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RE-EXAMINING THE LINKS BETWEEN CULTURAL VALUES AND INNOVATION

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ABSTRACT. The fact that the majority of the papers investigating the link between culture and innovation use Hofstede's cultural theory and indicators prompts a question of whether the alternative cultural theories and variables can provide us with a better understanding of this link. This issue is further necessitated by the strong criticism of the validity of Hofstede's cultural dimensions throughout their use. This study investigates the link between culture and innovation using four separate sets of cultural indicators: Hofstede's, Schwartz's, Inglehart's and Minkov's. The results of the empirical analysis highlight that individualism-collectivism unambiguously emerges as significantly linked with innovative activity regardless of the cultural theory utilised. Additionally, compared to Hofstede's, all alternative sets of cultural indicators provide a better model fit, avoid some of the long-standing multicollinearity problems, and provide a more grounded theoretical foundation, complete with a better replicability of such variables.

JEL Classification: A12, O30, Z13

Keywords: cultural dimensions, innovation, value orientations, Hofstede, individualism

Introduction

It is hard to overestimate the role of innovation in the modern economic environment. With studies presenting its impact on, among others, economic growth, sector performance and national competitiveness (i. a. Kim, Chai, 2017; Carayannis, Grigoroudis, 2016; Wong et al., 2005), innovative activity has become the key element of long-term economic development and has received keen attention from researchers and policymakers. As the number of studies on innovation grows, it becomes clearer that the differences in the innovative activity of different countries cannot be explained purely by the differences in the economic development or policies of the different regions or countries the firms are operating in. Society-level culture has been offered as one way to explain such variance.

Shane (1992) eloquently concluded the first interdisciplinary paper on culture and innovation with 'Culture matters'. Now, almost three decades and numerous papers later, there is little doubt left in this remark. A number of studies have confirmed the link between society-level culture and various aspects of innovative activity (see Kirkman et al., 2017). A large portion of these studies focused on Hofstede's cultural theory as the most influential and the first to introduce quantitative measures for the empirical analysis (Hofstede, 1980; Hofstede, 2011). However, given the long-standing criticism of Hofstede's theory and established issues

of replicability for some of Hofstede's cultural dimensions (Fellows, Liu, 2013; Minkov, 2018), it is reasonable to explore the possible alternatives for measuring culture that can be linked with innovative activity and examine the similarities and differences in the link between innovation and cultural indicators of these respective theories.

In the years after Hofstede published his theory, several cultural theories have emerged (Schwartz, 1994; Inglehart, 1997; Welzel, 2003), each unique in its approach to operationalising culture. On the other hand, the initial work of Hofstede was built upon and refocused, reflecting several decades of criticism and refining the factor analysis to produce more internally consistent and logically sound dimensions (Beugelsdijk and Welzel., 2018; Minkov et al. 2017, 2018a). While Bukowski and Rudnicki (2019) provided an extensive comparison of Hofstede's and Minkov's cultural indicators, no study has yet tried to compare the suitability of these indicators against other earlier established theories specifically to analyse the link between culture and innovation. The novelty of the paper lies in performing a large-scale comparative analysis of four sets of cultural indicators: Hofstede's, Minkov's, Schwartz's and Inglehart's cultural dimensions.

The purpose of the current study is to bridge this gap by analysing a link between culture and innovative activity using several sets of cultural dimensions from different theories for comparison. The paper uses several datasets of cultural data from various cultural theories against the data about innovation from the World Bank and the World Intellectual Property Organization. Correlation analysis and multi-level mixed effects regressions are employed to explore the link between innovation and society-level culture.

The comparative analysis of the theories presents evidence of a strong link between individualism-collectivism cultural dimension and innovative activity. This link is significant across cultural theories and different sets of indicators, suggesting a positive relationship between innovators' ability to break the established conventions and their innovative capabilities. The paper also presents the proof of suitability of using alternative cultural indicators and outlines how their relevant theoretical frameworks avoid some of the weaknesses of Hofstede's indicators.

The paper is structured as follows. The next section examines Hofstede's theory and its criticism, provides alternatives and discusses how they avoid the mentioned shortcomings. Next, a link between different cultural indicators and innovation will be hypothesized using previous theoretical and empirical studies, providing clarifications as necessary. After this, data and methodology used in the paper are provided, followed by the results of an empirical analysis and discussion. The last section concludes and discusses possible future directions of study and limitations of this paper.

1. Literature review

1.1. Operationalising culture

Culture belongs to one of the fundamental concepts that are easy to intuitively understand, but difficult to formally define. It encompasses a system of internal beliefs and values as well as external practices, providing a rich background for analysis of actions and motivations of individuals belonging to a particular society. In this regard, culture provides explanations why decisions that seem unreasonable to a member of one society are perceived as unquestionably obvious to a member of another one.

Operationalising culture can be explained as the use of primarily quantitative methods. This is done through the use of cultural theories that attempt to encompass several key cultural concepts into usually bipolar cultural dimensions, assigning a dimension score for each society.

More importantly, however, such theories provide justification on the importance of such dimensions and their potential in explaining differences in social, political and economic areas.

Arguably the biggest contribution into the field of quantitative cultural theories of 20th century was Hofstede's (1980) cultural theory, revised several times to reflect its initial shortcomings (Hofstede, 2001, 2011) and expanded to include additional dimensions (Hofstede, Bond, 1988; Hofstede et al., 2010). Four original cultural dimensions, individualism-collectivism, power distance, masculinity-femininity and uncertainty avoidance, proposed by Hofstede, were extensively used in studies that link culture with various economic concepts (Kirkman et al., 2017). Hofstede's theory in general became a staple of a majority of multidisciplinary studies.

