related to cultural and psychological aspects of individuals, organizations, societies and countries. For instance, Meijer and Ling (2001) have drawn attention to the possible effects of political and cultural factors along with economic and technological factors on mobile broadband service adoption within European countries.[6] Similarly, Lee and Peterson (2000) propose a cultural model of entrepreneurship under the presumption that a country's entrepreneurial orientation is related with its cultural base. Thus, the observed divergence, even among countries of similar economic status, in ICT adoption may be attributed to the attitudes and culture of the people in a country. This has, however, not been empirically verified in the context of ICT.

---

[5] Similarly, Meijer and Ling (2001) show large differences in mobile phone and Internet adoption within nine European countries. Pohjola (2003) also notes that the digital divide generated by the disparities in ICT spending is quite large, even between the EU countries. Gust and Marquez (2002) attributes such differences in adoption to regulatory policies followed by different countries.

[6] Fife and Perira (2002) also highlights the importance of social and cultural factors for broadband adoption. Nevertheless, these studies make no robust empirical analysis of possible cultural effects on the adoption decisions. The present study depart from these studies in that we consider ICT in a much broader sense and conduct empirical analyses across a larger number of countries.

3. Culture and ICT Adoption: Towards an Analytical Framework

ICT adoption, as in the case of any technology, is a result of a series of individual decisions. Attitudes and values mediate the needs that come forth from the experiences in daily life, and by using services and technology an individual seeks solutions when these needs are not met (Silverstone and Haddon, 1996). Innovation[7] is founded on ideas, and it is *people* who "develop, carry, react to, and modify ideas" (Van de Ven, 1986, p. 592). The values and attitudes an individual has and the reaction he or she expects from the larger group play an important role in the innovation process. Naturally there will be variation in individual needs as well as in individual, team, and organizational behaviour within any given national culture. Nevertheless, all individuals live and work within a cultural environment in which certain values, norms, attitudes, and practices are more or less dominant and serve as shared sources of socialization and social control. A mechanism for how culture can influence individual behaviour can be found in Fishbein and Ajzen (1975)'s theory of reasoned action. This theory states that attitudes lead to the intention to perform certain behaviour and intentions will eventually lead to actual behaviour. This intention to perform is also influenced by subjective norms, which means the strength of the perceived social support for certain behaviour as well as the expectations or approval of certain behaviour. Culture can influence actual behaviour through its influence on attitudes and subjective norms and consequently enhance the adoption and use of ICT or may provide important barriers for using them, through enhancing or inhibiting individual innovation. Hofstede (1984, 2001) and Trompenaars (1993) have shown that differences in values and attitudes influence the ways people interact and make use of their environment. Hence we hypothesize that cultural factors may be able to explain the differences in the adoption rate of ICT between countries.

[7] Note that innovation in this paper may be used in a wider sense to imply openness to any new idea. It may not necessarily imply the creation of new products and/or services, as is generally viewed in the economic literature.

The dominant cultural framework that has received much attention from scholars (Van Everdingen and Waarts, 2003; Lee and Peterson, 2000) is that of Hofstede (1984, 2001). We use this framework in order to facilitate comparison with other studies. Hofstede's framework originally consisted of four cultural dimensions (Power Distance, Uncertainty Avoidance, Individualism and Masculinity), a fifth dimension was later included (Long-Term Orientation). Each dimension and their expected relationship with ICT adoption will be discussed briefly below.

3.1 Power Distance (PD)

The power distance dimension refers to the inequality of the distribution of power in a country. In organizations this distribution of power is reflected in the hierarchy. Centralized decision structures, authority and the use of formal rules are therefore often the characteristics of organizations in countries with high power distance. Such organizations have been associated with lower rates of innovation and adoption (Zmud, 1982). The reason for this relationship can be found in more psychological orientated research. Studies have shown that employees are more innovative when they have more autonomy, are more empowered and work for leaders who have a less authoritative leadership style (Mumford and Licuanan, 2004). Furthermore cultures with high power distance are expected to have lower openness for new ideas as it involves decision-making on issues where there are hardly any historical trends and very little information (Lee and Peterson, 2000). In light of the above observations, we hypothesize that countries with a high PD score will have a lower rate of ICT adoption than countries with a low PD score.

3.2. Uncertainty Avoidance (UA)

Hofstede (1984, p. 83) defines uncertainty avoidance as "The degree to which members of a society feel uncomfortable with uncertainty and ambiguity". Adoption of a new technology involves risk and uncertainty. This has attracted research attention in economics, largely advocated by Paul Stoneman, incorporating the idea that adopting a new technology is similar to any other kind of investment under uncertainty. As the adoption of a new technology is concerned with doing something new, the extent of uncertainty attached to it is also greater (Stoneman, 2001). Given that the technology works, the question is whether it can be put to profitable use, and therefore the risk is largely an economic risk. Similarly, Freeman and Soete (2000) have considered variation in countries' ability to take risks and to assess new innovations as a reason for the slow diffusion rates across countries. Thus, any innovation, as Woodman, Sawyer and Griffin (1993, p. 293) state: "doing something for the first time", is associated with ambiguity and uncertainty. Since people in countries with a high score on uncertainty avoidance are more risk-adverse and do not like making changes (or "doing something for the first time") we suggest that countries with a high UA score have a lower rate of ICT adoption than countries with a low UA score.

