

RESEARCH PAPER

Shades of gray: Understanding the ethics of society's technology and innovation propensities using national culture

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ABSTRACT

This study examines the effects of national culture on national innovation. This is important because underlying values, which relate to national culture and are the basis of ethical stances, are predicted to affect directly country-level innovation propensities, which then can affect national economic well-being. Combining analyses from two databases, the paper explores the relationships between cultural dimensions, which are manifestations of underlying personal values held across a societal group, and national innovation outcomes. The first database uses Hofstede's national culture dimensions and the other is based on the global innovation index scores of 71 countries. Of the six cultural dimensions, only masculinity/femininity is not found to be significantly related to innovation outcomes. Power distance and uncertainty avoidance negatively relate to innovation outcomes for three and four years, respectively, of the five years tested. Individualism, long-term orientation and indulgence positively relate to innovation outcomes for all five years tested. A major implication is that these cultural variables are important for innovation progress. Findings also suggest that the ethical use of technology and its underlying innovation practices (based on the value systems underlying these cultural dimensions) could benefit from further exploration on the effects of culture. In particular, if a country wants to increase its innovative efforts, it may be well advised to stress individualistic, future-oriented and egalitarian tendencies.

Introduction

With the emergence of deeply invasive technologies, such as surveillance and genetic manipulation, the importance of ethical predispositions towards technological development processes (i.e., innovation) and the use of technology is becoming increasingly evident (Li, 2019). Innovation and the technologies that result from the process depend on context and perspective for their ultimate value (Daniel and Klein, 2014) and this leads to potential for both the 'light and dark side' (i.e., good and bad) of technological advancement. The ethics of innovation and technology are thus characterized by shades of gray. This idea is further developed from the notion that technology may manifest itself in different ways (Ihde, 1990; Feenberg, 1995, 2010). A major aspect of human environments is culture, which is conceptualized as shared understanding and behaviors among a group of people. Culture is inherently bound into the value system of groups of people; Hofstede (1984) defined culture as 'the collective programming of the mind distinguishing the members of one group or category of people from others'. While work habits across national cultures have been extensively studied by Hofstede acolytes, the impact of national culture on innovation and technological advancement have only recently been explicated empirically (e.g., Efrat, 2014; Medcof and Wang, 2017). This paper explores one way in which technology and innovation (and its potential for good or bad) can be researched using the concept of national culture.

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While philosophical treatises on the ethics of technology have been in existence for some time, studies of the ethics of technology and innovation are more recent. For example, Brey (2010) argues that large areas in the field are ‘currently underdeveloped or have been stagnant’. However, more recent approaches to understanding and evaluating technology are being developed (e.g., Coeckelbergh, 2018a). A key to this empirical turn in the field is research into the consequences of technological development using more empirical methods (e.g., Pitt, 1995; Kroes and Meijers, 2000; Achterhuis, 2001). This paper is a response to the empirical turn. It utilizes empirical data from two distinct datasets to evaluate the propensity for innovation across national cultures and thereby demonstrate the potential for research on the effects of national culture on technological and innovation-based ethics.

Rarely have the effects of technological intrusion into so many lives been so prevalent and ubiquitous (Li, 2019). In particular, the use in innovation and other social processes of network information and communication technologies (ICT) and invasive biotechnologies has changed the very relationship of technology to humans. Do we shape technology, or does it shape us? And if we shape technology, what is it about us and our core values that affects how we do the shaping? This study contributes to the debate and to the literature on national culture and innovation by empirically testing the supposition that cultures based on individualism and egalitarian pursuits (characterized by low power distance and uncertainty avoidance, but high on individualism, long-term orientation and indulgence) are inclined towards positive innovation outcomes.

The state of technology and innovation

It will be helpful to clarify what is meant by the terms ‘technology’ and ‘innovation’. Roberts’s (2007) definitions of technology and innovation help to distinguish the product from the process. Technology can be seen as an end product of the process of creativity, which is then commercialized in the process of innovation. For Roberts, innovation is the combination of an invention (the technology) and its commercialization. Others may prefer a more general description of innovation as any process that introduces something new (the word itself means something new). It is useful to distinguish between technology and innovation by defining technology as a thing or product and innovation as a process. In the case of technological innovation, the product is technology. In the case of organizational innovation, the things that make up the organizational process (i.e., innovation) can be referred to as techniques rather than technologies. Therefore, innovation is defined here as the process of introducing (i.e., creating, adopting and/or developing) new technologies or techniques. This definition can incorporate physical technologies (i.e., things) and techniques (i.e., skills or sub-processes that people can act upon) as well as technological and organizational changes (i.e., innovation as a process).