Several quantitative cultural theories were devised in decades after Hofstede's initial research, including, among others, Schwartz's (1994) theory of values, Inglehart's cultural dimensions (1997) and GLOBE's culture and leadership study (2004). These differ in the empirical approaches and methods, but share a similar starting point by analysing aggregated cultural surveys. Despite each utilising a different set of cultural indicators, these share some similarities based on the common nature of the environment the tried to describe. As Hofstede (2011) explained, the dimensions are constructs, created to represent a complex reality of the social world in a simple way. It is only natural then, that some aspects of such constructs will resemble those of the other theories.

A strong criticism of Hofstede's theory emerged in the beginning of 21st century, with authors questioning the validity of Hofstede's dimensions, their theoretical justification and replicability (Gelfand et al., 2004; Taras, Steel, 2009; Minkov, 2018, Minkov, Kaasa, 2020). Of particular interest is the criticism of Hofstede's initial four dimensions, which continue to be used in majority of studies that link culture with socioeconomic phenomena. Out of these, individualism-collectivism has had the greatest predictive power (Taras et al., 2010) and has conceptually emerged in various forms in other cultural theories, for instance, as Schwartz's autonomy-embeddedness value orientation (Minkov et al., 2017). Despite this, some concern remains over the questions chosen by Hofstede to represent this dimension and several researchers advocate to use different questionnaire items that produce greater internal reliability (Bond et al., 2002; Gelfand et al., 2004; Brewer, Venalik, 2011). Power distance, while originally devised by Hofstede as a separate dimension, is highly correlated with individualism and is claimed by many researchers to represent a similar concept of group belonging with an opposite sign (Gelfand et al., 2004; Minkov et al., 2017; Beugelsdijk and Welzel., 2018). Masculinity-femininity dimension consistently failed to be replicated and is not strongly linked with emerging cultural indicators of other dimensions (Ng et al., 2007; Beugelsdijk and Welzel., 2018, Minkov, 2018, Minkov and Kaasa, 2020). Finally, uncertainty avoidance was successfully replicated by Minkov and Hofstede (2014) for a limited subset of countries and was linked to several socioeconomic phenomena (Kapp et al., 2011). Regardless, similarly to masculinity-femininity, uncertainty avoidance has failed to replicate in later studies (Minkov, 2018, Minkov and Kaasa, 2020) and researchers doubt the theoretical validity of this dimension, claiming that some or most of the questions used in constructing this dimensions are more closely related with the individualism-collectivism dimension (Minkov, 2018; Minkov and Kaasa, 2020; Beugelsdijk and Welzel., 2018).

Following the criticism above, it stands to reason that the shortcomings of Hofstede's approach become more apparent as the field of cultural studies matures, and the advances in this field make original Hofstede's scores unusable and meaningless (Minkov, 2018, Beugelsdijk and Welzel., 2018). This study will attempt to provide further arguments towards the shift from Hofstede-centric approach to more modern theories that avoid the discussed problems.

Hofstede's initial four cultural dimensions could be represented by a single, or at most two non-correlated cultural dimensions, with several successful attempts (Beugelsdijk and Welzel., 2018; Minkov et al., 2017). The resulting dimensions build up on the Hofstede's idea and findings, but utilises more grounded definitions of cultural dimensions and ensures that the items used to construct these have strong internal consistency.

Minkov et al. (2017, 2018a, 2018b) propose one such set of indicators. They reconceptualise the individualism-collectivism dimension as a factor that reflects 'national differences in conformism, desire for social ascendancy, and differential treatment of in-groups and out-groups' (Minkov et al., 2017, p. 392). This highlights the most important features of the dimension, while simultaneously avoiding those only weakly related to the existing national measures, such as a degree of self-reliance, consistency or self-containment. For a second dimension, they choose flexibility-monumentalism that highlights differences that are not covered by the differences in the individualism-collectivism scores (Minkov et al., 2018a). This dimension presents a refocused idea of long versus short-term orientation, originally proposed as a fifth dimension and an extension of Hofstede's model and labelled 'Confucian work dynamism' (Hofstede, Bond, 1988; Hofstede, 1991). It encompasses differences in societal desires for self-enhancement and stability, as opposed to self-reliance. This differs substantially from Hofstede's approach to the indicator, which was focused on time orientation, perseverance and thrift (Hofstede, Bond, 1988). The one rather problematic aspect of these refocused dimensions is their moderate significant positive correlation, which makes interpretation of the results more difficult (Bukowski, Rudnicki, 2019).

Schwartz's (2006) theory of values is another strong alternative for future research to consider. Originally designed to measure individual value priorities (Schwartz, 1992), it has been later used to derive cultural dimensions (Schwartz, 1994). Schwartz's approach is unique, as it departs from the commonly assumed orthogonal nature of Hofstede's dimensions, instead inferring societal values from individual values and assuming their conceptual interdependence. He originally hypothesised two cultural dimensions, one along the autonomy-embeddedness (originally labelled conservatism) values, and one along hierarchy/mastery versus egalitarianism/harmony values. However, hierarchy-egalitarianism and mastery-harmony have emerged separately, and autonomy values were further distinguished into affective, focusing on hedonism, and intellectual, focusing on self-direction (Schwartz, 1994).