3.3. Individualism (ID)

The individualism dimension concerns the relation between the individual and the group to which the individual belongs. People in individualistic countries are more prone to make their own choices while people in collective countries conform more readily to the norms of the group. Noelle-Neumann's (1974) spiral of silence theory argues that people will be deterred from expressing their true opinion if they feel that it runs counter to the majority opinion. Since innovation is contrary to the prevailing group norm, countries with a strong emphasis on the group will be expected to have less innovation. Individuals in individualistic countries feel free to express their own views and are therefore more inclined to innovate and adopt new ideas. In other words, the citizens in individualistic countries are generally self reliant and freethinking. As reflected in Joseph Schumpeter's views, such freedom to think and act independently is expected to nurture the creativity of entrepreneurs making them more innovative.[8] We therefore expect countries with a high ID score to have a higher rate of ICT adoption than countries with a low ID score.

3.4. Masculinity (MA)

Masculine cultures are characterized by competition, ambition, a focus on performance and material values. Feminine cultures are characterized by solidarity, equality, consensus seeking and concern about social relationships. According to Hofstede (2001) organizations in masculine cultures emphasize rewards and recognition of performance, and training and improvement of the individual. These are characteristics common to innovative organizations. Therefore, one may expect countries with a high MA score to have a higher rate of ICT adoption than countries with a low MA score.

3.5. Long-term orientation (LTO)

The fifth dimension is concerned with the time orientation of cultures. Cultures with a long-term orientation are associated with thrift and perseverance, while cultures with a short-term orientation are associated with respect for tradition, fulfilling social obligations, and protecting one's 'face'. Since innovation is concerned with expected rewards in the future and contrary to tradition, our last hypothesis is that countries with a high LTO score will have a higher rate of ICT adoption than countries with a low LTO score.

4. The Data and Methodology

To accomplish our study we required information on ICT adoption and cultural dimensions across countries. The latter is represented by the Hofstede indices available at http://www.geert-hofstede.com/hofstede_dimensions.php.[9] These indices

[8] See Shane (1993) for an empirical study that illustrates the relation between innovativeness and individualism.

[9] Accessed in February 2004.

were developed by Hofstede in a comprehensive study of how culture influenced the values in the workplace. To this end he collected data from over 100,000 individuals from 50 countries and 3 regions during 1967-1973.

Following the general practice (see for instance Pohjola, 2003) we have measured the ICT adoption as the share of ICT expenditure in each country's GDP. This data has been directly taken from Pohjola (2003), who has arrived at these figures by combining the data from WITSA and the IMF. This data is a composite measure of IT hardware, office equipment, software, IT services and telecommunication and is available for a large number of countries (51) including Asian countries. These numbers are averages over the period 1993 to 2001. We exploit this dataset for those countries for which the corresponding Hofstede indices are available. Hence we have average share of ICT expenditure in GDP for 42 countries (Appendix 1).

Table 1: Structure of ICT investment

Year	IT equipment	Com. equipment.	Software
1980	16.56	61.14	22.29
1990	29.19	36.03	34.78
2000	53.96	21.17	24.88

Source: Calculated at constant price from Timmer et al (2003)

As with any analysis there is a possibility that the end results are sensitive to the measure of adoption selected, which is, in our case, the ICT expenditure as a percentage of GDP. To avoid this pitfall we use a second measure of ICT adoption, viz. the per capita computer (total number of computers divided by total population) in each country. This measure has the advantage of being strictly quantitative. Moreover, a bifurcation of different components of ICT investment has shown that computers (or IT equipments) have gained more ascendancy over other components over years (Table 1). The World Bank provides the number of self contained computers that are designed to be used by an individual, per 1000 people.[10] We have derived per capita computer as total computer divided by total population from this figure, using the population data provided in the same database for each country. As before, we consider only those countries for which Hofstede dimensions are available and hence this dataset consists of 49 countries. The countries included in this dataset are more divergent in terms of their income levels compared to the first dataset. Specifically, while more than 30% of the countries in this dataset are lower income countries, only 19% of the countries in the first dataset can be classified as such (Appendix 1).

We started our investigation by graphically analyzing the first dataset. For this purpose, we have divided the countries into two different groups for each cultural dimension by taking the median of each dimension from our sample as a cut-off point. Using the mean of Hofstede's dimensions as a cut-off point results in a small number of countries in the low group for the UA and LTO dimensions and a small number of countries in the high group for the ID dimension. The cut-off points and the resulting means and standard deviations for the low and high group of each dimension are given in Appendix 2. The results from a one-way ANOVA showed that the difference between the low and high group is significant for every dimension (Appendix 2) and we therefore conclude that the above procedure is appropriate to create two different groups.

The dataset on per capita computer is available year wise for the period 1998-2002. This data is also divided into two groups by taking the median as a cut-off point and is subsequently analysed in a similar way as the first dataset (See Appendix 1 and 2). Due to the fact that the second dataset contained not only more countries but also contained more diversity in terms of income levels across countries, we opted to do a regression as well. The results observed in graphical analysis are thus further substantiated. Deriving from our earlier discussion on the expected relationship

[10] This data is available at the World Bank website, http://devdata.worldbank.org/data-query/. Accessed in July 2004.

between cultural dimensions and ICT adoption, the following multiple regression model is estimated.[11]

$$ICT_j = \alpha + \beta_1 PD_j + \beta_2 ID_j + \beta_3 MA_j + \beta_4 UA_j + u_j \qquad (1)$$

where *ICT* represents the average ICT adoption, measured in terms of per capita computers, α and β's are parameters to be estimated, *PD* is the power distance, *ID* is individualism, *MA* is masculinity, *UA* is uncertainty avoidance and *u* is the random error term with standard assumptions. The subscript *j* stands for countries.