Two important questions are pertinent to the ethics of technology and innovation. The first is based on the product and the second based on the process (though not necessarily in that order). Is the technology/technique itself inherently ethical? Is the process of innovation inherently ethical?¹ A major argument in the literature on the ethics of technology is that, as a tool, the product (technology or technique) is inherently amoral (Reynolds, 1950). Indeed, despite recognizing the inevitability of technological development, Snider (1972, p.97) states that ‘we cannot stop technology; we can only give it direction and purpose’. As with any tool, it is its use that may be considered more or less ethical. For example, a machete is a technology (and quite literally a tool) that can be used to hack at and slice through things. Used ethically, it can help clear fields of unwanted brush.

¹Three major questions are posed by Brey (2010): ‘(1) What is technology? (2) How can the consequences of technology for society and the human condition be understood and evaluated? (3) How should we act in relation to technology?’ The focus here is on the difference between technology and innovation.

It may also be used to kill people. Most individuals would consider this second use unethical.² It is not the technology itself that is ethical or unethical, moral or immoral, but rather the use to which it is put. Following the definitions of technology and innovation outlined above, this logic suggests that it is innovation as a process that should be scrutinized as either ethical or unethical. When discussing the ethics of technology and innovation, it may be advisable to think in terms of process rather than product (Johnson, 2002). Given the previous discussion, this means a focus on innovation itself as a process.

For most innovation processes, there are benefits and costs and these are borne by different people and entities. A particularly salient issue for technological innovation today is the notion of network effects in the distribution of costs and benefits that derive from a new technology. In the past, many technologies were viewed as tools created for and used by an individual for individualized purposes. For example, the use of a hammer is limited to driving in nails. But a network-based technology, such as the telephone or the internet, involves a complicated interconnection of users and developers that depends on complementary etiquette in the use of the tool. The more complex a technology, the more unethical uses it seems to inspire. Network technologies are particularly prone to unethical uses and innovation of networked technologies increases the potential for technological malfeasance. Such technologies are also highly complex and chaotic, inducing self-organizing systems for which it is difficult to predict endpoints (Witt, 1996; Giddens, 1999; Martin, 2016). Indeed, the precautionary principle (Stirling, 2017) recommends a careful approach towards the regulation of such technologies. This has led to increased interest in the concept of ‘responsible innovation’ (Stilgoe *et al.*, 2013; Leone and Belingheri, 2017; Flink and Kaldewey, 2018; Reijers *et al.*, 2018), based on the philosophy of engineering ethics (Brey, 2010).

Is this progress or devolution (where some entities benefit, and some are harmed)? The next section considers whether technological innovation being used for benefit or harm may be dependent on the ethical values of the society. Naturally, the notion of national culture comes to mind, which may be useful in observing the use of technologies and the state of technological innovation in different cultures.

Individualism and power distance are constructs of national culture representing the presence or absence of individual freedoms and egalitarian pursuits. In past studies, these two cultural dimensions have been closely associated with national innovation propensity (Taylor and Wilson, 2012). Individualism (IND) has been defined as ‘the degree to which people in a society are integrated into groups’ (Hofstede, 2011, p.11) and power distance (PD) as ‘the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally’ (Hofstede, 2011, p.9). Low IND scores reveal collectivism, where ‘people from birth onwards are integrated into strong, cohesive in-groups’ (Hofstede, 2011, p.11). High IND scores indicate that individuals have unique rights as individuals, and high PD values indicate a culture heavily weighted towards societal hierarchy. Thus, cultures that score high on IND and low on PD can be considered highly egalitarian. Hofstede’s dimension of uncertainty avoidance (UA) is the ‘extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations’ (Hofstede, 2011, p.10). High UA should be negatively associated with innovation outcomes as innovation requires risk-taking (Mokhber *et al.*, 2017).

