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Information distance: Conceptual development and empirical tests of a novel measure of cross-national distance

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ABSTRACT

Socio-political risks (SPRs) are important drivers of firm-level risk. Beyond unexpected variation in socio-political environments over time, the difference between home and host country socio-political contexts induces risk as it increases the difficulty to understand a foreign environment. This risk is specifically important for internationally active firms, as they need to gather and interpret information stemming from different socio-political environments to manage their international operations. However, existing literature lacks both concept and measure to capture such information asymmetry. In this paper, we explain how cross-national distance is related to SPRs through information asymmetry, and develop a reflective measure of cross-national distance based on information theory, signal analysis, and financial market information. Conceptual and empirical evaluations and applications of the concept and measure proposed provide support for our approach.

1. Introduction

Socio-political risks (SPRs) are important drivers of firm-level risk (Kobrin, 1979; John and Lawton, 2018; Lawton et al., 2014). These SPRs include, but are not limited to, a wide set of risks such as, corruption (e.g., Cuervo-Cazurra, 2006; Brouthers et al., 2008), socio-political violence (e.g., Oh and Oetzel, 2017), policy risk (e.g., Jiménez et al., 2018), or military conflict (Arikan et al., 2019). SPRs are specifically challenging for multinational enterprises (MNE), because these firms operate across multiple national environments and have to integrate different national settings into a coherent international strategy. In that sense, MNEs have to consider two elements in their assessment of socio-political risk. On the one hand, the risk of unexpected changes to the national environment in the host country (i.e., the host-country SPR). On the other hand, the difference between their home and host country contexts (i.e., the between-country SPR). The need to deal with both challenges makes it more complicated to understand the foreign environment(s) for MNE than for local firms (Johanson and Vahlne, 1977).

Internationally active firms need to gather and interpret information stemming from different socio-political environments to manage their international operations. National, institutional, and cultural boundaries make it hard to find relevant information and additionally make it complex to draw the right conclusions from information at hand. This is as the prevalence and relevance of specific socio-political risks differs across countries and as information about both is not easy to get and comprehend. As a result, information asymmetries between countries translate into socio-politically grounded risks for MNEs, because MNEs (more than otherwise

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equivalent domestic firms) struggle to derive appropriate strategic action from observations about the (changing) socio-political environment in a foreign country (e.g., Shimizu et al., 2004; Van Nieuwerburgh and Veldkamp, 2009). Consequently, MNEs are exposed to socio-political risk stemming from both the inherent unpredictability of a foreign socio-political environment, and the difficulty of obtaining accurate information about a foreign socio-political environment (information asymmetry). In this contribution, we focus on the latter.

Scholars in IB often refer to concepts of cross-national distance to conceptualize and measure how (SPR-driven) information asymmetry translates into risk for MNEs (Verbeke et al., 2018). Existing research provides overwhelming empirical evidence that such cross-national distance influences firms' international strategies, such as country-market selection (Dow, 2000) and the choice of governance mode (Slangen and Van Tulder, 2009) or establishment mode (Dikova and Van Witteloostuijn, 2007). From psychic distance (Johanson and Vahlne, 1977), to spatial distance (e.g., Ragozzino and Reuer, 2011) to regulatory distance (e.g., La Porta et al., 2006) to cultural distance (e.g., Kogut and Singh, 1988), the IB literature has developed many conceptualizations of cross-national distance (Tihanyi et al., 2005). Nevertheless, while empirical support for the relevance of distance for international transactions is substantial, scholars criticize the frequently blurry conceptual foundations of the construct and its measurement in many research applications (Ambos and Håkanson, 2014). Specifically, the causal mechanisms between a specific type of distance and resulting risks and firm strategies often remain unclear. Consequently, the empirical support for the relevance of distance may stem from, e.g., information asymmetry, behavioral differences, different regulations, or a multitude of alternative explanations. As Maseland et al. (2018, p. 61 and p. 55) put it, "what is truly needed next is for us to step back and begin unpacking the black box we call 'distance'" to provide a better understanding of "how and why" distance matters. We provide a first inroad into the "how and why" questions by building a concept of distance based in information asymmetry only. Doing so, we show how the socio-political risk perceived by MNEs consists of two elements: the local environment and the MNE's ability to capture and absorb information from the local environment.

Cross-national distance as a representation of information asymmetry represents how much economic actors from foreign countries understand the SPRs inherent in the local economy. As highlighted above, information asymmetry closely connects to the structure of socio-political environments in the portfolio of an MNE and can create substantial risk exposure. To conceptualize and measure information distance, we link interdisciplinary perspectives from the fields of IB, information theory, statistical physics, and finance to capture information national distance reflectively. In our conceptualization and measurement, information distance relates to both, the degree to which foreign actors have difficulty in identifying and interpreting relevant information, which leads to an information asymmetry that increases with distance. Doing so provides a clear foundation for our approach and provides a conceptual logic why (information asymmetry increases risk) and how (distance increases information asymmetry through the mechanism described above). Following this assumption, we base the explicit development of our distance concept on stock index returns on financial markets and the institutional perspective from the field of IB.

We argue that, as appraisers of information (Fama, 1970), financial markets lend themselves to the development of information-based measures of cross-national distance. There is agreement in the literature of finance that national financial markets largely represent the behavior of investors regarding the activities of local firms (Coval and Moskowitz, 1999). While we agree with existing research that financial markets may not be fully efficient in appraising such information (Choudhry and Jayasekera, 2014), findings from the field of finance provide strong support for our assumption that market participants' assessment is strongly based on the underlying firm- and country-level information and that financial markets are relatively efficient in incorporating this information (e.g., Hotchkiss and Ronen, 2002). Accordingly, we expect financial markets to integrate country-specific socio-political risks into prices of securities. This is because the non-diversifiable risk that underlies risk in financial markets, the "systematic risk", is a direct function of the socio-political environment (Sharpe, 1964; Lintner, 1965).

Consequently, if we capture the amount of information necessary to bridge two markets (i.e., 'how much information do I need to understand market B if I have all information about market A'), we will capture financial markets' appraisals of differences between socio-political environments (i.e., across countries and/or markets). Ideally, we would account for all economic activities that take place in the respective countries to reflect all socio-political risks. Since this is impractical, we look at the center-of-gravity of national economies: the lead index of their main stock exchanges. We borrow from the field of statistical physics to do so. Using Shannon entropy (Bandt and Pompe, 2002), we directly measure information-based cross-national distance by capturing the amount of information that is necessary to explain the behavior of one lead index given another. The larger the amount of information necessary, the more distant we conclude the two socio-political settings in question to be.

By following this approach, we make relevant contributions to a number of salient issues in recent literature on cross-national distance and socio-political risks. First, we conceptualize cross-national distance with a specific theoretical focus (information asymmetry), and develop a reflective measure for it that is based on stock markets' behavior. We explain how socio-political risks are related to cross-national distance. We provide an information theoretic basis for the concept of cross-national distance. This provides an understanding for the reflective and time-variant cross-national distance across countries and solves many empirical challenges associated with fine-grained and formative measures, which are frequently used to capture the firm-level effects of socio-political risks. As such, the measure we suggest may also serve to test the robustness and fit of existing or newly developed measures of distance – if they are supposed to at least partially reflect information asymmetry. Second, we extend the concept of permutation entropy from statistical physics to an economic application in the context in cross-national distance. We run robustness checks of the new concept against existing ones to show how they are connected. Third, we integrate IB and finance, an endeavor repeatedly called for (Bowe et al., 2010; Puck and Filatotchev, 2020): we tap rich data from financial markets to help resolve an important problem in IB. Doing so may also spark a discussion about the relevance of cross-national distance in the field of finance. We provide the data on cross-national distance for a wide range of country pairs and years.[1]

2. Cross-national distance and its criticism

Cross-national distance reflects differences (e.g., in SPR) between countries and has been applied to explain phenomena ranging from entry mode (Brouthers and Hennart, 2007) to entrepreneurship (Busenitz et al., 2000) to staffing policy (Gaur et al., 2007) to company performance (Morosini et al., 1998). It has provided important insights. Yet, the more recent past has brought substantial critique of the concept and its application (Newman, 2012). This section begins with a brief summary of different types of cross-national distance. It then summarizes key conceptual and empirical problems with existing multidimensional measures of cross-national distance, specifically when meant to capture effects of differences of SPR across countries. Finally, it outlines how we proceed in developing a concept of cross-national distance that avoids the pitfalls identified.