Table 2: Correlation between Hofstede dimensions and control variables

	PD	ID	MA	UA	GDP	Dummy	Openness
ID	-0.713						
MA	0.092	0.005					
UA	0.163	-0.236	0.149				
GDP	-0.663	0.714	-0.090	-0.221			
Dummy	-0.395	0.535	0.065	-0.016	0.726		
Openness	-0.029	0.062	-0.045	-0.295	0.285	0.357	
Education	-0.488	0.455	-0.082	-0.049	0.522	0.482	0.119

Note: GDP is per capita GDP and EDU is Education indicator.

A regression analysis assuming a significant importance to cultural factors, however, may result in biased parameter estimate if we ignore other relevant variables identified in the literature. It is therefore important to think about some control variables that may influence the results. Following the literature, one obvious variable to use as a control variable is per capita income. It is apparent that the level of income in a country is a significant factor in determining the adoption decisions, and it has been highlighted by many earlier studies. However, as can be observed from Table 2 per capita GDP is highly related with some of the Hofstede dimensions, posing a multicollinearity problem. Therefore, we have controlled for income by replacing per

[11] Since the data on cultural dimensions are not available over time, we opted to do a cross section regression. Nevertheless, we do not expect the cultural and attitudinal settings of nations to witness a fundamental change over years

capita GDP with a dummy variable. The dummy takes the value 1 for high-income countries and 0 for low-income countries. The categorization of low income and high-income countries is based on the World Bank.[12] Countries coming under low income and lower middle-income groups are attributed value zero for the dummy and countries that come under upper middle income and high-income groups are attributed value 1. The dummy is found to have high correlation with GDP per capita while it is less correlated with the Hofstede dimensions (Table 2). In addition, we have also considered another control variable, which has less correlation with both Hofstede dimensions and the dummy variable, but is expected to have significant association with ICT adoption, viz. the level of education in each country. We expect a nation's ability to absorb knowledge, as reflected in educational attainment, to have positive association with ICT adoption decisions. This is particularly true in the context of information technology. We represent this variable by share of population with educational qualifications at the tertiary level.[13] This is represented by Barro-Lee estimates on the percentage of people who have completed higher school in the total population aged 25 and above.[14] Fortunately this variable is found to have less correlation with Hofstede dimensions (Table 2). Hence the final model is:

$$ICT_j = \alpha + \beta_1 PD_j + \beta_2 ID_j + \beta_3 MA_j + \beta_4 UA_j + \beta_5 EDU_j + \beta_6 D_j + u_j \qquad (2)$$

where EDU represents the education, D is the dummy variable for income, and the other variables are as explained in equation (1).

[12] Economies are divided according to 2003 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $765 or less; lower middle income, $766 - $3,035; upper middle income, $3,036 - $9,385; and high income, $9,386 or more. See http://www.worldbank.org/data/countryclass/classgroups.htm.

[13] The importance of educated workforce in ICT adoption has been highlighted by empirical studies as well (See Lucchetti and Sterlacchini, 2001). Also Comin and Hobijn (2003) have signified the importance of human capital endowments in technology adoption.

[14] The data is available at http://www.cid.harvard.edu/ciddata/ Appendix%20Data%20Tables.xls. Accessed in July 2004. See Lee and Barro (2001) for detailed description of this data.

5. Empirical Results

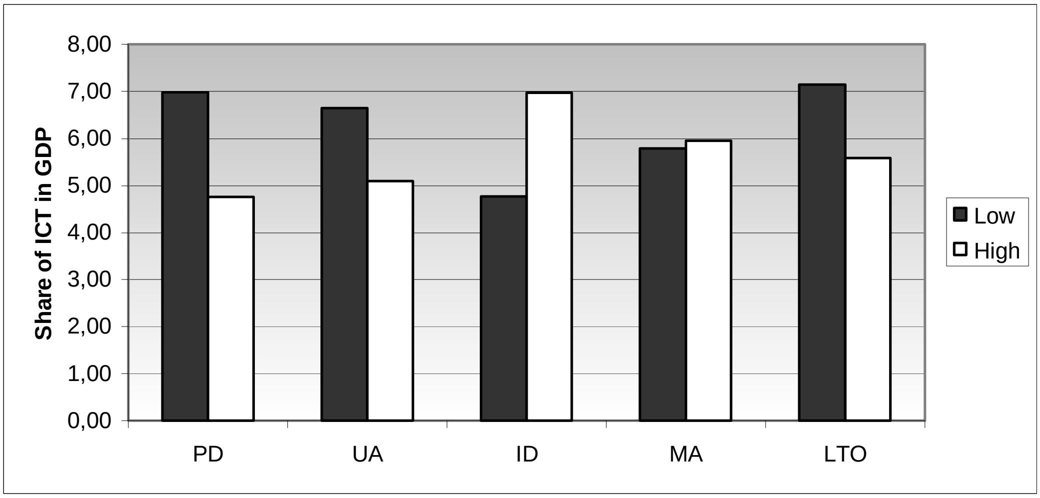
In Figure 2, we have plotted the average ICT adoption for the period 1991 to 2001 against the five cultural dimensions of Hofstede. It is clear from the Figure that low power distance countries have higher rates of ICT adoption than high power distance countries. The difference is statistically tested by using an independent t-test and is found to be significant (Table 3). Our hypotheses with respect to the uncertainty avoidance and individualism dimensions are confirmed as well. As can be seen, low uncertainty avoidance countries have higher adoption rates than high uncertainty avoidance countries and countries with more individualistic cultures show higher ICT adoption rates than more collective cultures. The differences are found to be significant in all these cases (Table 3).