Three other cultural dimensions may also be related to innovation in significant ways. Long-term orientation (LTO) refers to the way a society handles the juxtaposition of future and past events and where emphasis is placed. For example, societies scoring low in this dimension ‘prefer to maintain time-honoured traditions and norms while viewing societal change with suspicion. Those with a culture which scores high ... encourage thrift and efforts in modern education as a way

²Even this understanding of ethical value will depend upon the judgment of the perceiver. For example, for one perceiver the hacking down of a productive and beautiful forest area might be seen as unethical and for another perceiver the use of a machete to protect oneself from harm might be justified. Either way, it is the context in which the technology is used that is under ethical scrutiny.

to prepare for the future' (Nurunnabi, 2021, p.47). High LTO scores seem suited to positive innovation outcomes because the typical innovation process can be long and convoluted, requiring 'patient money' and significant investor endurance. High indulgence versus restraint (IVR) scores describe societies that allow 'relatively free gratification of basic and natural human drives related to enjoying life and having fun' (Nurunnabi, 2021, p.47). High IVR scores should also be associated with positive innovation. Many cultures that are low on the indulgence dimension emphasize more traditional ways of doing things to the impediment of innovation and change.

'Masculinity ... represents a preference in society for achievement, heroism, assertiveness, and material rewards for success ... [whereas] femininity, stands for a preference for cooperation, modesty, caring for the weak and quality of life' (Nurunnabi, 2021). On the one hand, masculine cultures reinforce performance and achievements. However, feminine cultures are also geared towards cooperation and quality of life while being more 'consensus-oriented', which could also reinforce innovation. The previous five dimensions are relatively easy to visualize in terms of their presence in egalitarian societies, whereas masculinity/femininity is not as obvious. Thus, of the six dimensions, this last is theoretically tentative as an important driver of innovation.

Culture is tied into the societal value system, which affects the shared understanding and behaviors of people within each society. Underlying values will determine where the emphasis will lie for technological development within any particular society. As Coeckelbergh (2018b, p.5) points out:

Whether we start from the assumption that society is the sum of individuals, or instead from a more relational, communal, or even organic view of the social, will influence our view of responsibility for technology and will lead to different views of responsible research and innovation. For instance, individualist understandings will emphasize individual consent, whereas more communal versions might focus on participatory and communal innovation.

One method for measuring the 'value' of technological innovation in ethics is based on utilitarianism; that is, something is good when many people benefit from it. However, the stakeholders who gain the benefits of new technologies are often not the stakeholders who bear the costs. Thus, one might imagine a cost-benefit analysis where B_i = benefits and C_i = costs to an individual (i) of the technological development. A net positive situation would be where total benefits (TB) outweigh total costs (TC) expressed as the positive sum of $W_B B_i - W_C C_i$ where i is the nth entity in the societal system and W_B and W_C are weights in valuing any technology's benefit or cost, which depends on culture. Thus, cultural values will determine whether a technology is seen as beneficial or detrimental. This derives from the fact that values underlie the ethics of a technology's acceptance and use; and these values also underlie the characteristics of national culture.

Examples abound of differences in the creation and use of technologies in different cultures. Sweden's open use of bio-tagging by its willing citizens is one example. China's openness to biotechnologies and AI-based surveillance technologies is another. We can define the benefits and costs of the technology by adding the following specific 'actors' in the system. When the actor is the general public, we use $I = P$. When the actor is the developer of the technology, we use $I = D$. Finally, when the actor is the government or an upper echelon of society, we use $I = G$. Swedes, for example, score high on IND and low PD, which is typical of an egalitarian society. We would expect such a society to require: $W_C C_D + W_C C_P + W_C C_G \leq W_B B_D + W_B B_P + W_B B_G$ (1). The Chinese, on the other hand, are low IND and high PD, which is typical of an authoritarian society. The Chinese government is also a very powerful player in technology acceptance and dispersion. In such a scenario, individual benefits and cost of technology are not important and can be eliminated from the assessment of what is good for society. Equation (1) would thus become: $W_C C_G < W_B B_G$ (2); that is, only technologies that are clearly beneficial to the government hegemony will be developed and/or utilized (clearly, $W_C C_D + W_C C_P + W_C C_G > W_C C_G$ when $W_C C_D + W_C C_P > 0$). Thus, technology use that might be seen as too costly to societal norms in egalitarian situations might still be utilized by less egalitarian societies that believe the government might benefit ($W_B B_G > W_C C_G$)

from their use. Thus, the same technology, such as AI-based surveillance, might be used in more intrusive ways and for potentially nefarious reasons in high PD, low IND cultures.