In this paper, we relate to four types of concepts of cross-national distance[2] that are used in IB literature. This is not meant to be a comprehensive review of these dimensions. Such a review is, for example, available in Bae and Salomon (2010). We instead choose popular constructs that belong to these conceptual schools as representatives of the broader underlying category. First, we are interested in *geographic distance* (a synonym for this used in literature is geometric distance). Geographic distance is the reason for logistical constraints that lead to liabilities of foreignness (Zaheer, 1995). It is also the main reference concept that scholars use to argue why "distance matters" in the sense of the law of distance (Ghemawat, 2001; Hymer, 1960). However, geographical distance has no explicit conceptual link with SPRs. Second, we investigate cultural distance. In its most used variety, this concept was developed by Kogut and Singh (1988). They aggregated differences in the different dimensions of the Hofstede (1980) framework to capture cross-national distance. This is the most-used framework in empirical IB papers that are concerned with cross-national distance (Bae and Salomon, 2010) with empirical application in many fields. While cultural distance relates explicitly to a specific section of the 'S' in 'SPR', the political element is not clearly connected.

Third, we consider frameworks of institutional distance. Following the development of cultural distance, later research developing multidimensional measures of cross-national distance often relies on Scott (1995), who provided the basis for a three-dimensional categorization of cross-national distance according to institutional theory. In referring to different strands of institutional theory and focusing on both difficulties in collecting and interpreting information, Berry et al. (2010) developed a set of nine dimensions that contribute to cross-national institutional distance. They referred to "national business systems" (Whitley, 1992), a perspective focusing on national government mechanisms (Henisz and Williamson, 1999; La Porta et al., 2006; López de Silanes et al., 1998), and national innovation systems (Nelson and Rosenberg, 1993). These nine dimensions explicitly include geographic and cultural distance. When we refer to "institutional distance" in this paper, we do so in the sense of Berry et al. (2010). Concepts of institutional distance, thus, do refer to both the 'S' and the 'P' in the SPR concept. Fourth, we investigate national-level antecedents (or "stimuli") of cross-national psychic distance. Dow and Karunaratna (2006) developed a set of such measures. The dimensions they developed overlap somewhat with those of "institutional distance," (and, thus, the 'S' and the 'P' in SPR) but the two sets are neither injectively nor surjectively complementary. Dow and Karunaratna (2006) also highlighted that the different stimuli of distance are not equally relevant. They referred to calls for further elaboration of the distance construct (Shenkar, 2001; Stöttinger and Schlegelmilch, 1998). Their main conclusion was that several dimensions play a role in creating distance stimuli (culture, language, education, industrial development, political systems, religions, time zones, and colonial links), and that the relevance of these dimensions for the overall extent of distance varies.

Despite the undisputed relevance of these concepts of distance, their conceptual nature has been substantially criticized in the literature (Zaheer et al., 2012). First, concepts have been criticized for not matching the metaphor ('geometric distance') they draw from (Shenkar, 2001). Second, and specifically relevant for our approach, they have been criticized for failing to capture SPRs relevant for MNEs. Third and lastly, they have been criticized for empirical and statistical reasons.

First, there appears to be a mismatch between how cross-national distance is conceptualized and the metaphor that it draws from: geometric distance. Shenkar (2001) pointed out how this mismatch, resulting from different levels of analysis, affects the interpretation of empirical results. Any construct on a country-pair level of analysis has to be symmetric, just like geometric distance (as, otherwise, it would not be on the *country-pair* level). Existing studies frequently do not match this assumption. Scholars often argue that cross-national distance (or sub-dimensions thereof) is represented by simple differences of national-level indicators, hence in principle relating to the country (and not (only) the pairing) level: the distance between country A and B is high/low because indicator X is high/low in the respective countries (e.g., Berry et al., 2010; Kogut and Singh, 1988). Such approaches therefore create only the illusion of symmetry but not conceptual symmetry (Shenkar, 2001). To address this, Håkanson and Ambos (2010) recommended developing inherently asymmetric concepts of distance on the country (or even the firm or individual) level. This would mean abandoning the metaphor of geometric distance, the country-pairing as a level of analysis, and choosing an asymmetric metaphor, as proposed as one potential solution by Shenkar et al. (2008).

Asymmetric concepts may help further the understanding of individuals' reasons for certain actions, explaining firms' strategic decisions, as they reflect the perception of distance on the decision-making level. Such concepts, however, cannot be used efficiently to

[1] Data are available from the cross-national distance data section of www.thomaslindner.info.

[2] We use "cross-national distance" as a summary name for all distance concepts.

derive normative recommendations for multinational firms' strategizing, for at least two reasons. First, firms would be confronted with a substantial aggregation challenge. To derive normative implications for strategizing, firms would need to capture and appropriately aggregate a vast amount of both asymmetric and symmetric (such as geographical distance) distances across stakeholders and countries. While already complex from a mathematical point of view, this appears to be even more complex from a theoretical perspective. When a firm from country A plans a transaction in country B, probably three types of asymmetric and symmetric distance would need to be accounted for: the asymmetric distance A-B, the reverse asymmetric distance B-A, and the symmetric distance as some clearly symmetric elements of distance also create distance-specific challenges and costs (such as operational costs stemming from geographical distance). Theory for a meaningful aggregation of such complex distance-relationships, however, appears to be missing. Second, some relevant elements of international strategizing, such as the diversification of returns, are almost exclusively dyadic effects and are affected only to a very limited degree by asymmetric properties of distance: diversification increases monotonically with an increasing number of imperfectly correlated cash-flow streams. Correlations are, by definition, symmetric.

Second, the four types of concepts of cross-national distance we introduce above also suffer from challenges related specifically to their ability to capture SPRs relevant for MNEs' business decisions. As we argue above, MNEs experience two relevant components of SPRs: unexpected changes to the 'rules of the game' in the target country (e.g., Dorobantu et al., 2020), and difficulties in precisely assessing the level of SPRs because of information asymmetry. Existing measures of cross-national distance (with the exception of geographic distance) frequently conflate the two, particularly because of the inherent asymmetry in the concepts. Cultural distance, for example, while entirely symmetric in a mathematical sense, does not capture information asymmetry in a symmetrical sense. It is easier, for example, for members of collectivistic cultures to understand decision-making in individualistic societies than the other way around, because the complexity of decision-making is lower in individualistic societies (e.g., Guess, 2004). Along similar lines, the institutional distance between countries with colonial ties will be easier to bridge for companies from the former colonizer's country than for companies from the formerly colonized country, because the power structures favor the former colonizer (Infante-Amate and Krausmann, 2019). As a result, the challenges existing institutional distance concepts have with asymmetry translate into capturing SPRs, because conflating distance and risk makes it more difficult for MNEs to develop strategies suitable to respond to SPRs.

Lastly, there are also several empirical challenges with existing dimensions of cross-national distance. First, it is hard to argue which dimensions of distance matter for what type of strategic challenge (and which do not). Second, and related, it is almost impossible to argue at what point all relevant sub-dimensions of distance influencing a specific strategic decision are covered. Third, the weighting of the relevance of different distance-dimensions for specific strategic decisions is problematic and remains largely unaddressed in the literature (Dow and Karunaratna, 2006). Fourth, it is not clear that the same sub-dimensions of distance are relevant for strategizing across all country-pairs. Fifth, as firms and economies evolve, the challenges firms face change over time. Therefore, cross-national distance needs to be captured dynamically. Researchers have repeatedly challenged that cross-national distance is often captured using static, and quite old, data (Eden and Miller, 2004; Kostova et al., 2008; Xu and Shenkar, 2002). Sixth, many statistical methods frequently applied in social science research apply only to reflective measures because it is impossible to establish measurement equivalence of formative dimensions that are incomplete (Jarvis et al., 2003). While the identified dimensions of cross-national distance in existing approaches might be reflective in terms of the respective sub-dimensions (e.g., culture or innovation system), they are formative for the overall construct of cross-national distance. Diamantopoulos and Papadopoulos (2010) discussed how using an inappropriate measurement model (reflective vs. formative) results in misrepresentation of relationships between constructs (MacKenzie, 2003) and in biased parameters representing those relationships (MacKenzie et al., 2005). Consequently, others proposed adding at least reflective measures to formative ones in statistical analyses to resolve identification problems (Diamantopoulos and Papadopoulos, 2010; Jarvis et al., 2003).

As we discuss below, the conceptual and empirical challenges illustrated apply to a much lower degree to our conceptually specific (information asymmetry) and reflective measurement of cross-national distance, which is based on firm-level data. By drawing on the theoretical basis of the capital asset pricing model, we can exploit the common variation ("systematic risk") in a stock market to understand the underlying socio-political structure. Then, by using an information-theory based concept of distance, we can extract the distance between two socio-political systems. To get there, we need good theoretical footholds and rich data. We obtain the former by relating to Zaheer (1995) and Scott (1995). We follow the steps proposed by Zaheer et al. (2012) in developing the construct: avoiding oversimplification, testing whether a measure is symmetric, accounting for firm heterogeneity, and considering the mechanisms behind the workings of distance proposed to resolve the issues put forward by Shenkar (2001). For the latter, we resort to financial markets. Of all economic institutions, financial markets are among the best for translating all available information into economic actions: buying and selling (Fama, 1970; Roll, 1988).