Table 3: Differences in ICT adoption: t-statistic for groups in terms of Hofstede dimensions

	PD	UA	ID	MA	LTO
t-value	4.50*	2.81*	-4.44*	-0.25	1.56

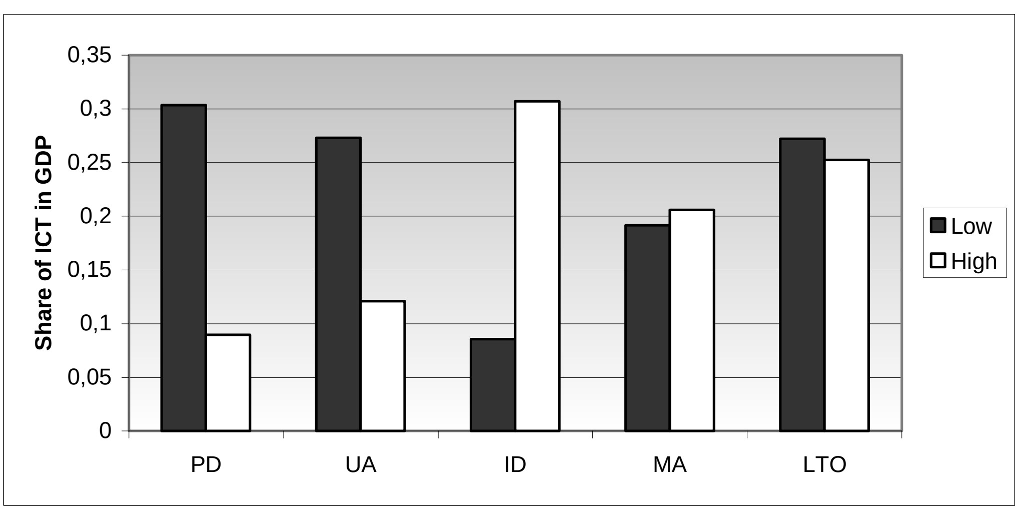
*Note: * indicates significance at 1 per cent level. The degrees of freedom for all the variables are 40 except for LTO, where it is only 17.*

Figure 2: Average ICT Adoption, 1991-2001



With respect to the masculinity dimension we observe no sizeable difference between the two groups. This makes us to infer that the adoption rates are not affected by a country's character in terms of masculinity/femininity, since both groups of countries have shown almost similar rates of adoption. In contrast to masculinity, long-term orientation does seem to have an effect, although it is in the opposite direction as hypothesised. Short-term oriented countries appear to have a higher rate of ICT adoption, however this difference between the two groups is found to be insignificant. It should be noted that since there were only 19 countries available for the long-term dimension in this dataset this non-significance can possibly be attributed to the small sample size. The above mentioned effects can also be seen in the scatter plots in which ICT adoption is set against all the cultural dimensions (Appendix 3).

Figure 3: Per capita computers, average 1998-2002



The countries in the second dataset, where we have ICT adoption represented by per capita computer, were grouped using their median as cut off point (Appendix 2). As can be seen from Figure 3 the results are similar to the previous graph. The power distance, individualism and uncertainty avoidance dimensions show notable difference between low and high scoring countries on ICT adoption. The masculinity and long-term orientation dimension do not show any difference, which is in line with our previous analyses.

Table 4: Regression results for ICT adoption and Cultural Dimensions

Parameter	Model 1 without control variables	Model 2 with education	Model 3 with Education & Dummy	Model 4 Without Power Dist.	Model 5 Without Individualism
Constant	0.4340*	0.3726*	0.3814*	0.1650**	0.4327*
	(0.1108)	(0.0989)	(0.0835)	(0.0678)	(0.0594)
Power Distance	-0.0030*	-0.0026*	-0.0027*	-	-0.0031*
	(0.0008)	(0.0008)	(0.0009)	-	(0.0008)
Individualism	0.0026*	0.0017***	0.0007	0.0022*	-
	(0.0009)	(0.0009)	(0.0008)	(0.0009)	-
Masculinity	-0.0009	-0.0012	-0.0013***	-0.0016**	-0.0012***
	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Uncertainty Avoidance	-0.0021*	-0.0024*	-0.0026*	-0.0025*	-0.0027*
	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0006)
Education	-	0.0126*	0.0086*	0.0098*	0.0090*
	-	(0.0033)	(0.0028)	(0.003)	(0.0027)
Dummy	-	-	0.1343*	0.1332*	0.1440*
	-	-	(0.0324)	(0.037)	(0.0272)
Adjusted R2	0.585	0.668	0.742	0.696	0.744
No. of Observation	49	49	49	49	49

*Note: Results are corrected for heteroskedasticity. Figures in parenthesis are standard errors. Dummy takes value 1 for high-income countries and 0 for low-income countries. * significant at 1 per cent level, ** significant at least at 5 per cent level and *** significant at 10 per cent level*

Because the second dataset included not only more countries, but also more diverse countries with respect to the cultural environments and income levels, a multiple regression analysis is carried out, with power distance, uncertainty avoidance, individualism and masculinity dimensions as the independent variables and average ICT adoption (per capita computer averaged across 1998-2001) as the dependent variable.[15] This model is also estimated controlling for the effects of income and education.[16] The long-term orientation dimension was excluded because of the small number of countries included in this dimension.[17] The results of the regression analysis are presented in Table 4.

