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Retraction

Retracted: The Asymmetric Utility of Cultural Distance in International Business based on the Cultural Bias

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] H. Fu, H. Li, and A. Wu, "The Asymmetric Utility of Cultural Distance in International Business based on the Cultural Bias," *Security and Communication Networks*, vol. 2022, Article ID 9633570, 13 pages, 2022.

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Research Article

The Asymmetric Utility of Cultural Distance in International Business based on the Cultural Bias

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As an index to measure the cultural differences between countries, culture distance (CD) is a widely used construct in international business and postulated to be symmetric in previous studies. However, CD symmetry across different countries is been demonstrated to result in the national CD paradox. A new asymmetry index utility cultural distance (UCD) is proposed to replace the previous one in this study. The cultural utility function is applied to calculate the UCD for a particular country, where the cultural bias could cause the asymmetric change of cultural score. The index is verified to be a significant variable in the regression analysis of China's outward foreign directing investment to 17 other countries in 15 years. The UCD demonstrated in this paper corrects the fallacious symmetry assumption on cultural distance and can maintain a consistent and effective conclusion on cultural differences in international business studies.

1. Introduction

International business always encounters many challenges, include the cultural difference between countries [1–5]. Professor Geert Hofstede [6] defined culture as the collective programming of the mind distinguishing the members of the group or category of people from others. In international business activities, the cultural differences among countries often means increased management difficulty, uncontrolled expected schedule, and additional costs or losses, which are arising by the inconsistency in personal habits, languages, ways of thinking, working attitudes, and so on [7–10]. In recent years, there are also been some studies suggesting that cultural differences have positive effects in IB [11–13]. Therefore, the cultural difference is one of the factors that has been considered in the studies of international business, where most scholars use the term "cultural distance" to describe the cultural difference between countries.

Cultural distance is defined as the degree to which the cultural norms in one country are different from those in another country [14]. Benefit from the launch of some global surveys on the culture or values of countries, cultural distance studies can be performed quantitatively by analyzing the culture data between countries. The cultural data is usually a set of cultural values on several bi-polar dimensions. Taking the culture data of each country as a vector, the cultural distance between countries can be calculated by a preconstructed distance formula.

The known cultural distance index can represent the cultural differences between countries and have been widely used in international business studies, while the symmetry assumption underlying is questioned by many scholars. Cultural distance, as a metric in mathematics, naturally satisfies the three basic conditions: positive definiteness, symmetry, and triangle inequality. According to the symmetry, the cultural distance from country x to country y is the same as the cultural distance from country y to country x. However, the influence of cultural differences between countries often tends to be asymmetrical in international business studies [15–17]. Of note, the same cultural distance between countries has different impacts on decision makers of each country, and two host countries with the equal cultural distance means different for the home country, too. These are the two types of asymmetry cases of cultural distance.

Since the equal cultural distance may produce different effects when the home or host country changed, that is, it is not a one-to-one mapping from the cultural distance to its

effect, so theoretically the cultural distance cannot be used as an explanatory variable to analyze the influence of the cultural difference in international business activities. The conclusions of the studies where defining the symmetric cultural distance as the explanatory variable are very likely to be inconsistent and undependable. In fact, the conclusions about the influence of cultural distance varied in the previous empirical studies. In the studies of the relationship between cultural distance and FDI location choice, Kang and Jiang [15]; Quer, Claver, and Rienda [16]; and Huang [17] respectively concluded that the influence of cultural distance was positive in the total sample but negative in the subsample, insignificant, and negative significantly. In addition, inconsistent conclusions also appeared in the research of entry mode choice, establishment mode choice, and enterprise performance, which is usually called the cultural distance paradox [18].

As a possible cause of the cultural distance paradox, the asymmetry of cultural distance has been discussed by some scholars. In existing studies, the importance of asymmetry of cultural distance have been realized [19, 20]. The scholars attempt to describe, explain and decompose the differences of cultural distance according to a different home or host countries, but no effective alternative index has been proposed to describe the asymmetry of cultural distance. Our aim is to analyze the principles and rules of asymmetric influence of cultural distance, correct the unreasonable symmetry assumption of cultural distance, and construct an asymmetric cultural distance index.

The rest of the paper is organized as follows. Section 2 is the literature review. In section 3 we introduce the asymmetric index, define the utility cultural distance (UCD), and analyze the properties of the cultural utility function. Section 4 presents several cultural utility functions which meet the conditions and illustrate the determination of the parameter using the negative exponential utility function. Section 5 verifies the validity of the index through empirical analysis based on the utility function mentioned in section 3. Section 6 is the conclusion.

2. Literature review

Cultural data used to calculate cultural distance are derived from a variety of culture or values surveys or studies globally. The classical Hofstede model includes power distance index, individualism versus collectivism, masculinity versus femininity, uncertainty avoidance index, long term orientation versus short term normative orientation, and indulgence versus restraint, respectively. The culture of a country can be scored between 0 and 100 on each of these six dimensions [6, 21–23]. Besides there are some other similar culture data like the data of the World Values Surveys(which are individual level data) [24, 25], the data of Global Leadership and Organizational Behavior Effectiveness(GLOBE) [26], Schwartz's cultural values theory [27–30]. In recent years, research on cultural data has also been carried out [31, 32].

Cultural distance is usually calculated by mathematical formulas based on these cultural data. For example, Kogut and Singh [14] constructed a cultural distance index basing on the Hofstede cultural dimension data to study the effect of national culture on the choice of entry mode. This index is an aggregative indicator and equals the arithmetic mean score of the cultural score difference in each dimension between the two countries after eliminating the influence of the variance of each dimension. It is often referred to as the KSI index of cultural distance and has been widely used in different situations and concerns, such as extend 4 culture dimensions to 5 or 6 dimensions [17, 33, 34], or replace the home country with another country [15, 35].

Besides, there are some other methods to calculate cultural distances, such as the MSS cultural index without considering variance [36, 37], the Euclidean distance based on the Hofstede culture data [38, 39]; Y. [40], the Mahalanobis distance considering dimensional correlation [41], the cultural distance by calculating the similarity of probability distribution after clustered [42, 43], the absolute difference after rescale and average the responses to three questions of WVS [44], a placeholder variable to indicate cultural distance [16, 45], and the cultural distance basing on some new cultural indicator system proposed for the practical problems [46–52].