3. A symmetric concept and information-based measure for cross-national distance

To develop the cross-national distance concept reflecting SPR differences across countries, we follow the procedure proposed by Zaheer et al. (2012), though in inverted order. First, we explain and discuss the mechanism that leads to the conceptualization of distance that we propose. Second, we account for firm heterogeneity by looking at indices composed of specific sets of firms, rather than full-country measures.[3] Third, we provide an empirical test derived from simple Euclidean geometry to assess the extent to which our distance concept and measure are symmetric. Fourth, we avoid oversimplification by both relating our distance concept to existing

[3] The methodology proposed here allows us also to compute distances between (listed) firms and countries, as well as between (listed) firms in different countries. This may be useful for firm-level studies using the concept of cross-national distance.

multidimensional measures of distance and showing that it can be used to answer firm-level issues that are relevant for IB research.

In this section, we introduce the mechanism we use to capture cross-national distance and show how it accounts for firm-level heterogeneity. This is important because it opens the black box of earlier measures that combine aggregates of national statistics to compute cross-national distance. In this vein, we argue that the measure we propose organically aggregates information across different SPR settings, which we think is superior to a mechanical arithmetic aggregation using, for example, weighted averages (like, e.g., Kogut and Singh, 1988). We discuss the remaining two points of the procedure proposed by Zaheer et al. (2012) in the next section.

In line with Scott (1995), we posit that an information asymmetry-based concept of distance between country markets with different SPRs should be related closely to both the ability to find information about SPRs and the ability to understand it. It thus needs to reflect the complexity stemming from the challenges of finding *and* interpreting information that differentiates SPR settings in two countries. The actions of firms in an institutional environment reflect both aspects, as firms are embedded in distinct normative and regulatory settings and interpret the resulting information context specifically as they evolve in that environment (Cantwell et al., 2010). In other words, firms' behavior and strategies are at least partially driven by the country-specific SPRs they face. Different institutional environments and SPR-settings thus lead to different behaviors of firms in those countries (Leuz et al., 2003). Firms being confronted with high levels of corruption in a country, for example, will show different behaviors than firms being confronted with expropriation risk or socio-demographic risks. Consequently, the structurally different behaviors of firms across countries reflect the cross-national distance between the SPR environments.

Financial markets evaluate firm behavior in a specific environment or SPR setting (Coval and Moskowitz, 1999). This means that information about the country-specific SPR environment of a firm is incorporated in its stock price (Morck et al., 2000). The evaluation of individual firms in a country might be driven by different elements of the environment and different SPRs (and potentially also to a different extent). Following the efficiency argumentation, however, the combined assessment of all firms in a country reflects the overall environment and thus, also reflects all SPRs relevant in a market. This notion is closely connected to the characteristics of "systematic risk", which remains after diversifying away all firm idiosyncrasies within a country. We do not propose that financial markets are perfectly efficient in their interpretation of firm behavior. We also do not propose that firms are embedded in national environments only, or that only national actors influence the assessment. However, financial markets' assessment of the underlying SPR environment can be assumed to be at least related to the underlying SPR environment because the SPR environment reflects the underlying market structure that remains after investors have diversified their portfolios to exclude all firm-specific risks (Sharpe, 1964; Lintner, 1965). This is the information we use to develop our concept of information distance as structural differences in the evaluation of firms across countries consequently reflect the information distance between the two markets. The extent of this relationship essentially is an empirical question, which we discuss below.

Moving forward, we need to clarify how, exactly, financial markets' assessment of firms across countries can be used to capture information distance. There is empirical evidence pointing towards stock price co-movement being related to cultural characteristics (e.g., Eun et al., 2015), and that institutional antecedents, such as SPRs, relate to the correlation between stock returns (e.g., Karolyi and Stulz, 1996). Stock-price synchronicity has also been linked to the legal environment and its risks (Hasan et al., 2014), following the idea that institutional characteristics define the foundations and risk settings within which financial markets function (López de Silanes et al., 1998). However, the theoretical foundation for these relationships beyond a general link to institutional theory remains incomplete. At the same time, distance measures based on (weighted) differences between averages of indicators are arguably only crude representations of the typically very complex bundles of information they relate to. Of course, the two are related, but the connection is made in the interpretation rather than in the measurement (e.g., GDP per capita differences as a measure of economic distance; Berry et al., 2010). In addition, much of the data that measures of cross-national distance are based on is quite old (Hofstede, 1980) or is only available months or years after the end of the year in question. To address such challenges in developing our measure, we need to find conceptual, measurement, and methodological solutions.

First, the level of analysis has to be set and matched to the envisioned characteristics of the concept. As discussed above, we intend to develop a symmetric measure of information-based distance that can be complemented with contextual information about the individual (or firm, or country) to capture potential asymmetry. Second, for a holistic measure of the information distance between two countries based on economic actors' responses to institutions and national SPRs, ideally one would account for all economic activities in both countries. Since this is impractical for several reasons, we resort to a frequently applied approximation from the field of finance: we identify the economic center of the respective nations. We argue that, in analogy with a center-of-gravity argumentation in geometric distance, the lead indices of national stock markets are the center-of-gravity of economic activity in a country. The use of stock market linkages as indicators for the connection of national economies has a long tradition in the field of finance that goes back to Ripley (1973). The degree to which markets behave the same is what we intend to measure. With this direct approach to conceptualizing differences between markets, we forgo difficulties in application and interpretation that are associated with concepts that take differences of compound averages to measure a certain dimension of cross-national distance.

Third, a straightforward way to estimate the information contained in one time series given another, as argued above, would be the correlation between the time series. However, it is an important stylized fact in the financial literature that stock prices are non-stationary and therefore unsuitable for computing correlations, since these require stationary data. Hence, scholars resort to using returns because they are more likely to fulfill stationarity requirements (Martens et al., 1998). Yet, it turns out that, particularly for long time periods, stock market index returns are not fully stationary either, and hence correlations between returns of such time series may well yield spurious results (Chen and Keown, 1981; Granger and Hyung, 2004; Rydén et al., 1998). This means that first differences of stock prices are not stationary either, and hence co-integration tests are not applicable. Thus, we resort to a method that requires even lower stationarity assumptions: permutation entropy. Statistically, this method only requires that the probability for a return observed at time t being smaller (or larger) than one at time $t + k$ does not depend on t (Bandt and Pompe, 2002).

In summary, permutation entropy of the return differences in lead indices across pairs of countries offers a conceptual, measurement, and methodological solution to challenges in earlier conceptualizations of distance. It allows the use of differences in financial markets' appraisal of firms across countries to derive cross-national distance. Entropy has long been used in portfolio management as a tool to optimize portfolio diversification (Philippatos and Wilson, 1972; Zhou et al., 2013). The term originates in statistical physics, where it is closely associated with the Second Law of Thermodynamics (Clausius, 1865). It has also been used to measure industry diversification of firms (Hoskisson et al., 1993; Jacquemin and Berry, 1979). In information theory, Shannon entropy is the general measure of information content in a time series (Bandt and Pompe, 2002). The interpretation of entropy as information content drives the interpretation in portfolio diversification models. The more information needed to describe a portfolio's returns, that is, the higher its Shannon entropy, the more diversified the portfolio is (Hoskisson et al., 1993; Philippatos and Gressis, 1975). We draw on this common interpretation of entropy in developing our measure of information distance.