The regression results are largely in conformity with our observations based on the two sets of graphs in the preceding discussion. In the basic model (column 1) three dimensions had significant coefficients, namely the power distance, uncertainty avoidance and individualism dimensions. All the dimensions have obtained expected signs, strengthening our earlier observations. As is seen in our earlier analysis, there is no evidence to show any significant impact of the masculinity dimension on ICT adoption. The results remained to be the same even after controlling for education.

Nevertheless, once we included the dummy to capture the effects of income levels along with education, the masculinity dimension shows a mild negative impact and the effect of individualism disappears while all other dimensions remain to be the same. One possible reason for this inconsistency regarding masculinity may be the very diverse nature of this technology. As is evident from the name itself, ICT can be used to communicate better. If this is the major purpose for which the technology is being adopted, then adoption rates might be higher in feminine cultures. On the other hand ICT can also be used to compete with others, after all information is power. In that case, the masculine countries might show a higher adoption rate. However, since

---

[15] We have tried the analysis for all the years for which the data is available separately, however, the results appeared to be the same. Hence we report the results only for the average ICT adoption.

[16] We have also estimated the model including openness to trade, proxied by (export +import)/GDP (all in 1995 US$ taken from World Development Indicators). But this variable is found to be insignificant in all the models, and is hence dropped from the final model.

[17]Note that the Hofstede dimensions for the Arabian countries Egypt, Iraq, Kuwait, Lebanon, Libya, Saudi Arabia and United Arab Emirates, East African countries Ethiopia, Kenya, Tanzania and Zambia, and West African countries Ghana, Nigeria, Sierra Leone are not available separately; rather they are given together. Hence, the data on computer per capita for these country groups is arrived using relevant population figures for each country. In the case of education, we take average for these countries.

we have made no distinction between the user aspects of the dependent variable, it is hard to make such judgement. The decline in the effect of individualism may be attributed to the high correlation observed between power distance and individualism (see Table 2). Therefore, we have dropped these two variables alternatively from the equation and the results are reported in last two columns of Table 4. All the coefficients are significant and have expected sign. Both control variables are found to be positive and significant in all the cases. The effect of individualism on ICT adoption is therefore less clear than the effect of power distance and uncertainty avoidance.

Thus, the results from both graphical and regression analysis shows the importance of cultural factors in determining ICT adoption across countries.[18] The results remain to be the same even after controlling for education and income. The power distance and uncertainty avoidance dimensions seem to be the most important. The fact that adoption of new ideas involves decision-making on issues where there are hardly any historical trends and very little information (Lee and Peterson, 2000) makes cultures with higher power distance to delay their openness to ICT. Similarly, the economic risk of adopting a new technology, which is more than the risk attached to the replication of an existing technology (Stoneman, 2001), might have induced economies with high uncertainty avoidance to shy away from adopting ICT at a large scale. The reason for this is that the people in a high uncertainty avoidance country perceive a higher risk than the people in low uncertainty avoidance countries.

5. Conclusions and limitations

The attempts to capture a more realistic notion of human nature to economics have expanded significantly over the last few decades under the realm of behavioural

---

[18] Van Everdingen and Waarts (2003) and Shane (1993) have also arrived at similar conclusions, but not in the context of ICT. While the former study was on the Enterprise Resource Planning (ERP) software the latter was on national innovativeness for an earlier time period.

economics. In this line, supplementing the economic insights on technology adoption, and the factors behind this adoption, this study has made an attempt to look into select cultural dimensions that are expected to influence the ICT adoption across countries. The results indicate that the adoption decisions are influenced by cultural settings of the economy.

Our analyses indicate that those economies with high power distance have shied to exert ICT as much as the countries with low power distance. The results for the countries with high uncertainty avoidance scores are similar; these countries have shown lower adoption rates than countries with low uncertainty avoidance scores. With respect to the individualism dimension, though a positive relation is observed in the graphical analysis, the regression results are somewhat inconclusive, owing to the multicollinearity caused by high correlation between individualism and power distance. The results for the masculinity dimension is quit the opposite to the above story. While our initial results reject any strong relationship between the masculinity dimension and ICT adoption, the regression results shows an unexpected negative, though less significant, impact. Examining this masculine/feminine distinction of technology may be a worthwhile topic for further research, as the very nature of this technology might play a significant role in determining the nature of this association. We had less information on short-term/long-term orientation, and hence the results for this dimension are less satisfactory. To summarize, if we combine the graphical results with the statistical analysis, we conclude that the power distance and uncertainty avoidance dimensions are the most significant cultural factors that can explain some of the differences in ICT adoption rates between countries. These results are observed regardless of the data we have used, signifying the acceptance of our central hypothesis; culture does influence the adoption of ICT.