The rationality of the symmetry hypothesis, although widely used, has been challenged. Oded. Shenkar [19] pointed out that the cultural distance symmetry suggested an identical role for the home and host cultures, which was difficult to defend in the context of FDI, for the home country effect was embedded in the firm while the host country effect was in a national environment, so there were few supports for the symmetry assumption. Tung and Verbeke [20] indicated that the cultural distance symmetry between the economic actors of different countries was often not warranted, and any suggestion that the same relationship would hold in the opposite direction should be avoided, especially if no robustness checks were performed. Guiso, Sapienza, and Zingales [53] study the relationship between cultural biases and economic exchange, and conclude that perceptions rooted in culture are important determinants. Baack, Dow, Parente, and Bacon [54] explore the influence of confirmation bias on perceptions of psychic distance, and confirm it exists in a sample of 200 Australian managers. Calza, Cannavale, and Nadali [55] analyze the influence of cultural value to entrepreneurial behavior based on behavioral reasoning theory, and find that most of cultural dimensions affect the reason justifications.

What's more, some related empirical studies concluded the discrepancy effects of the equally cultural distance on different countries, proving the existence of asymmetry [56–59]. Inconsistent conclusions appear in fields of export market selection [60–62], location choice of foreign direct investment (FDI) [15–17, 63], entry mode choice of multinational enterprises [14, 35, 36, 45, 64, 65], offshore governance choice [41], venture capital investment performance [66, 67], acquisition performance [37, 68, 69], organizational performance [33, 70, 71], new product development performance [72]; H. [73, 74], international expansion patterns [75, 76], and so on.

To avoid the problems caused by the symmetry assumption, Tversky and Kahneman [77] argued that

similarity should not be viewed as a symmetric relation, and explained the asymmetries by the relative salience of the sitmuli and the directionality of the comparison. Douglas; Dow and Karunaratna [78] split psychic distance into psychic distance stimuli (the macro-level factors) and perceived psychic distance (the decision-maker's perception) when constructing a multidimensional psychic distance measurement method, emphasizing that the same stimuli do not mean the same perception, which depending on the decision-maker's sensitivity. However, they just focused on the distance stimuli and did not further identify the different characteristics of perceived distance. Hoorn and Maseland [79] proved that cultural distance has different correlations with partner country culture, depending on which country one selects as the base country in one's distance calculations, so the cultural distance paradox may be understood from the found lack of measurement equivalence. They used mathematical methods to prove that cultural distance did not have equivalence when the base country changed, but a scheme to make it equivalence did not be proposed. Kapás and Czeglédi [80] argued that the cultural distance in the literature mixed the level effect and the distance effect and lead to biased conclusions on how cultural distance mattered for FDI, so in order to disentangle the two effects of the culture, they proposed an econometric method and used two dummy variables account for a negative and a positive cultural distance. They striped out the effect of the host country's cultural level, but the remaining influence was still mixed without distinguishing the different home country, so the cultural distance remained symmetry, which is proved to be unreasonable.

Until now, there is still a lack of exhaustive and complete research on the source, mechanism, expression and solution of the asymmetry of cultural distance. Therefore, there is a great need for a usable, reasonable and asymmetric alternative index to measure cultural difference, which will be discussed in this paper.

3. Theoretical analysis

In this section, before defining the asymmetric cultural distance index and giving the utility function, we propose a simple theoretical derivation to explain how the symmetry assumption invalidates the conclusion in the regression analysis of FDI.

3.1. The symmetry and the culture distance paradox. To simplify the problem, it is considered that the investment decision for one home country to two host countries is only affected by the cultural distance, while all other factors are the same, and the effect is assumed to be linear. It should be noted that only one dimension of culture with a value is considered here to avoid the aggregation problems caused by dimensions correlation and weight difference. The culture of each country is represented by a score, within a range, for example, from 0 to 100. Set the cultural scores of the home country and the host countries are c_0, c_1 and c_2, respectively, and the cultural distance is the absolute difference c_0 to c_1 and c_2, which represented by d_1 and d_2.

Under the symmetry assumption, the influence coefficient of cultural distance on FDI is constant, denoted by β, so it can be got through the regression model $FDI = \beta \cdot d + C$, where C represents the intercept and equal to the investment amount when the culture distance is zero. The investment amount of the home country to the two host countries can be calculated by:

$$FDI_1 = \beta \cdot d_1 + C, \tag{1}$$

$$FDI_2 = \beta \cdot d_2 + C. \tag{2}$$

So, if we know the investment amount FDI_1 and FDI_2 and the distance d_1 and d_2, the β can be calculated.

To study the asymmetric effect of cultural distance, d_1 is assumed to be a positive distance and d_2 is assumed to be a negative distance. The relative positions of cultural scores of the three countries are shown in Figure 1.

As mentioned above, the influence of cultural distance is actually asymmetric. Assuming the influence coefficients of positive and negative distance are k^+ and k^- respectively, then $k^+ \neq k^-$. In addition, based on general research conclusions, it is assumed that $k^+ < 0$, $k^- < 0$. The following equations also can be set:

$$FDI_1 = k^+ \cdot d_1 + C, \tag{3}$$

$$FDI_2 = k^- \cdot d_2 + C. \tag{4}$$

According to equations (1-4), we can get, when $d_1 = d_2$,

$$\beta = \frac{k^+ + k^-}{2}. \tag{5}$$

When $d_1 \neq d_2$,

$$\begin{aligned} \beta &= \frac{FDI_1 - FDI_2}{d_1 - d_2}, \\ &= \frac{k^+ \cdot d_1 - k^- \cdot d_2}{d_1 - d_2}, \\ &= k^+ \cdot \left(\frac{d_1 - k^- / k^+ \cdot d_2}{d_1 - d_2} \right). \end{aligned} \tag{6}$$

It can be seen that under the certain cultural distance coefficients k^+ and k^-, β is determined by the cultural distances d_1 and d_2. So, if the sample countries change, the relations between d_1 and d_2 will change too, leading to the plus or minus sign of β changes. It means different conclusions of the regression analysis. The variations are shown in Table 1.