In a similar fashion to Hofstede, Schwartz has refined both his theoretical approach and the resulting cultural dimensions' scores (Schwartz, 2006, 2008). The obtained value orientations have been criticised for strong significant correlation, both internally and with Hofstede's individualism, argued to hint at a lack of substantial novelty (Hofstede, 2001). On the other hand, utilising a single dimension to encompass several distinct value orientations might oversimplify the model and lead to misinterpretation of the empirical findings based on those (Jackson, 2001). In this regard, utilising Schwartz's value orientations might better explain some aspects of economic phenomena (Hsu et al., 2013). They were also criticised for low internal reliability (Minkov et al., 2017), and so bear a similar problem of arbitrary selection of items for cultural dimensions.

Yet another possibility is utilising value indices from Inglehart's cultural theory. It includes two main value indicators: secular versus traditional values and survival versus self-expression values. These value indicators are mostly utilised by papers in political science and sociology area, where Hofstede's theory did not gain popularity because of its static nature. Perhaps the biggest benefit of utilising Inglehart's value indices is their focus on cultural differences in dynamic context, known as the modernisation theory (Inglehart, Baker, 2000). In this regard, both value indices measure a society's shift from materialism to postmaterialism. However, this immediately exposes the greatest weakness of the resulting indicators. It is argued that if two factors are not enforced during a factor analysis, it would instead converge

to a single factor explaining most of the variance in the responses (Li, Bond, 2010. Theoretical justification of these indices has also been criticised by oversimplification of societal values and a single focus on economic development as a determinant of value shift (Haller, 2002).

In conclusion, no alternative seems to be perfect in either its theoretical or empiric implementation. However, it is important to note that these offer significant improvements over Hofstede's initial research in various areas, be it a stronger internal consistency of dimensions, a more solid theoretical justification of utilising the dimension or a departure from the static nature of the cultural factors. In the next section, the suitability of alternative cultural dimensions from the abovementioned theories when discussing the link between culture and innovative activity is analysed.

1.2. Innovation and culture

An important milestone that served as a reference point for most future studies was Shane's (1992) first interdisciplinary study on culture and innovation that has provided the evidence of a significant link between several cultural dimensions and the level of innovation. Shane explained his findings by suggesting that high individualism creates a desire to innovate, low power distance prevents the establishment of significant barriers to innovate and low uncertainty avoidance helps accept the risks that the innovative activity entails (Shane, 1993). These general explanations can be used to assume a similar mechanism of a link between culture and innovation regardless of the cultural theory utilised, as the actual cultural manifestations remain the same regardless of the cultural dimensions of different theories representing them.

Following Shane's (1992) findings, it is possible to link cultural dimensions with innovation through analysing cultural manifestations they represent. For Hofstede's theory, for instance, it is reasonable to assume that societies with higher levels of individualism are more likely to encourage innovative activity, as personal accomplishments are more desirable and noticeable in such societies. On the other hand, countries with a low score of individualism fail to provide the incentives and desire to innovate (Shane, 1992; Van Everdingen, Waarts, 2003; Efrat, 2014; Bukovski, Rudnicki, 2019). This translates into a following hypothesis:

H1a. Hofstede's individualism is statistically significantly positively linked with innovation.

Power distance can be negatively linked with innovation as it creates informal barriers that prevent the implementation of new ideas. This effect is twofold. First, innovators are discouraged from presenting the new ideas if they don't have sufficient authority in the organisation or society. In addition, societies that score higher on a power distance dimension are more conservative, and, therefore, oppose radical changes, which decreases the value of innovations. Empirical evidence of such link can be found in multiple studies (Shane, 1992; Van Everdingen, Waarts, 2003; Kaasa, Vadi, 2010; Efrat, 2014). More importantly, power distance dimension can be seen as flawed, essentially representing the same cultural differences individualism-collectivism dimension does with the opposite sign, rather then a separate cultural phenomenon (Minkov et al., 2018a, Beugelsdijk and Welzel., 2018). This is reflected in the next hypothesis:

H1b. Hofstede's power distance dimension is statistically significantly negatively linked with innovation.

While the usage of original Hofstede's scores can be questioned, the theoretical foundation and four decades of studies with varying degrees of success allow to claim that at least part of the theoretical foundation built by Hofstede remains useful. Care should be made, however, not to misinterpret the possible results simply because of their statistical (in)significance. As discussed above, Hofstede's individualism and power distance are strongly

negatively correlated, leading to possible distortion of the resulting significance. On the other hand, should one or both of these turns insignificant when utilised together in a regression, it would serve as a signal of long-standing problems in the internal consistency of these factors.

A higher score of uncertainty avoidance would cause societies to become more cautious towards pursuing and implementing innovations (Shane, 1992; Van Everdingen, Waarts, 2003; Kaasa, Vadi, 2010; Efrat, 2014). This effect can be similar to the power distance, but instead of preserving the status quo because of the lack of authority and voice, the status quo is pursued as a separate goal in the society regardless of the position. As Minkov and Hofstede (2014) note, uncertainty avoidance can be represented by two concepts: stress and anxiety regarding the unknown, and the desire to impose more or stricter rules to counter the abovementioned feelings. In the IBM questionnaire used by Hofstede these are represented by questions about following the work rules and the perceived duration of work for the same employer. Uncertainty avoidance, as it was conceptualised by Hofstede, however, does not include avoiding risky situations or stress altogether.