The above, of course, applies to both the creation and use of technology. If we focus on the creation of new technologies (innovation), an interesting question arises from these two country examples: From where is innovation most likely to arise? It is important because one would expect that free and open societies would allow the support necessary for independent entities to create new technologies (i.e., technological innovation). Only when inventors believe they may profit individually from their inventions will they spend their resources on the innovation process. That is, $W_B B_D > W_C C_D$. Following this logic, totalitarian and authoritarian societies will not create new technologies, but may adopt them if they fit with their cultural and institutional values. Hence, China adopted the internet, but only when the ‘Great Wall of China internet protocol’ was implementable and guaranteed that $W_B B_G > W_C C_G$. This initially prompted such companies as Google, from an individualist-based culture, to leave the Chinese web space.³

Following this logic, it is argued that individualistic democracies are likely to weight the developer’s benefits and costs (signified here as $W_B B_D$ and $W_C C_D$) more heavily. Therefore, more innovation will take place in high IND (individualist) cultures. In contrast, collectivist societies (or low IND cultures) are likely to have more equal distributions such as: $W_C C_D + W_C C_P + W_C C_G = W_B B_D + W_B B_P + W_B B_G$. This should result in less emphasis on innovation. Finally, highly despotic societies (with high PD) are likely to have the ruling class’s benefits and costs (signified here as $W_B B_G$ and $W_C C_G$) more highly rated. Dissemination in such a society will be negatively affected. Following this logic helps explain one study on the role of large individual investors’ culture (Cillo *et al.*, 2018), which found individualism to be the only dimension of Hofstede’s framework that never weakened the positive innovativeness–stock holding relationship. One would also expect a negative relationship with access to, and the use of, ICT in societies that are low in IND and high in PD. In such a scenario, $W_B B_G < W_C C_G > W_B B_D + W_B B_P$. However, in general it is clear that innovation requires information and ICTs facilitate the process, as in the case of employee-driven innovation (Gressgård *et al.*, 2014).

So far, the analysis has been based on logical observations and deductions. In order to test these assertions, the following hypotheses were developed which follow from the logic of benefits and costs. Specifically, a cost-benefit analysis suggests that cultures characterized by egalitarian tendencies will engage in more innovation. In the next section, the data and method used to test them are delineated.

Hypothesis 1. National cultures characterized by high individualism are more likely to engage in innovation.

Hypothesis 2. National cultures characterized by high power distance are less likely to engage in innovation.

Hypothesis 3. National cultures characterized by high uncertainty avoidance are less likely to engage in innovation.

Hypothesis 4. National cultures characterized by high long-term orientation are more likely to engage in innovation.

Hypothesis 5. National cultures characterized by high indulgence are more likely to engage in innovation.

Hypothesis 6. National cultures characterized by high masculinity are more likely to engage in innovation.

³Changes in the perception of costs and benefits for actors over time have resulted in flip-flopping of developers’ and governments’ positions over time. The large Chinese consumer market, of course, dictates the benefits equation for many technology developers.

Methodology

To test the hypotheses that national culture differences matter to innovation propensities, data were collected separately from two distinct publicly available secondary sources. Such a method avoids bias issues, such as common method variance. It is also notoriously difficult to study cross-cultural interaction because of the need for larger databases across countries. The first database is well known from Geert Hofstede's studies, which provide cultural values to each country for each cultural dimension (<https://www.hofstede-insights.com>). While there has been some criticism of the reification of such national culture measures (see Hoecklin, 1995), these cultural dimensions are still useful and are being used by researchers today. The second source provides data on innovation activities by country (<https://www.globalinnovationindex.org>). Information on these data sources can be found in Hofstede's studies of national culture (Hofstede, 1991, 2011) and from the global innovation index (Soumitra *et al.*, 2018).