A limitation of our study is the use of Hofstede dimensions, which have been subjected to many criticisms (see for example McSweeney, 2002; Hampden Turner and Trompenaars, 1997) ranging from denying the very existence of such a concept of *national* culture. We have used these indices in our analysis for two reasons. The first is that our results can more easily be compared with other studies, since most other studies have also used Hofstede (for a recent example see Van Everdingen and Waarts, 2003). The second reason is that Hofstede's framework was the only viable option for our purpose; other frameworks were found to be inadequate. For example, the framework of Hall (1976) is too broadly defined for our purpose, since it does not describe individual differences across countries while Schwartz (1994)'s framework shows much overlap with Hofstede's framework (Van Everdingen and Waarts, 2003). Hence, in spite of its flaws, we presume that the Hofstede framework is the only workable framework for our purposes. Another issue is that our first dataset consists of mostly high income or upper middle-income countries, compared to the second dataset. This, however, could also be interpreted as a supporting point as high-income countries are expected to differ less on economic factors, while they still differ on cultural factors. Moreover, this problem is less severe in the second dataset and since we find similar results for both datasets we do not attach much importance to these problems. Therefore, we conclude that apart from the generally considered economics factors, the attitudes of societies and their cultural environment do have important consequences for the differences in ICT adoption across countries.

Appendix 1: Hofstede Dimensions for the two datasets

Country	Dataset 1	Dataset 2	PD	UA	ID	MA	LTO	Dummy
Arab World	-	1	80	68	38	52	-	1
Argentina	1	2	49	86	46	56	-	1
Australia	2	3	36	51	90	61	31	1
Austria	3	4	11	70	55	79	-	1
Belgium	4	5	65	94	75	54	-	1
Brazil	5	6	69	76	38	49	65	0
Canada	6	7	39	48	80	52	23	1
Chile	7	8	63	86	23	28	-	1
China	8	9	80	40	20	66	118	0
Colombia	9	10	67	80	13	64	-	0
Czech Republic*	10	-	35	60	60	45	-	1
Denmark	11	11	18	23	74	16	-	1
East Africa	-	12	64	52	27	41	25	0
Ecuador	-	13	78	67	8	63	-	0
Finland	12	14	33	59	63	26	-	1
France	13	15	68	86	71	43	-	1
Germany	14	16	35	65	67	66	31	1
Greece	15	17	60	112	35	57	-	1
Guatemala	-	18	95	101	6	37	-	0
Hong Kong	16	19	68	29	25	57	96	1
Hungary	17	20	46	82	55	88	-	1
India	18	21	77	40	48	56	61	0
Indonesia	19	22	78	48	14	46	-	0
Iran	-	23	58	59	41	43	-	0
Ireland	20	24	28	35	70	68	-	1
Israel	21	25	13	81	54	47	-	1
Italy	22	26	50	75	76	70	-	1
Japan	23	27	54	92	46	95	80	1
Korea	-	-	60	85	18	39	72	0
Malaysia	24	28	104	36	26	50	-	1
Mexico	25	29	81	82	30	69	-	1
Netherlands	26	30	38	53	80	14	44	1
New Zealand	27	31	22	49	79	58	30	1
Norway	28	32	31	50	69	8	20	1
Pakistan	-	33	55	70	14	50	-	0
Peru	-	34	64	87	16	42	-	0
Philippines	29	35	94	44	32	64	19	1
Poland	30	36	68	93	60	64	-	1

Portugal	31	37	63	104	27	31	-	1
Singapore	32	38	74	8	20	48	48	1
South Africa	33	39	49	49	65	63	-	0
South Korea	-	40	60	85	18	39	75	1
Spain	34	41	57	86	51	42	-	1
Sweden	35	42	31	29	71	5	33	1
Switzerland	36	43	34	58	68	70	-	1
Taiwan	37	-	58	69	17	45	87	1
Thailand	38	44	64	64	20	34	56	0
Turkey	39	45	66	85	37	45	-	0
United Kingdom	40	46	35	35	89	66	25	1
United States	41	47	40	46	91	62	29	1
Venezuela	42	48	81	76	12	73	-	1
West Africa	-	49	77	54	20	46	16	0
Total Countries	**42**	**49**	**52**	**52**	**52**	**52**	**22**	**52**
Low Income Countries	**8 (19%)**	**15 (31%)**	**16 (31%)**	**16 (31%)**	**16 (31%)**	**16 (31%)**	**7 (32%)**	**16 (31%)**

Source**:** http://www.geert-hofstede.com/hofstede_dimensions.php *(Accessed in February 2004)*

Note: PD is power distance, UA is uncertainty avoidance, ID is individualism, MA is masculinity and LTO is long-term orientation. The figures in the first two columns indicate the countries included in each dataset. Dummy =1 for high-income countries and 0 otherwise.