Diagraming the regression line, as shown in figure 2, the slope of the line representing FDI changing with the positive distance is k^+, and the negative is k^-, assuming $k^+ < k^-$. It can be calculated out that when $d_1 = (k^- / k^+) \cdot d_2$, the FDI equal, like point A and point B. Keeping the d_2, and changing the d_1 to d_1'' d_1'' and d_1'', the point A will move to point D, point E, and point F. So, the regression line will be

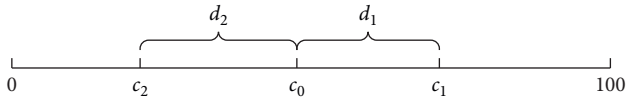

Figure 1: Illustration of the cultural distances between countries

Table 1: The conditions and signs of the coefficients of cultural distance β.

k^+ and k^-	d_1 and d_2	β and 0	sign of β
$k^+ < k^-$	$d_1 < (k^-/k^+)\cdot d_2$	$\beta < 0$	−
	$d_1 = (k^-/k^+)\cdot d_2$	$\beta = 0$	0
	$(k^-/k^+)\cdot d_2 < d_1 < d_2$	$\beta > 0$	+
	$d_1 > d_2$	$\beta < 0$	−
$k^+ > k^-$	$d_1 < d_2$	$\beta < 0$	−
	$d_1 = (k^-/k^+)\cdot d_2$	$\beta = 0$	0
	$d_2 < d_1 < (k^-/k^+)\cdot d_2$	$\beta > 0$	+
	$d_1 > (k^-/k^+)\cdot d_2$	$\beta < 0$	−
$k^+ = k^-$	Arbitrarily relation	$\beta < 0$	−

line DB, line EB and line FB, and the regression coefficient will be β' (−), β'' (+) and β'' (−), which is inconsistent.

If $k^+ = k^-$, the two lines will coincide, and all the points will be in the same line, so the β will not change for any d_1 and d_2. However, the empirical studies suggest not so as. From this perspective, the cultural distance paradox in turn reveals that the symmetry assumption is unreasonable.

More important, the inconsistent of β is coming from the different k^+ and k^- for d_1 and d_2, so if we find an index d^* and make $k^+ = k^-$ for d_1^* and d_2^*, the β will not change. According to equations (1-4), we can get

$$\frac{d_1^*}{d_2^*} = \frac{FDI_1 - C}{FDI_2 - C} = \frac{k^+ \cdot d_1}{k^- \cdot d_2}. \tag{7}$$

Therefore, the new index can be represented by a piecewise function with an arbitrary constant a:

$$d^* = \begin{cases} a \cdot k^+ \cdot d, & \text{if} c_i > c_0, \\ a \cdot k^- \cdot d, & \text{if} c_i < c_0. \end{cases} \tag{8}$$

The above analysis is under the assumption of the linear relationship between the FDI and the cultural distance. More generally, in order to get consistent and valid conclusions in studies of international business, the new index to substitute the cultural distance should evaluate the cultural differences and characterize the asymmetry feature.

3.2. Defining and calculating the UCD. As analyzed before, a new index to represent national cultural differences is needed. Like the cultural distant, it can also measure the extent of cultural differences. In addition to this, it can reflect the asymmetry effects caused by the equal distance, which make it a more suitable variable than the cultural distance in further analysis of cultural influence in international business.

Cause the new index shows that equal cultural distance means different effects for different countries, we call it the utility cultural distance (UCD), which is defined as follows.

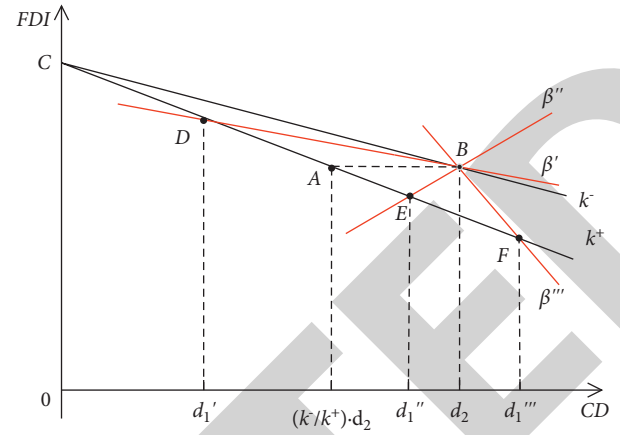

Figure 2: Illustration of β changing with d_1 and d_2

Definition 1. the utility cultural distance (UCD) to country j for country i is, from the standpoint of country i, a relative score to represent the extent of cultural difference between country i and country j, denoted by UCD_{ij}.

According to the definition 1, the asymmetry of cultural distance mentioned earlier can be described by two propositions.

Proposition 1. *for a pair of countries, though the cultural distance between them is the same for each country, the UCD to country j for country i is not equal to the UCD to country i for country j. This can be denoted by* $UCD_{ij} \neq UCD_{ji}$, *though* $CD_{ij} = CD_{ji}$.

Proposition 2. *for a country i, when the cultural distances between it and country j, country k are equal, the UCD to country j for country i is not equal to the UCD to country k for country i. This can be denoted by* $UCD_{ij} \neq UCD_{ik}$, *when* $CD_{ij} = CD_{ik}$.

The asymmetry of the UCD means the country i, the country j and country k are treated differently. In other words, from the standpoint of country i, the cultural scores of countries j and k have changed, converting to a new cultural score relative to the country i, which can be called the utility cultural score.

This converting always satisfies the preference axioms of completeness, reflexivity, transitivity, and continuity, so there must be a utility function to represent the converting from cultural score to utility cultural score for country i, which can be denoted by $u_i(x)$. Then, for country i, the three countries' cultural scores c_i, c_j and c_k will change to be the utility cultural score $u_i(c_i)$, $u_i(c_j)$ and $u_i(c_k)$, and the cultural differences between them will be the absolute difference between $u_i(c_i)$ and $u_i(c_j)$, and between $u_i(c_i)$ and $u_i(c_k)$, which is the UCD to them for country i. So, the UCD to country j for country i is

$$UCD_{ij} = \left| u_i(c_j) - u_i(c_i) \right|. \tag{9}$$

(9) means the UCD to country j for country i is equals to the absolute difference between their utility cultural scores got by the cultural utility function of country i.