This explains why employees in countries with high uncertainty avoidance scores will continue working for the same employer even if they are dissatisfied with their job (Minkov, Hofstede, 2014). Here, the job-related stress represents a known event, as opposed to the anxiety of the search for a new job, a risky event with unpredictable results. In Hofstede's approach, high score of uncertainty avoidance would mean that people in a society prefer a known risk to an unknown one.

However, because Hofstede's original dimensions were drawn from a single stable multinational company, it is unclear how job security questions could reveal this underlying anxiety. Despite Hofstede interpreting the duration of work for the IBM as an indicator for job security, it can be concluded that rather than separating societies into low- and high uncertainty avoidance, it instead separated them based on the perceived stability of a multinational company's position in the analysed country.

It could instead be argued that the desire to follow rules and avoid conflicts are both components of a collectivist society, promoting obedience and conflict avoidance (Minkov et al., 2017). In this regard, a statistically significant result would be meaningful not as a link between uncertainty avoidance and innovation, but as an extension of the link between individualism-collectivism and innovation.

H1c. Hofstede's uncertainty avoidance dimension is statistically significantly negatively linked with innovation.

Finally, there has been extensive analysis of the masculinity-femininity dimension among the researchers (Shane, 1992; Van Everdingen, Waarts, 2003; Efrat, 2014; Kaasa, Vadi, 2010; Bukowski, Rudnicki, 2019). It can be argued that societies closer to the masculine side of the dimension are on average more competitive and achievement-oriented, which increases the value of innovating. On the other hand, societies closer to the femininity side of the dimension are more inclusive and supportive, which creates a more favourable environment for innovating without the fear of failure. Because of this, some researchers (Shane, 1992; Bukowski, Rudnicki, 2019) argue that there is no significant link between innovative activity and masculinity dimension, while the others (Kaasa, Vadi, 2010; Van Everdingen, Waarts, 2003) argue that this link is significant and negative in nature. However, a positive link can also be hypothesised, as masculine societies, in Hofstede's interpretation, are more ambitious and independent, and so are more likely to have an internal motivation to innovate. This push factor can be associated with a higher level of innovative activity, as is hypothesised below.

H1d. Hofstede's masculinity-femininity dimension is statistically significantly positively linked with innovation.

Following the earlier discussion on Hofstede's individualism-collectivism dimension, it is reasonable to assume a similar link for Minkov's individualism-collectivism dimension. This can be worded as follows:

H2a. Minkov's individualism-collectivism dimension is statistically significantly positively related with innovation.

The link of Minkov's flexibility-monumentalism dimension with innovation can be hypothesised as positive on the basis of the concept it represents. Flexible societies favour adaptability and self-reliance, crucial for successful innovative activity. In addition, differences in flexibility-monumentalism scores are strongly significantly linked with differences in educational achievements (Minkov et al., 2018a), necessary for modern technological innovations. As the dimension is also based on long versus short-term orientation, it is reasonable to note here that the former corresponds to flexibility pole of the dimension and has been linked with high levels of innovative activity (Van Everdingen, Waarts, 2003; Bukovski, Rudnicki, 2019). This allows to state the following hypothesis:

H2b. Minkov's flexibility-monumentalism dimension is statistically significantly positively related with innovation.

As Schwartz's value orientations can be viewed as strongly linked with (Schwartz, 1994), or even be different facets of Hofstede's individualism-collectivism dimension (Hofstede, 2001), some of these can be hypothesised to be linked with innovation as well. It is also possible that, because of the stronger correlation between these, it is a combination of value orientation scores, rather than a single one, that reveals such link. Much like with Hofstede's individualism, societies with a high Schwartz's autonomy scores, especially intellectual one, are more likely to recognise achievements and create a favourable environment for innovative activity (Moonen, 2017). On the other hand, a high score of embeddedness is detrimental for innovating through formal and informal barriers and can even slow down the scientific progress (Taylor, Wilson, 2012). This leads to the following hypothesis:

H3a. Schwartz's autonomy-embeddedness value orientation is statistically significantly positively linked with innovation.

Societies with a higher score of egalitarianism can be expected to provide a better environment for innovative activity by allowing freedom of discussion. It must be noted, though, that despite hierarchical societies preventing the bottom-up flow of ideas, they can also foster innovative activity depending on the competence of leadership (Ahmed, 1998; Dickson et al., 2003). This mechanism is similar to the one hypothesised for Hofstede's power distance, as societies with higher embeddedness scores are more conservative and less open to new ideas. This is reflected in the following hypothesis:

H3b. Schwartz's egalitarianism-hierarchy value orientation is statistically significantly positively linked with innovation.

For the mastery-harmony value orientation, as with the Hofstede's masculinity-femininity dimension, both sides of the argument should be considered. On the one hand, societies that score highly in mastery value orientation tend place more value on accomplishments, which supports innovative activity (Moonen, 2017). On the other hand, unlike all discussed dimensions above, this effect is centred on the individual, rather than an environment. Because innovators by their nature possess some of the rare necessary qualities, it is difficult to predict how societies with high mastery score can foster innovation besides cultivating such qualities. Nevertheless, a higher proportion of innovators in the society can translate into a higher level of innovative activity, leading to the following hypothesis:

H3c. Schwartz's mastery-harmony value orientation is statistically significantly positively linked with innovation.