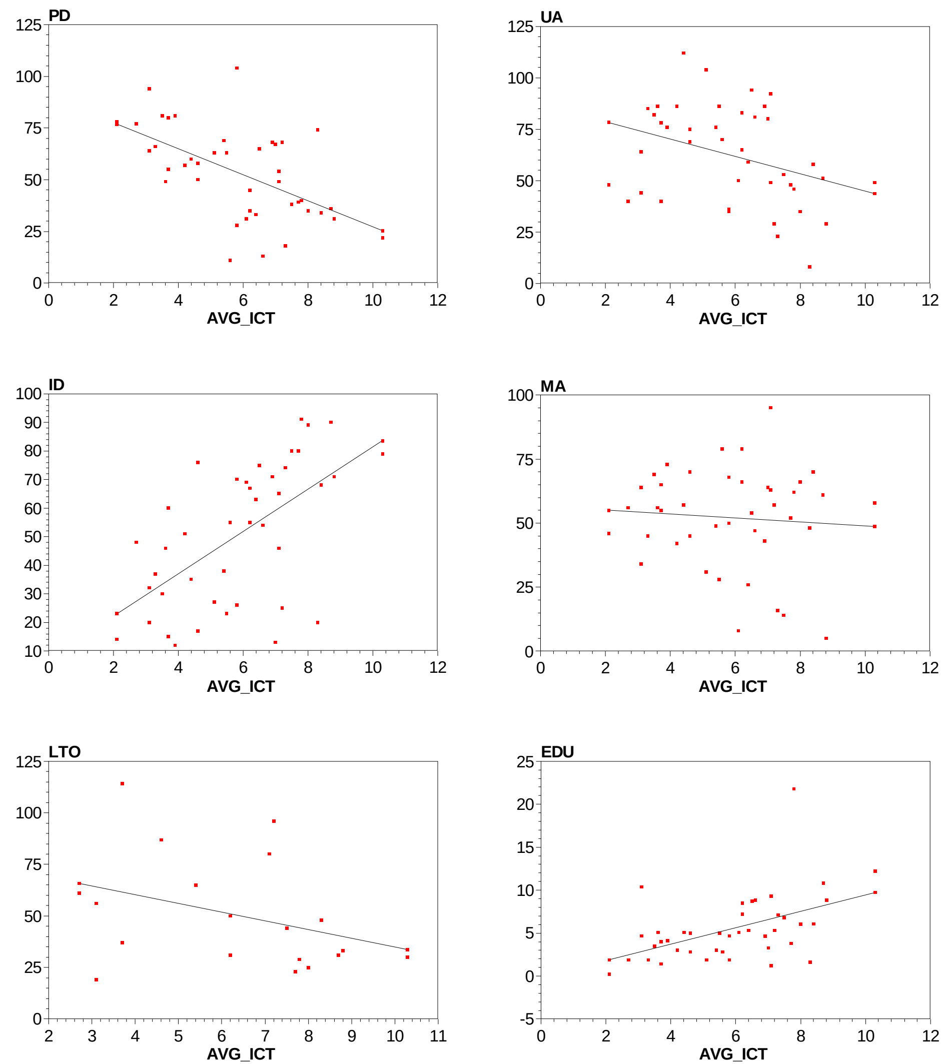
Arab World= Egypt, Iraq, Kuwait, Lebanon, Libya, Saudi Arabia and United Arab Emirates
East Africa= Ethiopia, Kenya, Tanzania and Zambia
West Africa= Ghana, Nigeria and Sierra Leone

Appendix 2: Descriptive statistics

Dimension	PD	UA	ID	MA	LTO
Dataset 1					
Median	54.5	62	54.5	55.5	44
M (low)	42.38	29.95	29.95	37.29	28.67
SD (low)	12.88	13.34	13.34	15.47	5.48
N (low)	21	21	21	21	9
M (high)	82.38	71.81	71.81	66.57	70.1
SD (high)	11.76	10.56	10.56	9.36	23.25
N (high)	21	21	21	21	10
ANOVA	97.35*	116.42*	127.13*	55.10*	27.09*
Dataset 2					
Median	60	46	52	65	31
M (low)	39.28	23.33	37.36	44.96	22.64
SD (low)	14.37	9.99	13.84	13.42	9.07
N (low)	25	24	25	25	11
M (high)	74.5	67.72	66.21	84.33	67.6
SD (high	11.08	13.42	13.42	11.27	25.56
N (high)	24	25	24	24	10
ANOVA	91.72**	123.12**	171.37**	70.15**	30.03**

*Note: M is mean, SD is standard deviation, and N is number of countries. *=F (1, 40) **=F (1, 47). All are significant at 1 per cent level.*

Appendix 3: Average ICT adoption and Hofstede Dimensions (Dataset 1)



Source: Average ICT adoption over 1993-2001 from Pohjola (2003) and Hofstede Dimensions from *http://www.geert-hofstede.com/hofstede_dimensions.php (Accessed in February 2004).*
Note: The number of countries included in LTO is less, as this dimension is not available for most countries. Only those countries for which the Hofstede indices are available are included.

References:

Caselli, F., & Coleman II. W. (2001). Cross-country technology diffusion: The case of computers, *American Economic Review,* 91(2): 328-335.

Comin, D., & Hobijn, B. (2003). Cross country technology adoption: Making theories face the facts, *Paper prepared for the Carnegie Rochester Conference on Public Policy*.

Fife, E., & Perira, F. (2002). Socio-economic and cultural factors affecting adoption of broadband access: A cross-country analysis, *www. marshall.usc.edu/ctm/publications/FITCE2002.pdf*, Accessed in February 2004.