Here, the cultural utility function is the key to realize the asymmetry UCD.

3.3. The cultural utility function. The cultural utility function, $u_i(x)$, is a mapping from the cultural score x of a country to its utility cultural score for country i. Therefore, its domain of the function is $[\underline{C}, \overline{C}]$, where the $\underline{C}$ and $\overline{C}$ are the lower and upper limits of the cultural score. For example, it is $[0, 100]$ when thinking about one of the dimensions of Hofstede's culture data.

The function $u_i(x)$ is used to express the asymmetry property of the distance $|u_i(c_j) - u_i(c_i)|$ on both sides of the cultural score $x = c_i$ for country i, so it is only the relative position of cultural scores that changes, not the order. In other words, for any $x_1, x_2 \in [\underline{C}, \overline{C}]$, if $x_1 < x_2$, then $u_i(x_1) < u_i(x_2)$. Thus, the function $u_i(x)$ is a monotone increasing function.

The utility cultural score is a relative score to compare and express the preferences, so we can specify a range for it. Making utility cultural score have a similar numerical representation with cultural score will facilitate analysis and comparison. When x equals to $\underline{C}$, the function $u_i(x)$ takes the minimum score $u_i(\underline{C})$, and we set $u_i(\underline{C}) = \underline{C}$. When x equals to $\overline{C}$, the function $u_i(x)$ takes the maximum score $u_i(\overline{C})$, and we set $u_i(\overline{C}) = \overline{C}$. So, thirdly, the range of the function is $[\underline{C}, \overline{C}]$.

Besides the properties about domain, monotony, and range mentioned above, the cultural utility function should have other special properties resulting from the asymmetry features.

Comparing the cultural utility functions of country i and country j, $u_i(x)$ and $u_j(x)$, we take x to be the cultural scores of the two countries, c_i and c_j, then we can get the cultural distance utility for each of the countries as follows:

$$UCD_{ij} = \left|u_i(c_i) - u_i(c_j)\right|, \tag{10}$$

$$UCD_{ji} = \left|u_j(c_i) - u_j(c_j)\right|, \tag{11}$$

That means if the two utility functions are the same, which is $u_i(x) = u_j(x)$, then $u_i(c_i) = u_j(c_i)$, $u_i(c_j) = u_j(c_j)$. The right sides of the (10) are equal:

$$\left|u_i(c_i) - u_i(c_j)\right| = \left|u_j(c_i) - u_j(c_j)\right|. \tag{12}$$

Necessarily, the left sides of them are equal too:

$$UCD_{ij} = UCD_{ji}. \tag{13}$$

However, (13) contradicts Proposition 1. So $u_i(x)$ and $u_j(x)$ are different, and we get a corollary as follows:

Corollary 1. *the cultural utility function is different for different countries, which means the $u_i(x)$ is different with respect to c_i.*

Now thinking about the cultural utility function of country i, $u_i(x)$, the relationship between the characteristics of the function $u_i(x)$ and country cultural score c_i should be analyzed.

Cultural score c_i is a number to represent the country's standpoint, so it has a kind of cultural bias, which is different from other countries. This kind of bias causes a country to have different attitudes toward other cultures in different directions. So, it is the source of the asymmetry UCD. We define it as follows:

Definition 2. the cultural bias of country i, denoted by cb_i, is the extent to which the country i exists a propensity to one of the two polars of a value dimension. It can be measured according to the relative position of c_i to $\underline{C}$, $(\underline{C} + \overline{C})/2$ and $\overline{C}$:

$$cb_i = \frac{\left[c_i - (\underline{C} + \overline{C})/2\right]}{\left[(\overline{C} - \underline{C})/2\right]}. \tag{14}$$

The corresponding relationship between c_i and cb_i is shown in Table 2. The range of cb_i is $[-1, 1]$, and its sign indicates the direction of culture propensity. When $cb_i = 0$, the country shows a neutral attitude toward the two extreme scores, so it will treat the equal cultural distance on both sides the same. When $cb_i \neq 0$, the country exists a kind of culture propensity, $cb_i > 0$ indicates the polar of $\underline{C}$, and $cb_i < 0$ indicates the polar of $\overline{C}$. The greater the absolute score of cb_i, which is $|cb_i|$, the higher the extent of culture propensity, and the attitudes toward cultural distance on both directions more different.

According to Corollary 1, the $u_i(x)$ is different with respect to c_i, and the cb_i can represent the preference characteristic of c_i, which we think is the source of the asymmetry UCD. Then, we can get the corollary as follow.

Corollary 2. *the asymmetry of the UCD is causing by culture bias, which is denoted by cb_i. The sign of cb_i indicates the direction of asymmetry, the magnitude of $|cb_i|$ indicates the extent of asymmetry.*

In Proposition 2, $UCD_{ij} \neq UCD_{ik}$ when $CD_{ij} = CD_{ik}$, so there may be two directions of asymmetry, which are $UCD_{ij} > UCD_{ik}$ and $UCD_{ij} < UCD_{ik}$. Setting $c_k < c_i < c_j$, the former means the utility of the positive distance is greater than the utility of the negative equal distance, and the latter means the opposite. As stated in Corollary 2, the two preferences are determined by the sign of cb_i, but the corresponding relationship between the directions and signs cannot be arbitrarily given and should be verified by empirical analysis. Hence, there are two hypotheses for the relationship between asymmetry and culture bias.

Hypothesis 1 **(H1):** the culture propensity increases the UCD. That is, if $cb_i > 0$, then $UCD_{ij} > UCD_{ik}$, if $cb_i < 0$, then $UCD_{ij} < UCD_{ik}$, given $c_k < c_i < c_j$, and $CD_{ij} = CD_{ik}$.

Hypothesis 2 **(H2):** the culture propensity decreases the UCD. That is, if $cb_i > 0$, then $UCD_{ij} < UCD_{ik}$, if $cb_i < 0$, then $UCD_{ij} > UCD_{ik}$, given $c_k < c_i < c_j$, and $CD_{ij} = CD_{ik}$.

The properties of the cultural utility function $u_i(x)$ are list in Table 3.

