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Sanjay Kumar

Valparaiso University, Sanjay.Kumar@valpo.edu

Jiangxia Liu

Valparaiso University, Jiangxia.Liu@valpo.edu

Ozgun C. Demirag

Pennsylvania State University - Main Campus

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National Culture's Impact on Effectiveness of Supply Chain Disruption Management

Sanjay Kumar
Valparaiso University

Jiangxia Liu
Valparaiso University

Ozgun C. Demirag
Pennsylvania State University- Erie

The purpose of this research is to understand the national cultural antecedents that may help explain differences in supply chain disruptions mitigation abilities of companies from different countries. An analysis of survey data on disruption planning and response collected from various organizations worldwide was performed using weighted least square regression and factor analysis. We find that culture influences disruption planning and response. Statistical findings suggest that differences in disruption planning and response abilities between companies from different countries could be partly attributed to national culture. All five Hofstede's dimensions of national culture, i.e., Power Distance, Individualism, Masculinity, Uncertainty Avoidance, and Long-term Orientation were shown to have a significant positive effect on disruption planning and response. National cultural dimensions and economic status of a country could be effectively used to predict disruption planning and response abilities of companies in various countries. Managers could benefit from our research as it could help them assess disruptions mitigation abilities of their partners located in other countries. Increasing international trade and globalization of supply chains accentuate the importance of our research.

INTRODUCTION

On February 1, 1997, Aisin Seiki suffered a major fire in its production facility. Toyota sourced brake valves almost exclusively from Aisin Seiki. By February 5, partly because of JIT production and lean inventory practices, Toyota shuttered all of its 30 assembly lines in Japan. Several hundred other suppliers were also forced to stop their operations. The potential loss for Toyota from the fire was an inability to assemble fifteen thousand cars a day, valued at over a quarter billion dollars. The severity of fire would take Aisin Seiki months to rebuild and recover.

The response and recovery efforts at Aisin Seiki are documented by Nishiguchi and Beaudet (1998) and Sheffi (2007). Within just one day of the fire, companies with little experience in making brake valves responded to a call for help. Over 200 companies, including Aisin Seiki's competitors, participated. The companies collaborated without any negotiations for technical rights or financial compensation. As a result, Toyota was able to start two of its assembly lines by February 6. All assembly

lines were operational at pre-fire levels by February 10, just nine days after the fire and four and a half days after stopping assembly lines.

Diversification and alternate sourcing are popular and well-studied supply chain risk management practices (Tomlin and Wang, 2010). Aisin Seiki and Toyota's effectiveness in handling the consequences of fire is sometimes attributed to their ability to temporarily diversify production and supplies (Nishiguchi and Beaudet, 1998). These practices, however, do not completely address the factors that contributed to the success of Aisin Seiki. For example, why did other companies and even competitors respond to call for help? What made those companies help without a prior agreement on property rights or compensation? More importantly, was there something distinctive about Aisin Seiki being a Japanese company?

A 2010 fire partially destroyed a German car door paint company's production facility. The company was the sole source of car door paint for a major automobile supplier. Fundamentally, there were little differences in the nature of disruptions at Aisin Seiki and the German company. However, the effectiveness of response and recovery were different. It took the German company over three weeks to source the door paint from alternate suppliers. In the process, there were numerous issues regarding sharing of original paint formulations, communication, coordination of activities, and negotiations on compensations (Whitney et al., 2012).

Effectiveness of Japanese companies in managing disruptions is not unique to Aisin Seiki. Anecdotal evidence in supply chain and operations management literature provides many examples where Japanese companies are attributed for their superior ability to manage disruptions. Several such examples exist for recovery from disruptions caused by Japanese Tsunami of 2011 (Olcott and Oliver, 2011). In contrast, some American or other Western companies are not attributed to have effective disruptions response and recovery abilities. Popular examples include the ineffectiveness of Ericsson in managing fire at Philips, which was a sole supplier for certain parts (Chopra and Sodhi, 2004). Impact on Land Rover when a supplier UPF Thompson became insolvent is also cited in literature (Chapman et al., 2002).

This research aims to understand the anecdotal differences in perceived abilities of companies from different countries when faced with supply chain disruptions. We argue that cultural factors play an important role in influencing the effectiveness of companies in disruption planning, response, and recovery. Many factors related to Japanese culture are attributed to Aisin Seiki's effectiveness. These factors include collaborative spirit, trust, capability sharing (Sheffi, 2007), supplier association and Keiretsu, all of which foster trust building and capability sharing among firms (Whitney et al., 2012).