Hofstede's data provide values for the cultural dimensions. Each country is given a number between 1 and 100 that corresponds to the index being measured. Individualism is defined as 'a preference for a loosely-knit social framework in which individuals are expected to take care of only themselves and their immediate families' (Nurunnabi, 2021, p.78). High scores indicate this preference. Low scores indicate 'a preference for a tightly-knit framework in society in which individuals can expect their relatives or members of a particular in-group to look after them in exchange for unquestioning loyalty'. Power distance (PD) 'expresses the degree to which the less powerful members of a society accept and expect that power is distributed unequally. The fundamental issue here is how a society handles inequalities among people'. High scores indicate the willingness of societal members to accept inequality among society members. Uncertainty avoidance (UA) is 'the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity' (Nurunnabi, 2021, p.79). High scores indicate such discomfort. High long-term orientation (LTO) scores reflect a focus on the future and progressive change, whereas low scores reflect a preference 'to maintain time-honoured traditions and norms while viewing societal change with suspicion'. High indulgence (IVR) scores indicate 'relatively free gratification of basic and natural human drives related to enjoying life and having fun'; while low scores represent restraints on citizen behaviors, suggesting impediments to innovation and change. High masculinity/femininity (MAS) scores indicate more 'masculine' societies that emphasize 'achievement, heroism, assertiveness, and material rewards for success' and low scores indicate 'feminine' societies with preferences for 'cooperation, modesty, caring for the weak and quality of life'.⁴

The output measures of innovation were gathered using available data from the global innovation index (GII) studies for the years 2016 through 2020, which are pertinent to commercial, scientific, and technological innovation. The GII scores per country were used as they avoid the bias associated with individual measures of innovation inputs and outputs, such as patents applied for and patents granted, which are skewed towards the large economies of the United States, China and Japan. The GII score already considers *per capita* differences across countries and thus provides a more unbiased measure of innovation propensity which considers all factors associated with national innovation efforts. The use of five years of data (going back to 2016) helps show either patterns of change or stability in the relationships tested. Data from the two distinct databases were cleaned and countries that did not allow for a full set of cross-country data were eliminated. Once this process was complete, 71 countries remained in the analysis. Linear regression was used to test for a direct relationship between the national culture dimension and the GII scores. Using multiple years allowed for studying any lagged effects.

⁴The use of definitions and values is from the source of the cultural dimensions database at <https://www.hofstede-insights.com>. The original cultural dimensions were first discovered and presented in Hofstede (1984) but have been updated over the years. The most recently updated six cultural values are in Hofstede (2011) and are also delineated in Nurunnabi (2021).

Results

Table 1 shows the descriptive statistics for the variables used in the study. Measures across time are very stable. For example, the correlation across the five years of GII scores ranges from 98–99%, all at $p < 0.01$ significance. There is also a significant negative correlation between the independent variables of IND and PD. IND is often negatively correlated with PD, which makes sense given the nature of the constructs, but they are distinct both theoretically and empirically. Despite this, the highest variance inflation factor (VIF) for the multi-variable regression models is about 2.5 – well below the recommended 5 for multicollinearity issues to become problematic.

Table 2 displays the models of all six cultural dimensions with the GII scores for each of the five years examined. The adjusted R^2 of the five models ranges from 67.4% to 72%, suggesting a strong explanatory power of the dimensions in general. Of the six dimensions, only MAS is not significant for any of the five years tested. Thus, H6 is not supported. IND, LTO and IVR are significantly and positively related to GII scores for all five years, thus supporting H1, H4 and H5. These relationships are strong across the five-year period, suggesting a robust relationship between the variables in general. PD and UA are significantly and negatively related to GII scores for three and four years respectively. Thus, H2 and H3 are partially supported as most years are statistically significant at the $p < 0.05$ level.