Table 2: The corresponding relationship between c_i and cb_i.

c_i	$\underline{C}$	$c_i < (\underline{C}+\overline{C})/2$	$c_i = (\underline{C}+\overline{C})/2$	$c_i > (\underline{C}+\overline{C})/2$	$\overline{C}$
cb_i	−1	−	0	+	1

4. Methods

The UCD to country j for country i, UCD_{ij}, can be calculated by the cultural utility function of country i, $u_i(x)$. Given the two countries' cultural score, c_i and c_j, the solution equation is: $UCD_{ij} = |u_i(c_i) - u_i(c_j)|$. So, the main problem is to find an appropriate utility function to describe the asymmetric changes of cultural score for country i in international business activities.

4.1. Two types of the cultural utility function. As discussed in Section 3.3, the cultural utility function should possess some properties, which are list in Table 3. However, there are many options for the form of the function meeting the requirement. Here, we divide them into two types: a linear or nonlinear function.

(1) Linear cultural utility function

In Section 3.1, we discussed the asymmetric effect of cultural distance under the assumption of a linear relationship. And (8) shows that the two coefficients that represent the changing of cultural distance on both sides are asymmetry. So, the slope of the linear utility function curve representing the changing of the cultural score c_j, which consistence with the cultural distance, are not equal too. The cultural utility function $u_i(x)$ could be a linear piecewise function, with two different slops on both sides of $x = c_i$ are different. If the domain and range is $[0, 100]$, giving $c_k < c_i < c_j$, and $cb_i > 0$, the function graphs can be shown in Figure 3, in which the (a) is under the Hypothesis 1, $UCD_{ij} > UCD_{ik}$, and the (b) is under the Hypothesis 2, $UCD_{ij} < UCD_{ik}$.

Denoting the two slops on both sides of $x = c_i$ to be l^+ and l^-, the difference of l^+ and l^- will be determined by $|cb_i|$, according to corollary 2. The utility function can be expressed as the following equation set:

$$u_i(x) = \begin{cases} l^- \cdot x, & x \le c_i \\ l^- \cdot c_i + l^+ \cdot (x - c_i), & x > c_i \end{cases} \quad \underline{C} = l^- \cdot \underline{C}, \overline{C} = l^- \cdot c_i + l^+ \cdot (\overline{C} - c_i), \frac{l^+}{l^-} = \begin{cases} L \cdot |cb_i|, & H1\text{istrue} \\ \dfrac{1}{(L \cdot |cb_i|)}, & H2\text{istrue} \end{cases}, cb_i = \frac{\left[c_i - (\underline{C}+\overline{C})/2\right]}{\left[(\overline{C} - \underline{C})/2\right]}. \tag{15}$$

where the L is an adjustment coefficient, indicates the maximum extent of asymmetry. When $|cb_i| = 1$, the country i has the most cultural bias and the ratio of l^+ to l^- will be the maximum score L or the minimum score $1/L$.

(2) Nonlinear cultural utility function

To make the utility function curve to be smooth and with no sharp points, the nonlinear function may be a more suitable form of cultural utility function. Because when the curve is differentiable over its domain, the asymmetry characteristic of the cultural distance utility, which is represented by the different derivative on both sides of $x = c_i$, will change continuously. The closer x is to c_i, the smaller the difference of UCD; the farther x is to c_i, the greater the difference of UCD. This seems to be more reasonable because in general, the cultural distance means obstacles and costs, so when the distance is larger, the cultural bias will lead to more obvious asymmetry.

If the domain and range is $[0, 100]$, giving $c_k < c_i < c_j$, and $cb_i > 0$, the nonlinear utility function graphs can be shown in Figure 4, in which the (a) is under the Hypothesis 1, $UCD_{ij} > UCD_{ik}$, and the (b) is under the Hypothesis 2, $UCD_{ij} < UCD_{ik}$.

The nonlinear utility function can be expressed using some functions with concavity or convexity, for example, quadratic utility function, negative exponential utility function, power utility function, logarithmic utility function, and so on. These utility function forms are commonly used functions, and their concavity and convexity characteristics have been discussed in detail, which is usually called the risk aversion coefficient. So, we can obtain the function equation by analyzing the relationship between the cultural bias cb_i with their risk aversion coefficients.

4.2. The negative exponential cultural utility function. In this paper, the negative exponential utility function is chosen to describe the asymmetric UCD. Here are the two reasons: (1) as a nonlinear utility function, it can better describe the actual asymmetry characteristic of the UCD, which has explained in section 4.1; (2) comparing with other nonlinear utility functions, the negative exponential utility function has a constant absolute risk aversion coefficient. This is also in line with the situation of cultural distance, for the asymmetry of utility is causing by the country's cultural bias, which is a constant value too, and will not change with the change of the host country's cultural score.

The function equation of the negative exponential utility function is

$$u_i(x) = A - B \cdot \exp(-\gamma_i \cdot x). \tag{16}$$

in which A and B are affine transformation coefficients, which will not change the properties of the utility function. γ_i is the absolute risk aversion coefficient, and it determines the concavity or convexity of the utility function and the concave or convex degree. Like in Figure 4(a), under Hypothesis 1, $cb_i > 0$, the function is convexity, which corresponds to $\gamma_i < 0$, so we can set $\gamma_i = -\Gamma \cdot cb_i$; like in Figure 4(b), under Hypothesis 2, $cb_i > 0$, the function is concavity, which corresponds to $\gamma_i > 0$, so we can set $\gamma_i = \Gamma \cdot cb_i$. Where the Γ is an

Table 3: The properties of the cultural utility function.