Permutation entropy filters signal from noise well and hence distinguishes information content from background fluctuation (Bandt and Pompe, 2002). That is exactly what we want to explore when comparing economic centers-of-gravity: How much does the institutional environment in country A structurally (i.e., beyond coincidence) have to do with that of country B? More precisely, the version of Shannon entropy that we use analyzes the occurrence of different sequences of increases and decreases and computes the information contained in such sequences as opposed to purely random sequences given by white noise. Formally, we consider the difference in returns between two lead indices as a time series x_t with N observations of T points in time. Then, we count how often certain sequences (π) occur and normalize by the number of observations (corrected for n, the length of the sequences). This figure (p) we interpret as a probability and compute the Shannon (H) entropy of it. In this step, we sum over the frequencies all possible permutations ($p(\pi)$) multiplied by their logarithm ($log_2 p(\pi)$). Finally, we normalize the entropy-measure by the length of the sequences (Bandt and Pompe, 2002) and obtain a reflective and compound measure of cross-national distance (*h, "information distance")*. The maximum value of this distance is 1, which indicates the amount of information contained in a time series of white noise. The minimum is 0, which indicates two series that are equivalent except for an intercept.

$$p(\pi) = \frac{\#\{t | t \leq T - n, (x_{t+1}, \ldots, x_{t+n}) \ has\ type\ \pi\}}{T - n + 1}$$

$$H(n) = -\sum p(\pi) \bullet log_2 p(\pi)$$

$$h_n = \frac{H(n)}{n - 1}$$

This procedure we apply to the difference between 30-day (n) moving averages of daily returns of 48 indices from countries that jointly represent close to 90 % of world GDP. Given some unavailable data, this results in 754 distances computed per period of observation (which ranges from the late 1800s to 2020), the number of which can be further increased. Data availability on a daily level allows us to update and customize information distance to specific time frames and to account for the evolution in cross-national distance (Zaheer et al., 2012). For an overview of indices, see Appendix 1. For robustness reasons, we also compute distances for 7-day moving averages. For methodological reasons, we add a random variable in the sixth decimal to avoid the exact same returns on days where exchanges do not trade. These days vary, of course, across countries. The window we use for analysis (T) is 128 days. The permutation order is varied from two (with 2 possible permutations) to three (with 6 possible permutations) to four (with 24 possible permutations). These methodological variations, as shown below, do not alter the overall interpretation of our measure. The values for our distance measure range between 0 (representing the case where two indices behave exactly the same) and 1 (which represents completely unrelated indices; the difference behaves like white noise) but can also be interpreted in absolute terms. As we show below, the unit of measurement can be transferred to bits of information.

The methods we apply have many parameters that can be tweaked. To show that the output data are robust against tweaking input parameters, we provide descriptive statistics for different calculation methods. Fig. 1[4] shows the time series for information distance between Spain and Germany for the year 2013. The bottom panel of the figure represents the raw difference between the two markets. The central panel shows results for the information content based on 7-day moving average returns and different permutation orders, and the top panel shows the same permutation orders based on a 30-day moving average return difference. Both sets of entropy plots show strong similarity between the results based on permutation orders 3 and 4, while the results based on solely up/down permutation (order 2) are erratic. Because of the normalization explained above, the maximum entropy observable in our data is unity, which corresponds to the information contained in white noise. The order 2 permutation entropy hence corresponds well to white noise, which is in line with expectations about returns on stock markets.

Table 1 shows the information distance between ten large economies in the world. We keep information distance in its original scale (even though rescaling would be trivial) to maintain the possibility to interpret the distance score in terms of information necessary to translate one return series into another. Table 1 shows, for example, the information distances from Germany to the other large European economies (France, Great Britain, and Italy) to be smallest, followed by Russia, to which Germany has built up strong economic ties since the 1990s. Incidentally, the country with largest distance to Germany among the ten economies shown in Table 1 (with the

[4] Fig. 1 shows graphs for 30-day moving averages. We also computed reflective distance for 120-day and 7-day moving averages. The results are very similar.

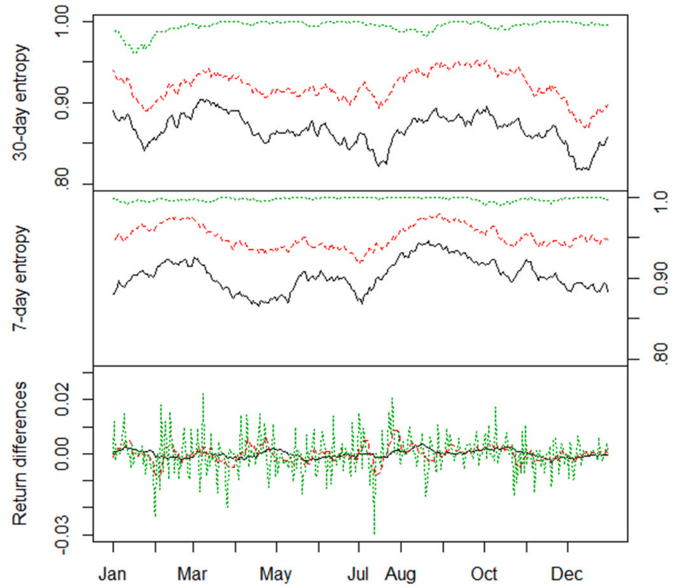

Fig. 1. Information distance between Spain and Germany for 2013. Return difference data in continuous time (bottom graph) based on respective lead index data. Dotted (green) line is day-to-day returns, dashed (red) line is 7-day moving average, and full (black) line is 30-day moving average. Second-from-bottom is permutation entropy based on the 7-day moving average and permutation order 2 (green, dotted line), order 3 (red, dashed line), and order 4 (full, black line). Top graph is permutation entropy based on the 30-day moving average with same color coding of permutation orders. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1
Average cross-national distance of the 10 largest economies by GDP.

	BRA	CHN	FRA	GBR	GER	IND	ITA	JPN	RUS	USA
Brazil		0.918	0.929	0.930	0.925	0.926	0.922	0.934	0.927	0.908
China	0.918		0.914	0.918	0.914	0.907	0.917	0.908	0.902	0.924
France	0.929	0.914		0.911	0.905	0.913	0.913	0.937	0.906	0.946
Great Britain	0.930	0.918	0.911		0.901	0.917	0.903	0.937	0.907	0.948
Germany	0.925	0.914	0.905	0.901		0.918	0.904	0.936	0.913	0.940
India	0.926	0.907	0.913	0.917	0.918		0.915	0.917	0.903	0.919
Italy	0.922	0.917	0.913	0.903	0.904	0.915		0.933	0.903	0.932
Japan	0.934	0.908	0.937	0.937	0.936	0.917	0.933		0.922	0.942
Russia	0.927	0.902	0.906	0.907	0.913	0.903	0.903	0.922		0.919
United States	0.908	0.924	0.946	0.948	0.940	0.919	0.932	0.942	0.919	

exception of Brazil) is the USA. This is somewhat surprising, because intuitively the German economy would be more closely tied to the US economy than to the Chinese economy. However, the information distance measure shows rather large distance from the USA for all economies, which is probably due to the unique role the US capital market plays in the global economy: because of easy access to capital in the equity market, the US stock exchanges are dominated by technology companies and firms growing more quickly than the industrial-firm dominated stock indices in Europe and Asia. Nevertheless, the degree to which information distance has external validity compared the other measures of cross-national distance will be the topic of more structured investigation in the next section.

So far, we have focused on the first two of the four recommendations made by Zaheer et al. (2012) as an answer to Shenkar's (2001) critique. We have outlined the mechanism behind how we capture information distance (financial markets as appraisers of country-level information (driven by SPRs) and taken into account firm heterogeneity (by looking at firm values rather than, e.g., GDP). It remains to be shown, however, to what extent our measure of information distance is symmetric, and whether its development is not oversimplifying. We address these two points in the next section.

4. Evaluation of concept and measure

In this section, we evaluate the characteristics of our distance measure and compare them to those of other measures of cross-national distance. In doing so, we address the remaining two points raised by Zaheer et al. (2012). First, we look at the properties of concepts of cross-national distance, the assumptions that underlie their measures, and the match between the two. As outlined above, a mismatch between assumption, interpretation, and metaphor that the concept draws from is what leads to illusions about measures of cross-national distance (Shenkar, 2001; Shenkar et al., 2008). Next, we provide an empirical test of the match of properties of our measure of distance with assumptions derived from the underlying metaphor. We analyze to what extent it is symmetric, as proposed by Zaheer et al. (2012). Finally, we investigate whether relevant elements of cross-national distance are omitted by focusing on our information-based construct instead of several formative ones. In this vein, we test how our conceptualization of information-based distance can be modelled as a consequence of existing measures of cross-national distance.

Our measure of information distance, as argued above, comes in bits of information as unit of measurement and has a clearly interpretable maximum and minimum. In transforming the 0/1 by inverting the normalization from H to h in the above formal description, one obtains the amount of information needed to describe the information content in the time series. For the fourth-order entropy based on 30-day moving averages, the information content associated with an entropy value of 0.9 is associated with 26.1 bits of information (0.9*(n-1) = 0.9*29). This means that the average distance between the respective stock exchanges per day for a given year is approximately 26 bits. Almost all other existing measures of cross-national distance (with the exception of geographic distance) are indices that are scaled either by inverse variance (Kogut and Singh, 1988) or by other means (Berry et al., 2010) as proposed by Mahalanobis (1936). Such indices are inherently disadvantaged in that they can only be interpreted relative to a reference value. Therefore, they carry the risk of biases given a certain home context. Moreover, weighted compounds of different variables cannot consider the full information in the distribution of observations. Table 2 gives an overview of units of measurement and other characteristics of different measures of cross-national distance.