Table 1. Descriptive statistics

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1 PD	59.34	21.92										
2 IND	43.89	23.59	-0.65**									
3 MAS	48.03	20.08	0.14	0.08								
4 UA	66.48	22.74	0.24*	-0.24*	-0.05							
5 LTO	46.47	23.54	0.06	0.14	0.05	0.10						
6 IVR	46.85	22.43	-0.40**	0.21	-0.01	-0.21	-0.43**					
7 GII 2016	42.54	11.78	-0.61**	0.71**	-0.06	-0.24*	0.40**	0.31*				
8 GII 2017	42.64	11.73	-0.58**	0.70**	-0.08	-0.22	0.44**	0.24	0.99**			
9 GII 2018	42.19	11.95	-0.57**	0.70**	-0.06	-0.21	0.46**	0.22	0.99**	0.99**		
10 GII 2019	40.99	11.22	-0.56**	0.69**	-0.05	-0.20	0.47**	0.17	0.98**	0.99**	0.99**	
11 GII 2020	38.82	11.67	-0.54**	0.69**	-0.05	-0.19	0.49**	0.16	0.98**	0.99**	0.99**	0.99**

** $p < 0.01$; * $p < 0.05$

Table 2. Regression models – dependent variable = GII scores

	2016		2017		2018		2019		2020		Significant at $p < 0.05$ for # of years
	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value	
Constant		0.000		0.000		0.000		0.000		0.000	
PD	-0.294	0.008	-0.257	0.017	-0.229	0.036	-0.222	0.068	-0.178	0.142	3
IND	0.298	0.005	0.327	0.002	0.341	0.001	0.330	0.005	0.352	0.003	5
MAS	-0.063	0.381	-0.088	0.218	-0.082	0.262	-0.087	0.290	-0.098	0.231	0
UA	-0.166	0.024	-0.153	0.037	-0.142	0.057	-0.175	0.031	-0.165	0.042	4
LTO	0.517	0.000	0.553	0.000	0.570	0.000	0.545	0.000	0.566	0.000	5
IVR	0.292	0.001	0.274	0.002	0.267	0.003	0.250	0.010	0.259	0.007	5
F	26.704	0.000	26.717	0.000	25.297	0.000	19.991	0.000	19.920	0.000	
Adj R^2		72.0		71.7		70.5		67.4		67.4	
ΔR^2				-0.3		-1.2		-3.1		0.0	

Table 3 displays the models examining IND and PD separately for the year 2020 data. Model 1 shows the model without PD included where IND is significantly and positively related to GII scores. Model 2 shows that when PD is examined without the effects of IND in the model, it is significant at the $p < 0.000$ level. However, when IND is included in the model with all six dimensions (model 3 of Table 3), the effects of PD become insignificant, suggesting that IND and PD interact to some extent and that IND has the stronger effect. However, once again, multicollinearity is not an issue as the highest VIF of the model is 2.4. Models 4 and 5 are single variable regressions of PD and IND, which demonstrates the power of the two dimensions alone. However, with a higher R^2 found for model 5 over model 4, IND once again appears to have the stronger influence on innovation scores.

To analyze further the two cultural values of IND and PD and their interaction, a k-means cluster analysis was conducted, which categorized the dataset of countries into four distinct clusters. Cluster 1 (characterized by high PD and low IND; $n = 14$) was then compared with cluster 4 (characterized by low PD and high IND; $n = 17$). Table 4 shows the final cluster center scores. Table 5 depicts the countries by the clusters into which they are categorized. Table 6 states independent samples t-tests between clusters 1 and 4 for all five years. Statistically significant mean differences are also found (but not tabulated here) for clusters 2 and 3. This *post hoc* analysis suggests that most cultures are either high on one or the other cultural dimension and that the two spectrums (cluster 1 and 4) have quite different statistically valid innovation scores. Table 7 provides a summary of the empirical findings with regard to the hypotheses.

Discussion

The empirical part of this study demonstrates that most of the cultural values studied are associated with technological innovation variables in either a positive or negative manner. The data show that innovation proclivity, as measured by the GII score, is generally lower in high PD cultures and higher in high IND cultures. When considered alone, high PD cultures have a negative effect on innovation, but when IND is included, the relationship becomes mostly positive for IND and insignificant for PD (probably because of the high negative correlation between PD and IND). *Post hoc* cluster analyses provide further evidence of the negative effect of PD and the positive effect of IND on innovation. This suggests higher levels of IND may help mitigate the dark patterns of technological innovation or technology use in high PD cultures. However, in cultures with both low IND