$u_i(x)$	properties		
domain		$[\underline{C}, \overline{C}]$	
monotonicity		monotone increasing	
range		$[\underline{C}, \overline{C}]$	
asymmetry ($c_k < c_i < c_j$, $CD_{ij} = CD_{ik}$)	Hypothesis 1	$cb_i > 0$	$UCD_{ij} > UCD_{ik}$
		$cb_i < 0$	$UCD_{ij} < UCD_{ik}$
	Hypothesis 2	$cb_i > 0$	$UCD_{ij} < UCD_{ik}$
		$cb_i < 0$	$UCD_{ij} > UCD_{ik}$

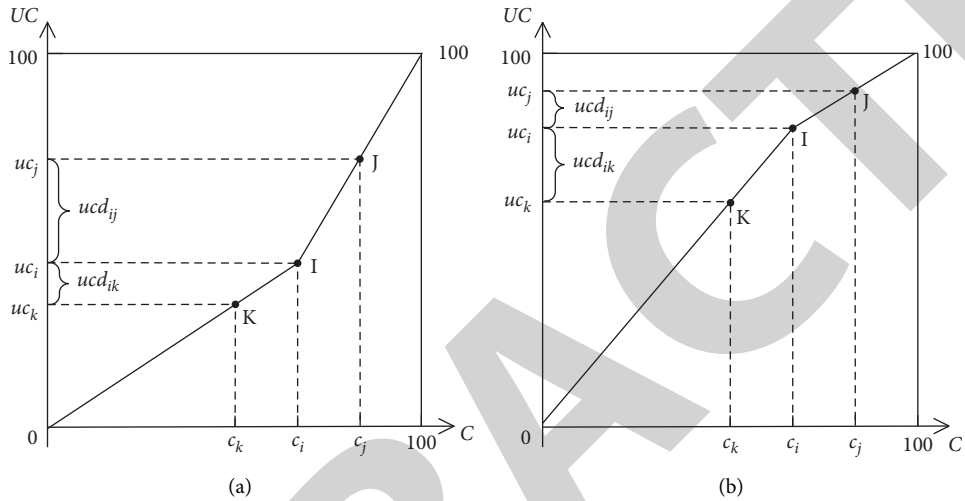

Figure 3: The illustration of linear cultural utility function.

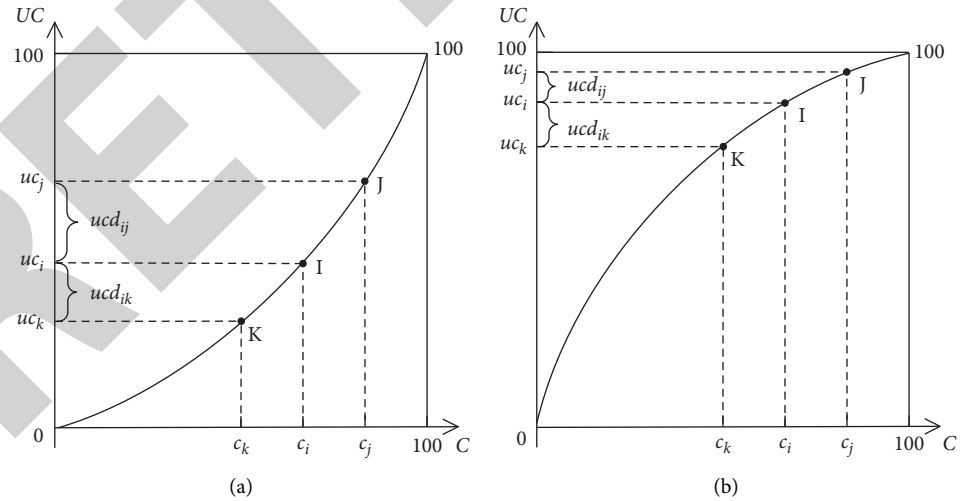

Figure 4: The illustration of linear cultural utility function

adjustment coefficient, indicates the maximum extent of asymmetry, which is the maximum concavity or maximum convexity.

Setting the range to be $[\underline{C}, \overline{C}]$, which means $u_i(\underline{C}) = \underline{C}$, $u_i(\overline{C}) = \overline{C}$, we can draw

$$A = B = \frac{\overline{C} - \underline{C}}{\exp(-\underline{C} \cdot \gamma_i) \cdot \left\{1 - \exp\left[(\underline{C} - \overline{C}) \cdot \gamma_i\right]\right\}}. \quad (17)$$

So, the negative exponential cultural utility function can be expressed as the following equation set:

$$\begin{cases} u_i(x) = \dfrac{\overline{C} - \underline{C}}{\exp(-\underline{C}\cdot\gamma_i)\cdot\left\{1-\exp\left[(\underline{C}-\overline{C})\cdot\gamma_i\right]\right\}}\cdot\left[1-\exp(-\gamma_i\cdot x)\right], \\ \gamma_i = \begin{cases} -\Gamma\cdot cb_i, & H1\text{istrue} \\ \Gamma\cdot cb_i, & H2\text{istrue} \end{cases}, cb_i = \dfrac{\left[c_i - (\underline{C}+\overline{C})/2\right]}{\left[(\overline{C}-\underline{C})/2\right]}, \end{cases} \tag{18}$$

where the adjustment coefficient Γ should be set appropriate because it determines the maximum concavity or convexity. If the value of Γ gets larger, the utility function curve will be steeper, it will go up very quickly and then flatten out, or flatten out and then rise sharply; if it gets smaller, the curve will go straight; both are inappropriate to reflect the change of utility cultural score.

4.3. The judgement of hypothesis and determination of parameter. After the previous analysis, a reasonable cultural utility function can be obtained, and the function equation can also be written out. However, two things need to be determined before using it to calculate the function value of a cultural score x. Firstly, which one out of the two hypotheses about the asymmetric rule is true. Secondly, what is the most appropriate value for the adjustment parameter, like the coefficient Γ in the equation of the negative exponential cultural utility function.

(1) The judgement of hypothesis

The asymmetry UCD, which has been discussed in section 3, is described in Proposition 1 and Proposition 2, and all we know for sure is that when $CD_{ij} = CD_{ik}, UCD_{ij} \neq UCD_{ik}$ for country i. According to Corollary 2, the asymmetry of the UCD is causing by culture bias. But the asymmetry rules, which means the corresponding relationship between them, cannot be arbitrarily given, because there is not sufficient evidence to prove which rule is true. So, we suggest that it should be verified by empirical analysis. Comparing the effectiveness of the UCD indexes in relative empirical analysis, while the indexes are calculated under each hypothesis, which index is more effective, the hypothesis is based on is true.

(2) The determination of adjustment parameter

The adjustment coefficient is the parameter to adjust the range of asymmetry, like the L in the linear utility function equation (16) and the Γ in the negative exponent utility function (18). Theoretically, it could take different values to satisfy the asymmetry requirements, but the descriptive power of the utility function would be affected. So, it should be set an appropriate value, otherwise, the utility function could not reflect the change of utility cultural score well. The traversal method is suggested to find the optimal value of the adjustment coefficient when the utility the cultural distance index is the most effective one in relative empirical analysis.