Fishbein, M., & Ajzen, I. (1975) *Belief, attitude, intention and behavior: An introduction to theory and research*, Reading, Mass: Addison-Wesley.

Freeman, C., & Soete, L. (2000). *The economics of innovation*, 2nd edition, Cambridge, the MIT Press.

Geroski, P.A. (2000). Models of technology diffusion, *Research Policy*, 29: 603-625.

Griliches, Z. (1957). Hybrid corn: An exploration of the economics of technological change, *Econometrica*, 48: 501-522.

Griliches, Z. (1992). The search for R&D spillovers, *Scandinavian Journal of Economics*, 94: 29-47.

Gust, C., & Marquez, J. (2004). International comparisons of productivity growth: The role of information technologies and regulatory practices, *Labour Economics* 11(1): 33-38.

Hall, B.H., & Khan, B. (2003). Adoption of new technology, *Working paper E03-330*, Berkeley, University of California.

Hall, E. T. (1976). *Beyond culture*, Garden City, New York: Anchor Press.

Hampden Turner C., & Trompenaars, F. (1997). Response to Geert Hofstede, *International Journal of Intercultural Relations*, 21: 149-159.

Hofstede, G. (1984). *Culture's consequences: International differences in work related values*, abridged version. London: Sage.

Hofstede, G. (2001). *Culture's Consequences : Comparing values, behaviors, institutions, and organizations across nations*. Sage Publications; 2nd edition.

Johnson, J.P., & Lenartowicz, T. (1998). Culture, freedom and economic growth: Do cultural values explain economic growth? *Journal of World Business*, 33: 332-356.

Jorgenson, D.W. (2001). Information technology and the US economy, *American Economic Review*, 9(1): 1-32.

Lee, J., & Barro, R.J. (1997). Schooling quality in a cross-section of countries, *NBER Working Paper No. w6198.*

Lee, S.M., & Peterson, S.J. (2000). Culture, entrepreneurial orientation, and global competitiveness. *Journal of World Business*, 35: 401-416.

Lucchetti R., & Sterlacchini, A. (2001). Factors affecting the adoption of ICTs among SMEs: evidence from an Italian survey, *Quaderni di ricerca n. 155*, Università degli Studi di Ancona.

Mansfield, E. (1963). The speed of response of firms to new technologies, *Quarterly Journal of Economics*, 77: 290-311.

McSweeney, B. (2002). Hofstede's model of national cultural differences and their consequences: A triumph of faith- A failure of analysis. *Human Relations*, 55: 89-118.

Meijer E.M., & Ling, R. (2001). The adoption and use of ICT services in Europe: Potential acceptance of mobile broadband services, *EURESCOM P903*,www.eurescom.de/~ftproot/web-deliverables/public/P900-series/P903/ICT_use_ ante.pdf, Accessed in January 2004.

Mumford, M.D., & Licuanan, B. (2004). Leading for innovation: Conclusions, issues, and directions. *Leadership Quarterly*, 15: 163-171.

Noelle-Neumann, E. (1974). The spiral of silence: A theory of public opinion, *Journal of Communication*, 24: 43- 51.
Pohjola, M. (2003). The adoption and diffusion of ICT across countries: Patterns and determinants, to be published in *The New Economy Handbook*, Academic Press. http://hkkk.fi/~pohjola/The%20adoption%20and%20diffusion%20of%20ICT.pdf.
Rogers, E. (1995). *Diffusion of innovations*, New York, The Free Press.
Rosenberg, N (1972). Factors affecting diffusion of technology, *Explorations in Economic History*, 10(1): 3-33.
Schwartz, S.H. (1994). Beyond individualism/collectivism: New cultural dimensions of value. Pp 85-119 in U. Kim, H. C. Triandis, C. Kagitcibasi & G. Yoon (Eds.), *Individualism and Collectivism: Theory, method and applications*, Thousand Oaks, CA: Sage.
Shane, S.A. (1993). Cultural influences on national rates of innovation, *Journal of Business Venturing*, 8: 59-73.
Silverstone, R., & Haddon, L. (1996). Design and domestication of ICT: Technical change in every day life. in R. Mansell & R. Silverstone (Eds), *Communication by Design*, Oxford, OUP.
Stoneman, P. (2001). *Technological Diffusion and the Financial Environment*, working paper 2001-03, University of Warwick.
Timmer, M.P., Ypma, G., & van Ark, B. (2003). *IT in the European Union: Driving productivity divergence?*, GGDC Research Memorandum GD-67, University of Groningen.
Trompenaars, F. (1993). *Riding the waves of culture: Understanding cultural diversity in business*, London, Nicholas Brealey.
van Ark, B., Inklaar, R., & McGuckin, R. H. (2002). *Changing gear: Productivity, ICT and service: Europe and the United States*, University of Groningen and The Conference Board, mimeograph.

Van de Ven, A. (1986). Central problems in the management of innovation. *Management Science*, 32: 590-607.

van Everdingen, Y., & Waarts, E. (2003). The effect of national culture on the adoption of innovations, *Marketing Letters*, 14(3): 217-232.

Woodman, R.W., Sawyer J.E., & Griffin, R.W. (1993). Towards a theory of organizational creativity, *Academy of management review*, 18: 293-321.

Zmud, R.W. (1982). Diffusion of modern software practices: influence of centralization and formalization, *Management Science*, 28: 1421-1431.