Some similarities between Inglehart's indicators and the dimensions of the previously discussed theories can be pointed out. The concept of secular values is linked to higher

autonomy, lower religiousness and higher tolerance for homosexuality and abortions. A high score of secular values translates into overall lower desire to conform and follow the rules, which could translate into higher level of innovative activity. In this regard, it is similar to Hofstede's concept of low power distance and high Schwartz's autonomy, leading to the following hypothesis:

H4a. Inglehart's secular-traditional dimension is statistically significantly positively related with innovation.

The self-expression value index is linked to a higher happiness, higher degree of trust and a higher degree of post-materialist values. The latter are defined as a higher perceived importance of fighting for freedom of speech and direct democracy over order in the country and combatting rising prices. These factors can also be indirectly linked to Hofstede's concept of individualism-collectivism and Schwartz's affective autonomy orientation. A society that scores highly on self-expression index can be hypothesised to produce more innovators, as it encourages self-improvement and self-expression. Using the same assumptions as above, the last set of hypotheses can be established:

H4b. Inglehart's self-expression-survival dimension is statistically significantly positively related with innovation.

These allow to hypothesise a positive link between both value indices and innovation. However, because Inglehart's value indices are essentially measuring similar aspects of the same cultural phenomenon, it is also possible that only one of these will emerge statistically significant because of a stronger impact of the underlying factors represented by the index.

2. Methodological approach

2.1. Data

Four sets of cultural variables are used: Hofstede's cultural dimensions (Hofstede et al., 2010), Schwartz's value orientations (Schwartz, 2006), Inglehart's value indicators, obtained on the basis of the World Value Survey (Inglehart et al., 2014), and Minkov's cultural dimensions (Minkov et al., 2017; Minkov et al., 2018a). Because of the difference in time and the number of countries included in each dataset, not all countries could be represented by all cultural datasets, limiting the selection.

The data about innovation were obtained from the Global Innovation Index dataset including observations for 38 countries and administrative regions over years 2013-2019. Global Innovation Output Sub-Index (GIIO) score was chosen as a dependent variable (Cornell University, INSEAD, and WIPO, 2020). This score is obtained by taking a simple average of two groups of innovation outputs: knowledge and technology outputs and creative outputs. The first group includes broad indicators for knowledge creation, such as the number of patent applications, scientific articles and citations, but also knowledge impact indicators, like GDP per capita growth rate or new businesses creation ratio and knowledge diffusion indicators, such as share of high-tech exports in total trade and net foreign direct investment outflows as a percentage of GDP. The second group includes creative outputs, such as indicators representing intangible assets (trademarks and Information and communications technology usage in business and organisational models), creative goods and services (national feature films, export of creative goods) and online creativity (number of top-level domains, Wikipedia monthly edits and YouTube video uploads). Because these are averaged out, it is possible for this indicator to be skewed when a country scores highly on a single factor. Nevertheless, because the score encompasses different interconnected indicators of output, GIIO presents a reasonable compromise between complexity of the resulting indicator and data availability.

An additional variable, included to control for financial capabilities not captured by GIIO inputs, is the lagged value of a logarithm of the country's GDP per capita, obtained from the World Bank data.

2.2. Methodology

To determine the link between cultural indicators and innovation correlation and regression analysis was used. The goal of the correlation analysis here is to assess the strength and significance of links between variables when not accounting for any other factors. Besides the obvious benefit of providing a reference for the regression analysis, it also highlights the possible multicollinearity issues and allows to validate the link between cultural dimensions from different cultural theories.

All variables used in the regression analysis were standardised in order for their regression coefficients to be comparable. For Schwartz's value orientations, where some orientations represent different sides of the same dimension (e. g. mastery is the opposite orientation to harmony), a single variable was created using the principal component analysis from two (three in case of autonomy-embeddedness orientation) variables. These were also adjusted by finding the centred value orientation scores before the factor analysis using Schwartz's methodological suggestions (Schwartz, 2003). The results of the principal component analysis are shown in Appendix A. The descriptive statistics of the non-standardised cultural data, as well as other variables, can be found in Appendix B.

For regression analysis, a multi-level mixed effects regression with random intercept was used. The first level is the country-level, with the second level representing different years of observations within a country. As each cultural theory represents a different view on the same society-level culture, only one cultural dataset was used in one model. Finally, year effects were added for each model with standard errors clustered at the country level. In the model below, the years are represented by a subscript i, and the countries are represented by a subscript j.

The general form of the regression model is as follows:

$$GIIO_{ij} = \beta_0 + \beta_1 GDP_{ij} + \sum_{m=1}^{n} \beta_{m+1} CD_j + u_j + \varepsilon_{ij}$$

where GIIO – Global Innovation Output Sub-Index, GDP – logarithm of lagged GDP per capita in USD, CD – cultural dimensions. Every model includes cultural dimensions from one cultural theory (n is equal to 4 for Hofstede, 3 for Schwartz and 2 for Minkov and Inglehart).

As a standard R^2 measure utilised in linear regression models is not used in mixed effect models, a widely accepted alternative proposed by Snijders and Bosker (1994) is used for each level of the model. It can be interpreted as the variance explained by all model predictors at the country and the observation level, respectively.