5. Empirical analysis

This study analyzed the impact of cultural differences on China's outward foreign directing investment (OFDI) and verified the effectiveness of the proposed index, the UCD. It is appropriate to (1) choose the FDI field, which is characterized by its popularity and susceptible to cultural differences, and (2) choose Chinese data where a large volume and many countries are involved, and other factors could be excluded for less influence, such as the political system, colonial relations, language and so on.

The index value, the UCD, will be processed in two steps. First, using the (18) of negative exponential cultural utility function to calculate the utility cultural score of all the host countries on each dimension of Hofstede culture data. Second, using the method of KSI cultural distance index to integrate the six dimensions of utility cultural score and get the UCD of each host country for China. In order to determine the hypothesis and the parameter, all the utility cultural score should be calculated many times under Hypothesis 1 and Hypothesis 2 and using different values of Γ respectively.

5.1. Model and data. The explained variable is the amount of OFDI of China to country j in year t, denoted by OFDI_{ijt}, where i means country China. According to the theory of foreign direct investment, the explanatory variables contain the economic development level GDP_{jt}, the resource endowment Resource_{jt}, the labor force population Labor_{jt} and the investment openness Openess_{jt} of the host country.

For research purposes, the explanatory variable of the cultural difference between the host country and China has three sets of indexes, which are the symmetry cultural distance index CD_{ij}, the asymmetry UCD index UCD^1_{ij} under Hypothesis 1, and UCD^2_{ij} under Hypothesis 2. When calculating the UCD^1_{ij} and UCD^2_{ij}, the parameter Γ takes 10 different values at an interval of 0.05 between 0.05 and 0.5.

In addition, there are some control variables such as the economic development level of the home country GDP_{it}, the country risk of the host country ECR_{jt}, the geographic distance Geodist_j, and the dummy variables of the free trade agreement FTA_{jt}, the bilateral investment treaty BIT_{jt}, double taxation avoidance agreement $DTAA_{jt}$, contiguity $contig_{jt}$, the common official language $comlang_{jt}$.

The variables of $OFDI_{ijt}$, GDP_{jt}, GDP_{it}, $Labor_{jt}$, $Geodist_j$ are taken the logarithm to reduce the dimension. And the three-panel regression models are as follows:

$$\begin{aligned} \text{LNOFDI}_{ijt} &= \beta_0 + \beta_1\text{LNGDP}_{it} + \beta_2\text{Resource}_{jt} + \beta_3\text{Labor}_{jt} + \beta_4 LN\text{Geodist}_j + \beta_5\text{Openess}_{jt} + \beta_6 CD_{ij} + \beta_7 ECR_{jt} + \beta_8 LNG\ DP_{it} + \beta_9 FTA_{jt} + \beta_{10} BIT_{jt} + \beta_{11}\text{DTAA}_{jt} + \beta_{12}\text{Contig}_{ij} + \beta_{13}\text{Comlang}_{ij} + \mu_{it}, \\ \text{LNOFDI}_{ijt} &= \beta_0 + \beta_1\text{LNGDP}_{it} + \beta_2\text{Resource}_{jt} + \beta_3\text{Labor}_{jt} + \beta_4 LN\text{Geodist}_j + \beta_5\text{Openess}_{jt} + \beta_6 UCD^1_{ij} + \beta_7 ECR_{jt} + \beta_8 LNG\ DP_{it} + \beta_9 FTA_{jt} + \beta_{10} BIT_{jt} + \beta_{11}\text{DTAA}_{jt} + \beta_{12}\text{Contig}_{ij} + \beta_{13}\text{Comlang}_{ij} + \mu_{it}, \\ \text{LNOFDI}_{ijt} &= \beta_0 + \beta_1\text{LNGDP}_{it} + \beta_2\text{Resource}_{jt} + \beta_3\text{Labor}_{jt} + \beta_4 LN\text{Geodist}_j + \beta_5\text{Openess}_{jt} + \beta_6 UCD^2_{ij} + \beta_7 ECR_{jt} + \beta_8 LNG\ DP_{it} + \beta_9 FTA_{jt} + \beta_{10} BIT_{jt} + \beta_{11}\text{DTAA}_{jt} + \beta_{12}\text{Contig}_{ij} + \beta_{13}\text{Comlang}_{ij} + \mu_{it}. \end{aligned} \tag{19}$$

Table 4: The variables description and data source.

Variable	Denotation	Explanation	Data source
Explained variable	$LNOFDI_{ijt}$	Logarithm of the OFDI amount	China Statistical Yearbook
Explanatory variables	$LNGDP_{jt}$	Gross GDP of the host country	World Bank Database
	$Resource_{jt}$	Resource endowment	World Bank Database
	$LNLabor_{jt}$	Labor force population	World Bank Database
	$Openess_{jt}$	Market openness degree	World Bank Database
	CD_{ij}	Cultural distance	The Hofstede Centre
	UCD_{ij}^{1}	Utility cultural distance under H1	The Hofstede Centre
	UCD_{ij}^{2}	Utility cultural distance under H2	The Hofstede Centre
Control variables	$LNGDP_{it}$	Gross GDP of the home country	World Bank Database
	ECR_{jt}	Country risk of the host country	Euromoney institutional
	$InGeodist_{j}$	Geographical distance	CEPII
	FTA_{jt}	Having free trade agreement	China FTA network
	BIT_{jt}	Having bilateral investment treaty	China FTA network
	$DTAA_{jt}$	Having a double taxation avoidance agreement	China FTA network
	$contig_{jt}$	Being contiguous	CEPII
	$comlang_{jt}$	Having a common official language	CEPII

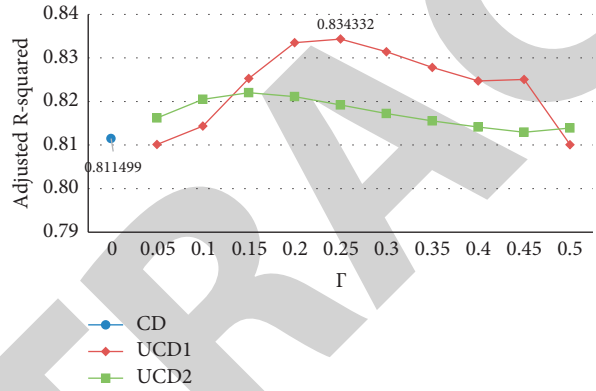

Figure 5: The Adjusted R-squared values of different models.