Table 3. Regression models – dependent variable = GII scores for year 2020

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value
Constant		0.000		0.000		0.000		0.000		0.000
PD			-0.432	0.000	-0.178	0.142	-0.537	0.000		
IND	0.469	0.000			0.352	0.003			0.690	0.000
MAS	-0.133	0.096	-0.048	0.579	-0.098	0.231				
UA	-0.172	0.036	-0.182	0.038	-0.165	0.042				
LTO	0.558	0.000	0.636	0.000	0.566	0.000				
IVR	0.303	0.001	0.242	0.019	0.259	0.007				
F	22.895	0.000	18.743	0.000	19.920	0.000	25.525	0.000	57.366	0.000
Adj R ²		66.6		61.7		67.4		27.7		46.8
ΔR^2				-4.9		5.7		-39.7		-20.6

Table 4. K-means cluster analysis

	Final cluster centers				ANOVA	
	Cluster				F	Sig.
	1	2	3	4		
	90	64	54	31	112.998	0.000
PD						
IND	25	27	61	73	87.373	0.000
N	14	27	13	17		

Table 5. Countries in database by (PD-IND) clusters

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Albania	Brazil	Argentina	Australia
China	Bulgaria	Belgium	Austria
Guatemala	Burkina-Faso	Czech Republic	Canada
Indonesia	Chile	Estonia	Denmark
Malaysia	Colombia	France	Finland
Mexico	Costa Rica	Italy	Germany
Mozambique	Croatia	Japan	Hungary
Panama	Egypt	Latvia	Iceland
Philippines	El Salvador	Lithuania	Ireland
Romania	Greece	Malta	Israel
Russian Federation	India	Poland	Netherlands
Serbia	Iran	South Africa	New Zealand
Slovakia	Jamaica	Spain	Norway
Ukraine	Kenya		Sweden
	Korea		Switzerland
	Lebanon		United Kingdom
	Morocco		United States of America
	Namibia		
	Pakistan		
	Peru		
	Portugal		
	Senegal		
	Singapore		
	Slovenia		
	Thailand		
	Trinidad-and-Tobago		
	Uruguay		

and high PD, innovation propensity is low and the effect on the ‘dark’ use of technology may be high. That is, the patterns observed are consistent with the pattern of technologies being created for benevolent purposes in a high IND culture and then utilized in unexpected manners in other high PD cultures. An example of such a situation is the use of surveillance technologies in China, which has a low IND and somewhat high PD culture. In fact, China was classified as cluster 1 of Table 4,

Table 6. Clusters 1 and 4 means t-tests for GII scores

	Cluster number	N	Mean	Std. deviation	Std. error mean	t Stat (equal var)	t Stat (no equal var)
GII 2016	1	14	35.436	6.5404	1.748		
	4	17	56.847	5.2277	1.2679	-10.137	-9.915
GII 2017	1	14	36.014	7.2822	1.9463		
	4	17	56.876	5.9928	1.4535	-8.756	-8.589
GII 2018	1	14	35.443	7.7522	2.0719		
	4	17	56.529	5.7865	1.4034	-8.67	-8.426
GII 2019	1	13	35.477	8.248	2.2876		
	4	14	55.243	6.0567	1.6187	-7.135	-7.053
GII 2020	1	13	33.423	9.0356	2.506		
	4	14	53.136	6.4259	1.7174	-6.571	-6.489

Table 7. Summary of hypotheses findings

Hypothesis	Finding
<i>Hypothesis 1. National cultures characterized by high individualism are more likely to engage in innovation</i>	Supported
<i>Hypothesis 2. National cultures characterized by high power distance are less likely to engage in innovation</i>	Partially supported
<i>Hypothesis 3. National cultures characterized by high uncertainty avoidance are less likely to engage in innovation</i>	Partially supported
<i>Hypothesis 4. National cultures characterized by high long-term orientation are more likely to engage in innovation</i>	Supported
<i>Hypothesis 5. National cultures characterized by high indulgence are more likely to engage in innovation</i>	Supported
<i>Hypothesis 6. National cultures characterized by high masculinity are more likely to engage in innovation</i>	Not supported

along with Albania, Indonesia, Malaysia and ten other countries. For instance, global positioning systems (GPS) that can help track down a lost child can also be used by despotic authorities to monitor every citizen's location. While it is important to point out that a direct causal relationship cannot be determined by the data available here, the correlational relationships are compelling.