We capture information distance directly on the country-pair level by applying permutation entropy to differences in returns between two country markets. In this sense, our measure is similar to both geometric distance and the psychic distance stimuli proposed by Dow and Karunaratna (2006). Direct interpretation as a distance avoids the illusion of symmetry in an empirical sense. Simply deducting a value (e.g., GDP per capita) in one country from that in another and taking the absolute value of the resulting difference yields an expression that is, of course, mathematically symmetric. Yet, the relation to the underlying construct (GDP per capita) remains and makes symmetric interpretation difficult. While this may sound like a superficial characteristic on first sight, a comparison with geographic distance makes its relevance apparent. Geographic distance cannot be interpreted at the country level, only at the pairing level. This makes it conceptually symmetric; that is, it eliminates any potential reference to a direction in the underlying difference.

Next, in analogy to the triangle inequality, we propose an evaluation of measures of cross-national distance that explores how distances between three countries are transitive. In this context, transitivity means that if distances between countries A and B and between countries B and C are known, it should be straightforwardly possible to compute the distance between countries A and C. Transitivity should almost perfectly be fulfilled – except for a dummy variable – for one-dimensional symmetrical measures of cross-national distance. From simple geometry, we can conclude that if A, B, and C lie on a straight line (i.e., are measurement points from a one-dimensional construct), we can compute $\overline{AC}$ exactly if we know distances $\overline{AB}$ and $\overline{BC}$ except for a dummy variable indicating which case we are observing (see Fig. 2).

Table 3 shows the regression results for the degree to which transitivity holds for information distance as well as the Berry et al. (2010) dimensions. The focus is on the degree to which the two pairwise distances, AB and BC, explain the distance AC. It is evident that for information distance, nearly the full variation in AC is explained by the two distances. For the other dimensions, the explained variance ranges from 35.9 % (knowledge distance) to 84.3 % (political distance). Consequently, we conclude that information distance is to the largest extent transitive. Transitivity is a joint test of one-dimensionality and symmetry, yet it is not able to distinguish between the two assumptions. Geographic distance is not fully transitive, because it is a consequence of a distribution on a two-dimensional surface of a three-dimensional body. Yet, it can safely be assumed to be symmetric. Together with the descriptive statistics and the defining equations above, this test also shows that our measure of distance is a metric: it is symmetric, non-negative, and zero for distance between a country and itself (and only for this case), and it fulfils the triangle inequality. In sum, the evaluation of conceptual and measurement characteristics of information distance both matches the characteristics of the underlying metaphor and captures the effects of existing formative measures of cross-national distance.

We argue above that information distance, as opposed to most other popular measures of cross-national distance, reflects information-based cross-national distance as a whole. It measures the consequence of economic actors' reactions to the institutional environment and SPRs – not the drivers of such reactions. As a result, we should check whether it captures the effects of established formative measures intended to measure the same construct, in our case cross-national distance. Conceptually, we argue that this is the case because financial markets are good as, or at least better than other economic actors, at efficiently interpreting and incorporating available information (including SPRs) in a market (Fama, 1970; Fama and MacBeth, 1973). In addition, because the firms listed in a country's lead index typically dominate the economy beyond their sheer size, we argue that the information contained in those firms' stock price also reflects activities in the socio-political environment outside of the firm. Finally, we argue that lead indices represent the center-of-gravity of national economies and are hence characteristic of a country's economic structure. Of course, there will also be components of cross-national distance (for example, transportation cost emerging from geographic distance), which are less obviously reflected in information distance. While we suggest that there is a relationship from such more remote aspects of cross-national distance, we acknowledge that information distance will reflect some aspects less than others. Nevertheless, we argue that information distance does reflect many dimensions of cross-national distance, particularly those associated with the information asymmetry between the respective countries.

In order to substantiate these theoretical reasons, we proceed to empirically testing how information distance relates to existing fine-grained (formative) measures of cross-national distance. This empirical investigation into the relationship between information distance and existing concepts of cross-national distance can provide external validity. If there are relationships between the existing measures of cross-national distance and information distance, we will argue that the measure we develop does not oversimplify by

Table 2
Computation methods, data, and units of different (sets of) dimensions of cross-national distance.

Measure	Method	Data	Unit of measurement	Characteristics
Geographic Distance	Euclidean Distance: $\lvert \vec{x_i} - \vec{x_j} \rvert$	Location of Capital Cities	Meters	Corresponds to the distance metaphor; does not consider cultural or historical attributes
Compound Cultural Distance (Kogut and Singh, 1988)	Normalized Euclidean Distance: $\frac{1}{4}\sum_{k=1}^{4}\frac{(H_{ik}-H_{jk})2}{V_k}$	Hofstede Cultural Dimensions	None (Index)	Does not correspond to the distance metaphor; based in survey methodology; considers cultural attributes
Cross-national Distance (Berry et al., 2010)	Mahalanobis Distance: $\sqrt{(\vec{x_i}-\vec{x_j})^T S^{-1}(\vec{x_i}-\vec{x_j})}$	World Development Indicators, POLCON Indicators, CIA Factbook, etc.	None (Index)	Does not correspond to the distance metaphor; uses variety of distance dimensions; considers cultural attributes
Psychic Distance Stimuli (Dow and Karunaratna, 2006)	Single factor solution for m variables in dimensions X_n: $X_{mn} = X_{mni} - X_{mnj}$	Language Categorization, Enrollment levels, GDP, POLCON, etc.	None (Factor Loading)	Does not correspond to the distance metaphor; uses variety of distance dimensions; considers cultural attributes
Information distance	Permutation Entropy	Returns of lead indices	Bits	Corresponds to the distance metaphor; based in financial market information

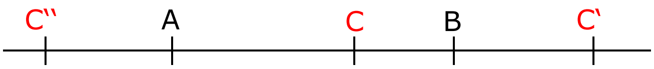

Fig. 2. Possible location of country C relative to countries A and B for a one-dimensional construct.

Table 3
Results of the transitivity regressions, distance between countries AC explained by distances AB and BC (standard errors in brackets).

DV: AC	AB		BC		Adjusted R^2	F Statistic
Market distance	0.434***	(0.010)	0.566***	(0.010)	0.998	1,522,691.000***
Administrative distance	0.452***	(0.011)	0.317***	(0.011)	0.482	3062.736***
Cultural distance	0.449***	(0.011)	0.474***	(0.011)	0.801	13,249.520***
Demographic distance	0.434***	(0.011)	0.383***	(0.011)	0.576	4471.773***
Economic distance	0.388***	(0.011)	0.433***	(0.011)	0.568	4322.165***
Financial distance	0.398***	(0.011)	0.393***	(0.011)	0.501	3300.602***
Geographic distance	0.307***	(0.009)	0.599***	(0.009)	0.688	7252.518***
Global connectedness distance	0.443***	(0.011)	0.334***	(0.011)	0.483	3068.386***
Knowledge distance	0.370***	(0.011)	0.329***	(0.011)	0.359	1840.243***
Political distance	0.471***	(0.011)	0.487***	(0.011)	0.843	17,647.690***

Note. Simulated results for 6578 country triplets. *, **, and *** indicate significance at the 0.05, 0.01, and 0.001 levels, respectively.

reflectively capturing cross-national distance. A challenge in this regard is the overlap of sets of constructs that researchers propose make up cross-national distance. We test geographic distance (great circle distance between national capitals), a Kogut and Singh (1988) compound measure of Hofstede's (1980) cultural dimensions, the remaining psychic distance stimuli (Dow and Karunaratna, 2006), and the remaining Berry et al. (2010) dimensions as explaining variables of information distance. We use these dimensions to explain the information distance between pairs of countries. We expect all dimensions to contribute. The degrees of contribution, however, cannot be expected to be equal (Diamantopoulos and Papadopoulos, 2010; Dow and Karunaratna, 2006).

Table 4 shows the regression results of a simple linear model that explains the distance values that we conceptualized and computed with the respective dimensions of existing concepts as independent variables. First, we look at the sets individually, then jointly. The data are simulated for those pairs of countries for which information on all dimensions is available. Clearly, all dimensions in all tests contribute to the explanation. The largest contributors to the variation in cross-national distance are the psychic distance stimuli and geographic distance. Our analysis mirrors the findings of Håkanson and Ambos (2010), who suggested that whereas cultural distance is not a very good predictor of (psychic) cross-national distance, geographic distance is. Information distance also remains relevant after controlling for geographic distance. While it may seem intriguing that some of the cross-national distance measures contribute positively to information distance and that some do so with a negative sign, this is a logical consequence of existing cross-national distance measures being sometimes positively and sometimes negatively correlated with each other (Berry et al., 2010). Yet, a substantial amount of variance remains unexplained.