The host countries selected in this paper are distributed 2 in North America (Canada and the United States), 2 in Oceania (Australia and New Zealand), 1 in Latin America (Mexico), 4 in Europe (Germany, France, Britain and Russia), 6 in Asia (Indonesia, Japan, South Korea, Singapore, Thailand and Vietnam), and 2 in Africa (Nigeria, South Africa). The time is from 2005 to 2019 for a total of 15 years. Excluding the OFDI to tax avoidance countries such as Hong Kong, Macao, and the Cayman Islands, British Virgin Islands, the total investment to these 17 countries has been between 50% and 60% for 15 consecutive years, and the countries are diverse in terms of development level, geographical location, culture and other aspects, which is of certain representative significance. The selected variables and data sources are shown in Table 4.

5.2. The true hypothesis and the optimal parameter. The regression analysis is carried out in EViews 10. Firstly, the panel unit root test is carried out on each variable, and it is found that some variables are not stable, but passing the cointegration test, so the panel regression could be done. The panel data contains variables that do not change with time, basically covering the factors that may produce fixed effects. In addition, cross-section correlation is found by residual analysis. So, a mixed panel error correction model is selected for the panel data regression.

Using the value of cultural distance index CD_{ij}, two sets of values of UCD_{ij}^{1} and UCD_{ij}^{2} for ten different values of Γ, three groups of regression are performed. Comparing the Adjusted R-squared values of different models, as is shown in figure 5. The greater the Adjusted R-squared value is, the better the model fits, which means the variables are more appropriate.

On the whole, most of the UCD_{ij}^{1} are superior to UCD_{ij}^{2}, which can partially support the conclusion that Hypothesis 1 is true. That is to say, the asymmetry rule of the UCD is that the culture propensity increases the UCD.

And for UCD_{ij}^{1}, when the Γ equals 0.25, the Adjusted R-squared value is 0.834332, which is the highest value. So, the optimal value of Γ is 0.25. Compared to the symmetry index of cultural distance, which is 0.811499, the explanatory power of the model increases by about 2.28%.

5.3. The effectiveness of the asymmetry index. Comparing the coefficients and the significance of CD_{ij}, UCD_{ij}^{1} and UCD_{ij}^{2} in the regression results, as are shown in Table 5. It can be found that the coefficient CD_{ij} is not significant at 5%, which means it is not a sufficient effective index to explant the FDI.

Table 5: The coefficients and p-values of CD_{ij}, UCD^1_{ij} and UCD^2_{ij}.

Values of Γ	CD	UCD1	UCD2
0	−0.1817* (0.0661)		
0.05		−0.1610 (0.1947)	−0.2328*** (0.0021)
0.1		−0.3536*** (0.0080)	−0.2591*** (0.0001)
0.15		−0.5952*** (0.0000)	−0.2680*** (0.0000)
0.2		−0.6576*** (0.0000)	−0.2554*** (0.0001)
0.25		−0.5883*** (0.0000)	−0.2306*** (0.0002)
0.3		−0.4897*** (0.0000)	−0.2029*** (0.0010)
0.35		−0.4027*** (0.0000)	−0.1770*** (0.0034)
0.4		−0.3352*** (0.0000)	−0.1541*** (0.0092)
0.45		−0.1990*** (0.0000)	−0.0014** (0.0222)
0.5		−0.0448 (0.2043)	−0.0035** (0.0109)

Note. ***indicates significant at the 1% level, **indicates significant at the 5% level, *indicates significant at the 10% level.

On the contrary, most of the coefficients of UCD^1_{ij}, which has been verified to be the true asymmetry rule, are significant at 1%, except when the value of Γ is too small (less than 0.1) or too large (greater than 0.45), which means the asymmetry index of the utility cultural distance UCD^1_{ij} while Γ equals 0.25, could be an effective explanation variable to FDI and is an effectiveness index to describe the cultural difference between countries.

6. Conclusions

To solve the fallacy of symmetry assumption of cultural distance, firstly, this study proposes an asymmetric index, the UCD, to substitute the previous symmetry index of cultural distance. By theoretical analysis, the index describes the asymmetric utility the cultural distance for a particular country due to the cultural bias. Secondly, to calculate the UCD to country j for country i, a cultural utility function $u_i(x)$ is introduced, and the index value can be got by $UCD_{ij} = |u_i(c_i) - u_i(c_j)|$. Thirdly, according to the relationship between the cultural bias and the asymmetry properties of the utility function, the equation of $u_i(x)$ are listed, with an adjustment parameter and an unsure hypothesis. Then we determined the hypothesis and the optimal parameter through a regression analysis of cultural differences to the Chinese OFDI, which also verifies the effectiveness of the asymmetry index in practical applications. Therefore, the UCD proposed in this paper is a proper index and can maintain a consistent and effective conclusion on culture differences in international business studies.

However, there are some limitations in this paper. Firstly, due to the limited completeness of data, there may be some deviation in the data verification of the cultural utility function in the theoretical analysis. However, this study focuses on the method of solving the symmetry illusion of cultural distance, and data analysis is only for the auxiliary role. Moreover, the conclusion can still verify the rationality of asymmetric hypothesis during the analysis on existing data, and the significant coefficient of the UCD in the regression analysis also indicates that the deviation of data does not affect the conclusion.

Therefore, our future work is to further verify the effectiveness of the proposed asymmetry index in other cooperation types of international business and analyze more bilateral data of home and host countries. In terms of theory, we will continue to explore (1) whether there is a more appropriate form of utility function to describe the asymmetric properties of the UCD; (2) whether there are other factors that affect the change of parameters in the function equation excepting the cultural bias of the home country, like the two polars of the cultural dimensions; (3) whether the value of adjustment parameter varies with the cultural dimension changes, if that, what the underlying influence factors and how to determine it.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure

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Conflicts of Interest

The author(s) declared no potential conflicts of interest with respect to the research, author- ship, and/or publication of this article.

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