To check whether the residuals of all models are normally distributed, kernel density plots and Shapiro-Wilk tests were used. The former are close to being normally distributed, the latter fail to reject the null hypothesis regarding the normal distribution of residuals at $p = .05$. Accordingly, both of these provide the evidence that the residuals of the models are normally distributed. To control for possible multicollinearity, VIF-test was performed for all regressions. Additionally, if a model included two or more highly correlated cultural indicators, a separate regression model was run only including one cultural variable at a time from the set of cultural variables. As a threshold for high correlation, a value of 0.6 was chosen.

3. Conducting research and results

The correlation table for all variables used in the empirical analysis is presented in Table 1.

Table 1. Correlations between innovation variable and cultural indicators

Var	GIIO	GDP	PDI	IDVH	MAS	UAI	IDVM	FLE	MH	AE	EH	SC	SE
GIIO	1												
GDP	.78*	1											
PDI	-.585*	-.679*	1										
IDVH	.534*	.589*	-.71*	1									
MAS	-.125	-.178*	.075	.1	1								
UAI	-.344*	-.155	.077	-.121	.084	1							
IDVM	.772*	.797*	-.683*	.747*	-.216*	-.059	1						
FLX	.564*	.443*	-.127	.16*	-.002	-.304*	.421*	1					
MH	-.041	-.187*	.153	-.308*	.145	-.246*	-.321*	.163*	1				
AE	.658*	.701*	-.705*	.675*	-.182*	.107	.875*	.272*	-.444*	1			
EH	.256*	.535*	-.516*	.565*	-.285*	.13	.560*	-.252*	-.648*	.628*	1		
SC	.703*	.629*	-.433*	.396*	-.13	-.067	.735*	.697*	-.205*	.656*	.169*	1	
SE	.604*	.722*	-.771*	.752*	-.189*	-.275*	.736*	.188*	-.238*	.733*	.594*	.379*	1

GIIO – global innovation output sub-index, PDI – power distance, IDVH – individualism-collectivism (Hofstede), MAS – masculinity-femininity, UAI – uncertainty avoidance, IDVM – individualism-collectivism (Minkov), FLX – flexibility-monumentalism, MH – mastery-harmony, AE – autonomy-embeddedness, EH – egalitarianism-hierarchy, SC – secular-traditional values, SE – self-expression-survival values.
* Significant at 1%.
Source: author's calculations

The results show a significant correlation between innovation indicator and several cultural indicators. It is significantly positively correlated with individualism-collectivism dimension, both from Hofstede's and Minkov's datasets, Minkov's flexibility-monumentalism, Schwartz's autonomy-embeddedness and egalitarianism-hierarchy, and Inglehart's secular-traditional and self-expression-survival values. It is also significantly negatively correlated with Hofstede's power distance and uncertainty avoidance dimensions.

It should be noted that the GDP per capita is significantly linked with all cultural variables, as well as with innovation, which warrants its use in the regression, but raises the possible multicollinearity issue. This is especially true for the Minkov's individualism-collectivism dimension and Inglehart's self-expression-survival value. However, for all regressions the resulting VIF score was at or below 3, well below the cut-off value of 10. Finally, Hofstede's individualism-collectivism dimension is strongly significantly negatively correlated with power distance dimension, requiring a separate inclusion of these in the regression to properly estimate each effect.

The correlations also indicate that different cultural theories can be viewed as different methods of explaining the same underlying phenomena. For instance, Hofstede's individualism is strongly statistically significantly positively related with Minkov's individualism, as they have similar theoretical framework, but also with autonomy-embeddedness and egalitarianism-harmony from Schwartz's theory and both indices from Inglehart's.

Next, a regression analysis is performed to check for the link between innovation and cultural variables. The results of the regression analysis are presented in Table 2. Hofstede's cultural dimensions were utilised in regression (1), with additional regressions (1a) and (1b) utilising reduced models without individualism-collectivism and power distance dimensions, respectively. Minkov's cultural dimensions were used in regression (2), Schwartz's value orientations were included in regression (3), with additional interaction variable between autonomy-embeddedness and egalitarianism-hierarchy in regression (3a), and Inglehart's value indices were used in regression (4).

Table 2. Results of mixed effects regression models (standardised coefficients) of the Global Innovation Output Sub-Index

Variable	(1)	(1a)	(1b)	(2)	(3)	(3a)	(4)
Log GDP per capita (t-1)	.65***	.660***	.671***	.481***	.663***	.697***	.528***
	(.137)	(.126)	(.131)	(.116)	(.132)	(.118)	(.144)
Power distance	-.081	-.121					
	(.094)	(.119)					
Individualism-collectivism (Hofstede)	.064		.109				
	(.136)		(.14)				
Masculinity-femininity	.01	.023	.002				
	(.116)	(.107)	(.116)				
Uncertainty avoidance	-.22**	-.224**	-.217*				
	(.083)	(.084)	(.085)				
Individualism-collectivism (Minkov)				.295*			
				(.129)			
Flexibility-monumentalism				.227*			
				(.091)			
Mastery-harmony					.059	.098	
					(.097)	(.097)	
Autonomy-embeddedness					.419***	.347**	
					(.119)	(.111)	
Egalitarianism-hierarchy					-.313*	-.323**	
					(.145)	(.122)	
Autonomy-embeddedness x egalitarianism-hierarchy						.256**	
						(.091)	
Secular-traditional							.349***
							(.088)
Self-expression-survival							.094
							(.142)
Intercept	.18*	.183*	.18*	.202*	.156	-.01	.231*
	(.075)	(.077)	(.075)	(.083)	(.088)	(.11)	(.091)
Observations	266	266	266	266	266	266	266
σ^2_c	.268	.267	.27	.222	.223	.191	.246
	(.057)	(.054)	(.058)	(.057)	(.037)	(.032)	(.054)
σ^2_{res}	.044	.044	.044	.044	.044	.044	.044
	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)	(.006)
AIC	94.95	93.32	93.22	85.06	86.22	82.58	88.33
$R^2_{1S\&B}$	.687	.685	.685	.733	.732	.764	.709
$R^2_{2S\&B}$	.707	.705	.705	.756	.756	.789	.73