The implications of these findings for theory development include the importance of utilizing national culture variables in assessing the technological innovation potential of a country or economy. The study also demonstrates how considering the benefits and costs of actors within the socio-technical environment of an economy can help to explain these innovation propensities, although directly measuring these costs and benefits is difficult. It also shows that these relationships can be explained by the value system of the economy – i.e., the culture.

The results suggest that technological innovation flourishes in egalitarian cultures. This may not seem novel, but with talk of innovation in China as 'innovation with Chinese characteristics' (Li-Hua, 2014), it suggests that some, at least in the Chinese government, believe that the logic of a cost-benefit analysis can be circumvented. Chinese characteristics can be seen to include a one party system, which is not much different from the governing bureaucracies of the emperors. But innovation in such circumstances requires manipulation of the weights used in the earlier cost-benefit equations to focus primarily on the ruling class. In fact, Johnson (2015) argues that most

inventions in the days of China's emperors (when China was the world's leading innovator) can be traced to service on behalf of the emperor and no one else. Innovations where $W_B B_G < W_C C_G$ when $G =$ the emperor would never happen. The logic presented here explains how egalitarian economies innovate in things like ICTs and open technologies, whereas non-egalitarian societies will fail. However, distribution and enhancements of innovations may be a different matter entirely. Hence the ability of the Chinese government to build hospitals quickly or re-engineer the internet to meet its own standards of compliance. Working towards the ethical use of technological innovation might require considering the underlying values of society. Furthermore, manifestations of these values can be measured by Hofstede's national cultural dimensions.

Conclusion

A major advantage of the empirical study described here is that it relies on data from two independent, publicly available databases. This reduces the potential for in-study biases, such as common method variance. Thus, the relationships that are supported by the tests demonstrate both internal and external validity. However, this design does not allow for specific testing of constructs or variables outside those available in the datasets. Of course, the main purpose of this paper is to demonstrate that national culture values are associated with innovation propensities and the ethical issues that underlie these propensities. Further research should focus on specific observations of ethical values with innovation that may be influenced by culture. For instance, an experimental design might compare data on innovation propensities from two countries that are distinctly different in national culture. However, the results here do verify that national culture can be associated with innovation propensity.

Values change over time. For example, attitudes towards individual privacy have changed in the Western world as people become accustomed to sharing information across social media platforms (see Coeckelbergh, 2018b). Therefore, research needs to take a longitudinal perspective. In this preliminary work, data were examined over five years to test the robustness of the relationships proposed. The relationships proved robust over this short period, but this might not be the case in the future. In the data of this study, the effects of PD and UA seem to lessen over time.

Furthermore, our acceptance of new technologies as progress may expose us to danger from the use of these same technologies in 'darker' ways. China is a good example of a country that may be doing just that – taking technologies developed in the West and developing them for potentially nefarious purposes (see Johnson, 2015). Understanding the effects of the underlying values of culture is helpful in determining how important this danger may be. While high IND cultures are open to innovation in general, they may or may not be ready for the unethical use of the technologies that emerge from the innovation process. Focusing on the use of technologies and these underlying values is the basis for the ethical determination of innovation outcomes.

This paper focuses on technological innovation. However, there is also an imperative to consider the ethical and cultural implications for social innovation. The approaches used in this paper of 1) considering the unequal costs and benefits of stakeholders, and 2) the cultural dimensions of stakeholders, can and should be applied to social innovation. There are parallels in the work on responsible innovation (Stilgoe *et al.*, 2013; Leone and Belingheri, 2017; Flink and Kaldewey, 2018; Reijers *et al.*, 2018). Understanding the underlying cultural values and the costs and benefits of stakeholders could generate more efficacious citizen science efforts.

In conclusion, this paper demonstrates the advantages of utilizing national culture data to study innovation processes. This is a first step towards understanding the ethics of technological use and the innovation process in the national context. Further research into the area using other national culture data such as the GLOBE studies (House *et al.*, 2004) and newly developed constructs and indexes is warranted. Thus, using Hofstede and GLOBE factors can help determine when a technology or innovation process is likely to be 1) created and 2) utilized, and whether this might be in a positive (i.e., light) or detrimental (i.e., dark) manner or, more likely, some shade of gray.

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