There seems to be more to capture in formative measures of cross-national distance, and more research into micro-foundations appears to be necessary to fully understand what composes cross-national distance in the holistic interpretation we use in developing the reflective information-based distance measure. In terms of relative weighting, the results shown in Table 4 may be starting

Table 4
Regression results for information distance (standard errors in brackets) as a function of geographic distance (model 1), Kogut and Singh (1988) compound cultural distance (model 2), the remaining psychic distance stimuli (Dow and Karunaratna, 2006) in model 3, the remaining Berry et al. (2010) dimensions of cross-national distance (model 4), and a full model with all formative measures (model 5).

DV: Information distance	(1)	(2)	(3)	(4)	(5)
Constant	100.950***	101.413***	93.745***	99.584***	92.378***
	(0.620)	(0.660)	(0.832)	(0.914)	(1.054)
Geographic distance	38.322***				52.746***
	(1.285)				(1.350)
Compound cultural distance		4.415*			7.711***
		(1.735)			(1.516)
Language stimulus			16.127***		16.867***
			(0.937)		(0.896)
Religion stimulus			26.049***		7.391***
			(1.732)		(1.621)
Industrial development stimulus			−18.409***		−48.632***
			(1.500)		(1.943)
Education stimulus			−17.702***		−10.434***
			(1.388)		(1.370)
Democracy stimulus			4.782*		−57.756***
			(2.330)		(3.366)
Socialism stimulus			−11.752***		−5.153***
			(1.489)		(1.381)
Economic distance				3.168*	18.069***
				(1.340)	(1.568)
Financial distance				4.728*	12.183***
				(2.212)	(1.958)
Global connectedness distance				−18.858***	28.383***
				(1.958)	(2.391)
Knowledge distance				18.727***	20.173***
				(1.072)	(1.053)
Political distance				8.101***	−13.132***
				(1.546)	(1.551)
Administrative distance				29.165***	38.445***
				(2.994)	(2.734)
Demographic distance				−15.926***	15.716***
				(1.391)	(1.657)
Observations	7502	7502	7502	7502	7502
Adjusted R^2	0.106	0.001	0.132	0.090	0.380
F statistic	888.996***	6.476*	190.323***	106.522***	307.665***

Note. *, **, and *** represent significance on the 0.05, 0.01, and 0.001 levels for two-sided tests, respectively. Data are simulated for random pairs of countries. Data are standardized by their mean and standard deviation for ease of interpretation. Information distance is additionally multiplied by 1000 to improve the readability of results.

values for relative weights of the respective dimensions. In firm-level empirical applications, however, the weights will also depend on the specific research questions. For information distance, the results from Table 4 provide support for our reasoning that it reflects the information contained in several formative sub-dimensions. This means that, assuming the formative measurements from literature are to some extent valid (i.e., causality flows from them to the latent construct institutional distance), the information distance measure we propose is consistent with them in that causality flows from the formative measures to the reflective measure, through the latent construct. Even though we only look at antecedents of institutional distance, we find empirical support for our claim that information distance is related to the latent construct of cross-national distance. The strong relationships between information distance and all existing measures tested indicate that information distance does not neglect relevant variation and hence does not oversimplify.

We have addressed the four points raised by Zaheer et al. (2012) conceptually and empirically. This gives our concept and measure of distance internal and external validity. With regard to the latter, as well as the fourth point of Zaheer et al. (2012), we however believe we need to do more and show the relevance of information distance for concrete empirical applications. After all, empirical researchers in IB are interested in explaining relevant governance and strategic decisions as functions of cross-national distance, which can complement existing formative measures only if this is the case. Consequently, in the next section we replicate existing research while replacing the measures of cross-national distance applied therein with information distance.

5. Empirical application

We next test the explanatory power of information distance for relevant strategic decision-making in international settings. To do so, we closely replicate Berry et al. (2010), which empirically investigates the “law of distance” (Ghemawat, 2011). We select Berry et al. (2010), as the paper pursues an objective very similar to ours. The illustration is not meant to replace or weaken the contributions of the replicated paper. Rather, we intend to make two contributions. First, we of course intend to show the relevance and explanatory power of our concept and measure of distance. Second, introducing a new concept provides an opportunity to replicate earlier results based on similar concepts.

We closely follow the approach of Berry et al. (2010) and investigate firms' propensity to invest in different countries abroad. The "law of distance" suggests that, similar to gravity models that are used in economic geography (e.g., Anderson, 1979, 2011; Bergstrand, 1985), the intensity of IB activities decreases with distance (Ghemawat, 2001; Ghemawat, 2011). This can be linked to the idea of liabilities of foreignness (Nachum et al., 2008; Zaheer, 1995), which in turn increase with distance. We can also link the law of distance to SPRs. This is as the prevalence and relevance of specific socio-political risks differs across countries and as the challenge to gather and interpret information increases with distance.

We expand the sample drawn by Berry et al. (2010) and look at a resulting sample of firms from 146 country pairs. We do so for two reasons: first, because we intend to test the explanatory power of our measure using the largest possible sample[5]; and second, because we follow recent critique of single end-point samples in distance studies (Brouthers et al., 2016). We also provide a formal derivation of the single-country sample problem in Appendix 3. The level of analysis in this illustration is the firm-country-year; that is, firms are at risk of making a greenfield investment in a number of countries each year. Observed investments are coded as 1, and firm-country-years without investment are coded 0. In total, we have 232,475 firm-country-years between 2009 and 2013 (which corresponds relatively closely to the setting of Berry et al. (2010) and Dow and Karunaratna (2006)). Following Berry et al. (2010), we control for firm size, R&D intensity (if R&D is unreported, this is coded 0), and firm experience. We also add firm profitability as a control, a dummy indicating whether R&D was unreported or reported, as well as industry and time fixed effects. Table 5 presents results from this analysis. We use the nine dimensions of distance between two countries as defined by Berry et al. (2010) in model 1. Moreover, we run a model using Dow and Karunaratna's (2006) psychic distance stimuli as predictors in model 2. Finally, we test the model using the 30-day order 3 entropy information distance measure presented above (model 3). Following Dorobantu et al. (2020), we run *glm()* probit models with logistic link function in an R 3.4.5 software suite to test the prediction that more distant countries are less likely to receive investments.

We find that all sets of dimensions of distance, including information distance, have similar predictive power for investment decisions. However, we find that the multidimensional approaches to capture distance (Berry et al., 2010; Dow and Karunaratna, 2006) show differential effects: the different dimensions have effects in different directions. Five of Berry et al.'s (2010) nine dimensions and two of Dow and Karunaratna's (2006) five dimensions show positive results. From a theoretical point of view this is problematic, as the effect directions run against the law of distance (more distance should be associated with fewer investments across all dimensions). Of course, there may be reasons for why these effect directions vary for some firms in some settings. But the broad sample of 232,475 observations should allow us to observe average effects, which seem to still run contrary to theoretical expectations. Consequently, we believe that these counterintuitive findings might be the result of the above-mentioned conceptual and measurement problems associated with the basic approaches to distance in Berry et al. (2010) and Dow and Karunaratna (2006). This replication thus shows that the information distance measure we propose leads to empirical results in line with theory and addresses empirical shortcomings of existing measures of cross-national distance capturing differences in SPRs across countries.

6. Discussion and conclusion

We began this project by arguing that information distance is a phenomenon that creates uncertainty and risk specifically for firms active in different socio-political contexts. We argue that firms' behavior and strategy are, at least to a certain extent, driven by the specific socio-political risks they are confronted with. From these stepping stones we conclude that a reflective information-based measure of cross-national distance that is conceptually similar to geometric distance is called for. Analysis of this literature and calls for an integration of IB and finance (Agmon, 2006; Bowe et al., 2010; Puck and Filatotchev, 2020) have led us to use financial market information for quantification.

We capture information-based cross-national distance reflectively by observing differences in financial markets' assessment of firms in different countries. We interpret structural differences between the behaviors of lead indices in different countries as reflecting differences in SPR across countries. Hence, our measure of information distance reflectively captures cross-national distance reflecting SPRs. Two key properties of cross-national distance concepts are analyzed in detail in this paper. First, we look at the fundamental assumptions that geometric distance shares with other concepts of cross-national distance. We believe that the possibility of interpreting geometric distance straightforwardly, without resorting to the context measure of a particular country or a reference pair of countries, is crucial. Many other concepts of cross-national distance do not share this characteristic. Looking at criticism of cross-national distance (Shenkar, 2001), we believe that the illusion of symmetry is eventually a consequence thereof. Consequently, we design our concept of distance such that it can be interpreted straightforwardly as distance and comes in a unit of measurement with well-defined end points to its scale, not as an index. This adds to the understanding of cross-national distance. Second, we put information-based distance in context with existing measures of cross-national distance. We provide evidence that it reflectively captures the construct of which popular sub-dimensions of cross-national distance are sub-dimensions. Many statistical tools require reflective and uncorrelated formative measures to yield unbiased results (MacKenzie et al., 2005). One way to overcome such biases is to complement formative measures with reflective ones (Diamantopoulos and Papadopoulos, 2010). Therefore, we believe that the reflective measurement approach we provide benefits empirical research as well as business practice. We assess our information-based concept of distance following the propositions of Zaheer et al. (2012) and make sure to appropriately discuss the underlying

[5] The analysis reveals very similar results for a U.S.-only sample of firms (as in Berry et al., 2010). We maintain, however, that a multi-country sample is a superior test of the law of distance compared with a single-start-point study (Brouthers et al., 2016).