Random slope variance: σ^2_c – country-level variance, σ^2_{res} – residual variance.
$R^2_{iS\&B}$ – variance, explained by predictors at the i-th level of regression.
Standard errors in parentheses. * significant at 5%, ** significant at 1%, *** significant at 0.1%
Source: author's calculations

For all of the analysed regressions, the GDP per capital is significantly positively related with innovation. This is a reasonable result, since in these models it represents the general economic development level of a country which fosters innovation through access to monetary and labour resources.

Hofstede's uncertainty avoidance dimension is significantly negatively related to innovation. This result also remains significant in both reduced models that utilise three of Hofstede's cultural dimensions. This is consistent with earlier studies as well as the hypothesised link. It is important to stress here, however, that such result might be interpreted as the extension of the Hofstede's individualism-collectivism link with innovation, which itself remains insignificant in all regressions, likely because of the weak internal consistency of the indicator. Both individualism-collectivism and power distance remain insignificant in models 1a, 1b and additional reduced models that only included one cultural factor in addition to GDP per capita.

For Minkov's cultural dimensions, both individualism-collectivism and flexibility-monumentalism are significantly positively linked with innovation. The reason behind the statistical significance of the Minkov's individualism-collectivism dimension but not Hofstede's dimension lies in the differences of operationalisation for these dimensions, as discussed above. Minkov et al.'s (2017) individualism-collectivism dimension additionally includes questions on conflict avoidance, which Hofstede considered a part of the uncertainty avoidance dimension. The link of Minkov's individualism-collectivism dimension with innovation also mirrors the conclusions of numerous earlier papers (i. a. Shane, 1992, 1993; Van Everdingen, Waarts, 2003; Efrat, 2014). This provides evidence that conflict avoidance is significantly linked with innovation, but should not be viewed separately from the individualism-collectivism dimension.

Regarding Schwartz's value orientations, autonomy-embeddedness is significantly positively linked with innovation at $p = .001$ and egalitarianism-hierarchy is significantly negatively correlated with innovation at $p = .05$. As all three bipolar dimensions based on Schwartz's value orientations are highly intercorrelated, an additional set of regressions was run that included only GDP per capita and one cultural variable at a time as a robustness check. For this set of regressions, none of the Schwartz's value orientations remained significant at $p = .05$. The likely explanation for this is that the increase in innovative activity is caused by a cumulative impact of high autonomy and high egalitarianism, rather than the separate effects of these. An additional regression was run using an interaction variable of these two value orientations, with yielded an interaction variable significant at $p = .01$ and an overall improved fit of the regression. This allows to hypothesise the following relationship: in countries with high autonomy scores egalitarianism facilitates innovative activity, while in countries with low autonomy scores innovative activity is fostered by the higher hierarchy score.

From Inglehart's cultural indices, only secular-traditional values are significantly positively linked with innovation. While both of these linked with higher autonomy of individuals in society and lower degree of abiding the rules, countries that score highly for any of these dimensions also have a higher GDP per capita and overall better economic prerequisites for innovative activity. Out of these two, however, a high score of secular-traditional value index is more strongly associated with aspects that facilitate innovative activity, rather than self expression-survival index, which is more closely linked with the pursuit of personal pleasures.

Conclusion

The correspondence between the stated hypotheses and the empirical results is presented in Table 3.

Table 3. Hypothesised and empirical link between cultural dimensions and innovation

Hypothesis	Dimension	Hypothesised link	Empirical link
H1a	Individualism-collectivism (Hofstede)	Positive	Not significant
H1b	Power distance	Negative	Not significant
H1c	Uncertainty avoidance	Negative	Negative
H1d	Masculinity-femininity	Positive	Not significant
H2a	Individualism-collectivism (Minkov)	Positive	Positive
H2b	Flexibility-monumentalism	Positive	Positive
H3a	Autonomy-embeddedness	Positive	Positive
H3b	Egalitarianism-hierarchy	Positive	Varies*
H3c	Mastery-harmony	Positive	Not significant
H4a	Secular-traditional	Positive	Positive
H4b	Self-expression-survival	Positive	Not significant

*Positive for high autonomy scores, negative for low autonomy scores.
I: author's calculations

Innovative activity relies strongly on innovators, their capabilities and skills, motivation, dedication and available resources. But this study shows that the role of the environment is equally important: innovators operating in less hierarchical societies and in those that value them more than innovations themselves can increase their chances at innovating successfully. It can be suggested that the environment in which innovators are operating is both directly and indirectly linked with the innovative processes, influencing the willingness to innovate and the effectiveness of such processes. This paper provides evidence of the link between cultural aspect of environment and innovation.