Table 5
Regression results for binomial generalized linear model.

DV: invest dummy	(Berry et al., 2010)	(Dow and Karunaratna, 2006)	(Information distance)
Constant	−7.949*** (1.044)	−8.592*** (0.725)	−4.246*** (0.938)
Geographic distance	−0.028*** (0.007)		
Cultural distance	0.019*** (0.005)		
Financial distance	−0.042*** (0.008)		
Administrative distance	−0.046*** (0.003)		
Demographic distance	0.014*** (0.003)		
Knowledge distance	−0.023*** (0.002)		
Economic distance	0.012*** (0.002)		
Connectedness distance	0.219*** (0.014)		
Political distance	0.0001*** (0.00002)		
Lanugage stimulus		−0.247*** (0.011)	
Religion stimulus		−0.086*** (0.015)	
Industrial development stimulus		0.286*** (0.036)	
Education stimulus		−0.112** (0.042)	
Democracy stimulus		0.476*** (0.028)	
Information distance			−3.939*** (0.650)
Firm assets (logged)	0.281*** (0.017)	0.287*** (0.009)	0.276*** (0.009)
R&D Dummy	−0.388*** (0.092)	−0.250*** (0.045)	−0.193*** (0.045)
R&D Intensity	0.538*** (0.104)	0.004*** (0.001)	0.004*** (0.001)
Firm Age	0.0004 (0.001)	0.002*** (0.0004)	0.001 (0.0004)
Observations	65,645	232,475	232,475
Log likelihood	−8401.190	−26,657.250	−27,175.780
AIC	17,504.380	54,198.500	55,227.560

Note. Firm assets are logged, and lagged by one year, as well as R&D intensity, which is R&D expenses over assets. Firm age is years since foundation. The distance variables are Berry et al. (2010) dimensions of cross-national distance. Stimuli are Dow and Karunaratna (2006) stimuli of psychic distance. Information distance is annual averages of order four permutation entropy and 30-day moving averages as presented above. All distance measures are lagged by one year. Standard errors in brackets. *, **, and *** indicate significance on the 0.05, 0.01, and 0.001 levels for two-sided tests. AIC stands for Akaike Information Criterion. Note: An analysis using geographic or cultural distance alone also yields very similar predictions (with the expected sign).

mechanism, incorporate firm heterogeneity, discuss conceptual and empirical symmetry, and avoid oversimplification.

Despite following clear guidelines from existing literature both for conceptual and empirical development of information distance, we make two important assumptions in the process. We, first, assume on the conceptual level that financial markets are sufficiently efficient interpreters of information stemming from the underlying national context. Second, we assume on the empirical level that lead indices are representative of national economies. Both are indeed strong assumptions.

However, we argue with regard to the former that any conceptualization of distance benefits from an explicit assumption about how the behavior of economic actors translates into a concept or measure of cross-national distance. By relying on financial markets, we use an efficiency assumption of those markets in our reasoning. It has been stressed, particularly after the financial crisis, that this efficiency is not without constraints (Choudhry and Jayasekera, 2014). Yet, we maintain that of the available possibilities to find information about what determines the reaction of economic actors to their environment, financial markets are among the most efficient. Given that different countries have differently developed financial markets, it might be that the efficiency with which information distance captures distance depends on the development of the respective capital markets. We maintain, however, that part of this is directly captured by differing relative behavior across markets. Also, it is clear that financial markets capture much more information than just the institutional SPR environment on the national level. Yet, we stress that the SPR environment is definitely part of what is captured, particularly when we look at annual country-pair aggregations of the information distance. We provide evidence that information about cross-national distance as applied in IB research can be derived from the high-level analyses we conduct. It remains to be seen in future research, which changes in national-level SPR settings translate into sustained increases or decreases in information distance, though. In sum, we argue that even if the level of efficiency in information interpretation varies, we still present a clear mechanism of how actions of economic actors are translated into cross-national distance. Further, our empirical assessments provide evidence that markets are sufficiently efficient to provide our measure with predictive power for relevant firm-level decisions.

Regarding the latter, we look at lead indices as representations of the economic activity in a country. It might be argued that different compositions of lead indices across countries lead to distortions in information distance, and hence that we capture additional distance that is a direct consequence not of national institutions but of firm characteristics. Financial markets indeed incorporate information on a firm level and information about the market as a whole (Morck et al., 2000; Roll, 1988). Therefore, information contained in the return series that represents the largest elements of a national economy goes beyond the selection of firms in the index. At the same time, the very selection of firms for an index can be argued to be a consequence of the national economic structure, thus representing the national SPR characteristics. Consequently, we believe we have good reasons to assume that the behavior of the lead index of a country is a good representation of the underlying national SPR context. In future research, we suggest to investigate further how different sectors of economies in different countries are connected, potentially breaking the distance down to the level of individual firms. Distinguishing between the formal and informal aspects, it would also be interesting to see which part of distance is influenced by the formal political sphere, and which part by less formalized attributes of social systems. Further, we think it is a very promising avenue for future research to understand institutional sources of cross- national distance, both in terms for which transactions which dimensions matter how much, and also which dimensions matter between different pairs of firms or environments.

Our concept and measure are naturally not without limitations. First, information distance is explicitly designed to capture information asymmetry. Of course, information asymmetry is only one component of socio-political risks, and hence information distance can only be one component of a comprehensive measure of SPRs. In order to explain MNE decision-making more completely, information distance needs to be paired with a measure of host-country context, ideally reflecting socio-political risks as well. Second, information distance only captures some components of cross-national differences, particularly those components reflected by stockmarkets. As a result, listed firms are more represented in information distance than family-owned firms or SMEs. Third, information distance draws on permutation entropy as a measure of how much information is needed to explain one stock index given another. The focus on indices, while straightforward to relax, shifts the focus of information distance on firms included in the lead indices of their respective home countries. Finally, information distance relates to information asymmetry, which is not the only source of liabilities of foreignness. As a result, other components of liabilities of foreignness may also drive distance-effects, and studies focusing on those components may work better using a different measure of cross-national distance.

While making strong assumptions in the development of information distance, we still believe we provide a number of relevant contributions to the field and the measurement of distance as an important component of socio-political risk. First, we explain how SPRs matter for MNEs through two channels: the chance of unexpected changes to the 'rules of the game' (North, 1991), and an MNEs' difficulty in understanding the 'rules of the game' in a foreign country. Because literature does not provide a conceptually and empirically clean way of capturing the information asymmetry driving the latter component, we propose information distance as a cross-national distance measure based in information theory. Information distance is a reflective measure of cross-national distance based on financial market data, which means the underlying data are readily available and updated frequently. We think this can help research into entry modes, liabilities of foreignness, and other relationships that use the concepts of distance, information asymmetry, and SPRs more broadly to gain rigor and relevance. This may happen either as a complement to existing fine-grained measures or as a stand-alone measure of holistic distance. The proposed methodology can also be extended to establish measures of distance on the country-firm or even firm-firm level (within or across countries). It also allows the further development of a regional perspective on distance as proposed by Tung and Verbeke (2010). As such, it allows us to make firm-specific predictions for distance effects. Theoretical predictions for such effects could be, for example, connected to organizational culture or organizational identities. Second, by analyzing the fundamental properties of concepts of cross-national distance and its sub-dimensions, we add conceptual clarity to the discussion of cross-national distance, a core construct in IB research. The comparison of information distance with existing concepts of cross-national distance also provides evidence for the conceptual and empirical challenges that existing measures of distance face. Finally, we integrate research from IB and finance, an endeavor repeatedly called for (Agmon, 2006; Bowe et al., 2010). Doing so may also spark a discussion about the relevance and assessment of cross-border transactions in the field of finance.

Data availability

The data on cross-national information distance are available from the cross-national distance data section at www.thomaslindner.info.