One component of culture in particular stands out from the analysis. It is responsible for capturing societal differences in regards to following the rules, group favouritism, desire for personal achievement and recognition. In Hofstede's and Minkov's theory, it is represented by a label individualism-collectivism, while regarding Schwartz's and Inglehart's theories it is a combination of several cultural factors. The link between individualism-collectivism and innovative activity is rather obvious result of the theoretical implications behind it: countries, where innovation is desired and encouraged, innovators are given freedom to act as risk-takers and the barriers to innovate are low, will emerge as leaders in the innovative activity rankings. In this regard, it is rather surprising that Hofstede's individualism-collectivism turned out not to be statistically significantly linked with innovation. Hofstede's uncertainty avoidance, on the other hand, remains statistically significant after several employed robustness checks. One explanation to this result is the fact that Hofstede's individualism-collectivism dimension does not capture the cultural aspects that other operationalisations of individualism do, while his uncertainty avoidance does. This hints at a possible misattribution problem and weak consistency of Hofstede's dimensions.

Among Schwartz's value orientations only autonomy-embeddedness is significantly positively linked with innovation in the base model. When accounted for the possible interaction between autonomy-embeddedness and egalitarianism-hierarchy, however, all three value orientations and the interaction variable become statistically significantly linked with innovation. If Schwartz's value orientations are to be considered as facets of individualism-collectivism dimension, their usage allows researchers to more precisely link these facets with innovative activity. However, the idea of separate links between each value orientation and innovative activity ultimately fails under robustness checks, suggesting that it is a combination of autonomy-embeddedness and egalitarianism-hierarchy aligned in the same direction that predict higher levels of innovative activity and not these separately.

From Inglehart's value indices, only one appeared to be statistically significantly related to innovation. Both of these remain significant in a model with no GDP per capita included, but only one emerges significant when this macroeconomic factor is added. It could be argued that the strong link between economy and culture, already present in Inglehart's initial assumptions regarding the shift from materialist to postmaterialist society causes the cultural model to collapse to a single factor when combined with the macroeconomic factors. As secular-traditional values index is strongly, statistically significantly, and positively correlated with both individualism-collectivism and flexibility-monumentalism from Minkov's theory, while self-expression-survival index only exhibits a strong link with individualism-collectivism, it is reasonable to assume that the former better captures both of these cultural aspects relevant for innovation.

Minkov's cultural dimensions reveal the hypothesised relations. They provide the strongest evidence of a direct link between individualism-collectivism and innovation. This

model also includes an additional aspect relevant for innovation that is not separately discoverable by the other models.

This study has several strong implications. The consistently statistically significant relationship between innovation and cultural dimensions from alternative theories hints at an opportunity to employ alternative cultural theories in quantitative multidisciplinary studies without resorting to outdated Hofstede's measurements. In this regard, all analysed cultural theories perform well, uncovering the same underlying link between individualism-collectivism and innovation. Minkov's cultural dimensions provide the strongest alternative to Hofstede, as they uncover a separate unique link between flexibility-monumentalism and innovative activity without sacrificing the significance of the relationship between individualism-collectivism and innovation. Because of this, it is reasonable to focus future studies on examining flexibility-monumentalism as possible factor of innovation. It is also advisable to check whether this dimension is relevant for other economic phenomena. Hofstede's theory serves as a very useful reference point for many later theories, but it may be reasonable to retire his cultural indicators and utilise the lessons learned to not make the same mistakes when operationalising culture. Finally, other aspects of environment, including legal, political and fiscal, could be considered for the future research when linking innovation with national aspects.

The limitations of this study stem from its methods and usage of indicators. While cultural dimensions are presented as static in the analysis, which may somewhat distort the resulting significance. However, culture is a rather slowly changing process and the relationship between the cultural dimensions and innovation is based on the differences between the societies, rather than the absolute scores. Fortunately, there exists evidence showing that, while cultures do slowly shift their values and beliefs, the differences between them remain largely stable (Beugelsdijk et al., 2015). Additionally, while unlikely, it is possible that other cultural theories may construct factors unrelated to individualism-collectivism and flexibility-monumentalism that are strongly related to innovative activity. The existence of such factors in the currently existing cultural theories, however, is unknown to the author.

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Appendix A

PCA statistics

Table 1A. Principal component analysis results for Schwartz's value orientations

Cultural dimension	Value orientation	Factor loading	Explained variance
Mastery-harmony	Mastery	.707	78%
	Harmony	-.707	
Autonomy-embeddedness	Affective autonomy	.565	85.8%
	Intellectual autonomy	.563	
	Embeddedness	-.604	
Egalitarianism-hierarchy	Egalitarianism	.707	79.1%
	Hierarchy	-.707	

Source: author's calculations

Appendix B

Cultural data statistics

Table 1B. Descriptive statistics of the data (non-standardised) (N=266)

Variable	Mean	Std. dev.	Min	Max
GIIO	40.131	11.096	19.4	68.6
Lagged log GDP per capita	9.883	0.988	7.275	11.542
Power distance	57.289	21.398	13	104
Individualism-collectivism (Hofstede)	50.079	24.389	13	91
Masculinity-femininity	51.789	19.551	5	95
Uncertainty avoidance	63.474	22.599	8	95
Individualism-collectivism (Minkov)	9.5	81.143	-171	182
Flexibility-monumentalism	8.579	93.546	-187	234
Mastery-harmony	-.001	.827	-1.315	1.537
Autonomy-embeddedness	.328	.737	-1.147	1.719
Egalitarianism-hierarchy	-.017	.829	-1.964	1.682
Secular-traditional	.129	.553	-.987	1.132
Self-expression-survival	.271	.559	-.676	1.321

Source: author's calculations