Appendix 1. Information distance data description

We compute information distance between the 49 countries listed in Table A1. In principle, this would result in 1176 annual averages computed per method and year given full data availability. Because of incomplete data for some of the lead indices, the number is reduced to 754, as mentioned above. If more than one index is available (most notably in the case of the United States), we choose the most comprehensive one. In the empirical applications we use annual averages. Therefore, some country-pairs show up there even though full data are not available for all years. We always eliminate the first and last year for which we have observations to avoid border-effects resulting from unavailable elements in moving averages or observation windows. The method would allow industry splits or deep-dives on the firm level, but for the moment we choose to forgo this opportunity for the sake of conceptual evaluation and clarity.

Table A1
Countries for which information distance is computed including share of nominal World GDP in 2005 USD (according to World Bank data).

Country	Country code	Index	Data available for all years	Share of World GDP
Argentina	ARG	MERVAL Index	Yes	0.82 %
Australia	AUS	All Ordinaries Index	Yes	2.05 %
Austria	AUT	ATX	Yes	0.56 %
Belgium	BEL	Euronext BEL-20 Index	Yes	0.69 %
Brazil	BRA	Bovespa Index	Yes	3.14 %
Canada	CAN	S&P TSX Composite Index	Yes	2.42 %
China	CHN	Shanghai Composite Index	Yes	12.47 %
Croatia	CRO	CROBEX Index	No	0.08 %

(continued on next page)

Table A1 (*continued*)

Country	Country code	Index	Data available for all years	Share of World GDP
Czech Republic	CZK	PS Index	No	0.27 %
Denmark	DAN	OMX Copenhagen 20 Index	No	0.44 %
Ecuador	ECU	Bolsa de Quito General Index	No	0.12 %
Estonia	EST	OMX Tallinn Index	No	0.03 %
Finland	FIN	OMX Helsinki 25 Index	No	0.35 %
France	FRA	CAC 40 Index	Yes	3.69 %
Germany	GER	DAX	Yes	4.90 %
Greece	GRE	Athens Composite Index	Yes	0.32 %
Hong Kong	HKG	Hang Seng Index	Yes	0.36 %
Hungary	HUN	BUX Blue Chip Index	Yes	0.18 %
Iceland	ICE	OMX Iceland All-Share Index	No	0.02 %
India	IND	BSE 30 SENSEX	Yes	2.45 %
Indonesia	IDO	Jakarta Composite Index	Yes	1.20 %
Ireland	IRE	ISEQ 20 Price Index	No	0.30 %
Israel	ISR	Tel Aviv 100 Index	Yes	0.38 %
Italy	ITA	FTSE MIB Index	Yes	2.81 %
Japan	JPN	Nikkei Index	Yes	6.46 %
Jordan	JOR	Amman General Index	No	0.04 %
Latvia	LAT	OMX Riga Index	No	0.04 %
Lithuania	LIT	OMX Vilnius Index	No	0.06 %
Luxembourg	LUX	Lux General Index	Yes	0.08 %
Malaysia	MAL	Kuala Lumpur Composite Index	Yes	0.41 %
Mexico	MEX	IPC Index	Yes	1.66 %
Netherlands	NED	AEX Amsterdam Index	Yes	1.12 %
New Zealand	NZE	NZSE 50 Index	Yes	0.25 %
Norway	NOR	OMX Oslo 20 Index	No	0.69 %
Philippines	PHI	PSEi Index	No	0.36 %
Romania	ROM	BET Index	No	0.25 %
Russia	RUS	RTSI Index	Yes	2.73 %
Serbia	SRB	BELEX 15 Index	No	0.06 %
Singapore	SGP	Straits Times Index	Yes	0.40 %
Slovenia	SLO	SBITOP Index	No	0.03 %
South Korea	RSK	KOSPI Composite Index	Yes	1.72 %
Spain	ESP	IBEX 35 Index	Yes	1.83 %
Sweden	SWE	OMX Stockholm 30 Index	No	0.76 %
Switzerland	SWI	Swiss Market Index	Yes	0.90 %
Taiwan	TAW	Taiwan Weighted Index	Yes	n.a.
Ukraine	UKR	UX Index	No	0.24 %
United Kingdom	GUK	FTSE 100 Index	Yes	3.52 %
United States	USA	S&P 500 Index	Yes	22.03 %

Appendix 2. Details of empirical application

In the empirical illustration, we test the "law of distance." We do so controlling for several firm-specific variables and with different dimensions of distance. The estimation method is generalized linear modelling (binomial) with a logistic link function. We introduce fixed effects on year and industry levels. The main finding in the results is that the different individual dimensions of cross-national distance (geography, culture based on Hofstede, culture based on GLOBE, information distance) make similar predictions about the dependency between the likelihood to invest in a certain location and cross-national distance. Data on some of the dimensions in the Berry et al. (2010) framework (particularly culture) are less available than for the other dimensions. Therefore, the number of observations is lower for this type of replication. The tendencies documented are the same, however, in both the larger and the smaller sample. In the overall sample, there are 480 combinations of home and host countries. The table below shows descriptive statistics for this empirical application.

Table A2
Descriptive statistics of the empirical application concerning the "law of distance".

Variable	N	Mean	STD	Min	Max
Investment Dummy	232,475	0.048	0.255	0	1
Assets (th USD)	232,475	12,640,860	34,393,768	0	373,109,737
R&D Dummy	232,475	0.345	0.476	0	1
R&D Intensity	232,475	0.138	10.114	0.000	995.377
Firm Age	232,475	45.556	41.476	−8	493
Geographic Distance	232,475	7.724	4.349	0.279	19.837
Cultural Distance	76,566	13.666	6.419	1.984	26.732
Financial Distance	220,527	4.946	3.894	0.003	25.080

(*continued on next page*)

Table A2 (*continued*)

Variable	N	Mean	STD	Min	Max
Administrative Distance	232,475	16.456	13.965	0.032	90.243
Demographic Distance	232,475	11.129	11.609	0.016	51.548
Knowledge Distance	207,444	15.125	14.329	0.001	57.757
Economic Distance	232,475	7.961	12.177	0.016	84.474
Connectedness Distance	232,475	2.511	2.803	0.015	12.483
Political Distance	232,475	2587.263	1599.118	0.185	11,421.840
Language Stimulus	232,475	−0.192	1.218	−3.868	0.526
Religion Stimulus	232,475	0.216	1.039	−1.551	1.528
Industrial Development Stimulus	232,475	0.828	0.650	0.001	2.482
Education Stimulus	232,475	0.611	0.539	0.001	2.243
Democracy Stimulus	232,475	0.454	0.556	0.001	2.059
Information distance	232,475	0.926	0.021	0.813	0.970

Appendix 3. The single-country sample problem in distance studies. Or: distinction between distance and context

This is a mathematical derivation of the “single-country problem”, which Brouthers et al. (2016) outline in a less formal way.

Let v and w be linear functions of a set of independent variables, of which x is national context and Δx a distance measure based on absolute differences between the contexts.

$$v = f(x, y, z, \ldots) = \alpha_0 + \alpha_1 x + \alpha_2 y + \alpha_3 z + \ldots$$

$$w = f(\Delta x, y, z, \ldots) = \beta_0 + \beta_1 \Delta x + \beta_2 y + \beta_3 z + \ldots$$

$$\Delta x = |x_i - x_j|$$

$$i \neq j, x > 0 \forall i, j$$

If we want to compare α_1 to β_1 in the case of only one reference point (x_i) and independent predictors we get

$$\alpha_1 = \frac{\partial v}{\partial x} = \frac{v_2 - v_1}{x_2 - x_1}$$

$$\beta_1 = \frac{\partial w}{\partial \Delta x} = \frac{w_2 - w_1}{\Delta x_2 - \Delta x_1} = \frac{w_2 - w_1}{|x_i - x_{j,2}| - |x_i - x_{j,1}|} =$$

$$= \frac{w_2 - w_1}{(x_i - x_{j,2}) - (x_i - x_{j,1})} = \frac{w_2 - w_1}{x_{j,1} - x_{j,2}}, for\ x_i > x_{j,1} > x_{j,2}$$

$$= \frac{w_2 - w_1}{-(x_i - x_{j,2}) - (x_i - x_{j,1})} = \frac{w_2 - w_1}{-2x_i + x_{j,1} + x_{j,2}}, for\ x_{j,2} > x_i > x_{j,1}$$

$$= \frac{w_2 - w_1}{-(x_i - x_{j,2}) + (x_i - x_{j,1})} = \frac{w_2 - w_1}{x_{j,2} - x_{j,1}}, for\ x_{j,1} > x_{j,2} > x_i$$

If we now assume the same dependent variable ($v = w$) and that the x_j in the equations for β are the same as the x in the equation for α, we see that the coefficients α and β are equivalent if the reference country x_i is at the top or bottom of the scale of all countries in the study. The remaining possible permutations of x_i, $x_{j,1}$, and $x_{j,2}$ are symmetric to those shown here.

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