Culture represents a set of shared understanding about organizational issues, objectives, and practices (Mello and Stank, 2005). National culture is the collective mental programming of people (Hofstede et al., 2010). Cross national research focuses on shared cultural values as a primary course of differentiating between nations (Tsui et al. 2007). According to Pagell et al. (2005) "national culture is an equally relevant lens" to view and understand the country specific "systematic differences...to advance the field of operations management." They provide evidence to indicate that national culture affects operational decision making in business organizations.

Despite growing interest in supply chain disruption management there is dearth of empirical work associating the cultural antecedents to supply chain disruptions. Such associations could be of interest to supply chain decisions-makers. In today's competitive environment most supply chains are global. Decision-makers would benefit by knowing the disruptions mitigation abilities of their partners located in other countries. Other decisions such as location of facilities and inventory positioning could be made effectively by identifying the vulnerability of various supply chain stages.

We use widely accepted measures of national culture developed by Hofstede (1980), which were then restudied over time (Hofstede, 2013). The measures provide a quantitative scheme to measure national culture. Specifically, culture is measured in five dimensions of Power Distance, Uncertainty Avoidance, Individualism, Masculinity, and Long-term Orientation. Hofstede (2013) and Pagell et al. (2005) provide description of these dimensions. These five dimensions have been successfully used to explain cross-country differences in many fields including organization behavior, information technology, human

resources, marketing, and operations management. Example applications of Hofstede dimensions could be found in Desislava (2010) and Rujirawanich et al. (2011).

The aim of this research is to show that national culture can explain a significant part of difference in Disruption planning and Response (DPR) as observed in different countries. To this effect we collected data from various organizations worldwide that survey companies about their disruption planning and response. We perform a secondary data analysis on the surveys using structural equation modeling. To the best of our knowledge, ours is the first attempt to relate supply chain disruptions mitigation abilities with a country's national culture.

We contribute to the supply chain disruption management literature by systematically exploring the relationship between national culture and DPR. Our statistical findings show that dimensions of national culture help explain the DPR differences observed in different countries. All five Hofstede's national culture dimensions have a significant positive impact on DPR. Economically superior countries have better DPR effectiveness. We perform a factor analysis to test if DPR effectiveness could be predicted using national culture dimensions. Five culture dimensions and the economic status of a country were found to have a statistically significant predictive power. A DPR Prediction model was developed. A comparison between DPR predicted from our model and observed from survey data shows that our model is effective in predicting DPR effectiveness at the country level. The comparison also helps validate our model.

Rest of the paper is organized as follows. In next Section we review relevant literature. Then we present our conceptual model and outlines the hypotheses. Data, methodology, and statistical analysis are presented. Then, we extend the model to use the cultural factors as a predictor for supply chain disruptions response and recovery. Implications and conclusion of our research are then presented.

LITERATURE

There is rich and growing literature in the field of supply chain disruption management. The disruptions are often unfamiliar in nature, and not easily resolved and understood. The importance of managing disruptions is highlighted by Hendricks and Singhal (2003) who showed a marked decrease in shareholder wealth following a disruption. Filbeck et al. (2013) extend the results to competitors, which under certain market conditions are shown to experience lower stock returns from disruptions. These studies indicate that effective disruption management could add value to a company.

Primary focus of supply chain disruptions research is on identifying and analyzing tactical, operational, and strategic choices that could help mitigate disruptions. See Ellis et al. (2011), Rao and Goldsby (2009), and Craighead et al. (2007) for thoughtful literature reviews. However, understanding culture is also important because decision-making and applicability of operational strategies could depend on national culture (Hope and Muehlemann, 2001). de Koster and Shinohara (2006) study the applicability of Japanese business practices in Europe. They conclude that Japanese human resources management practices are not suitable and effective when applied to companies in Western European countries. Therefore, the strategies chosen by managers could differ based on cultural context of a company. Depending on national culture, companies in different countries may have different potentials for managing disruptions.

Research in international management is rich in identifying the correlation between national culture and business practices. Many of these studies use the quantitative measures of national culture developed by Hofstede. The dimensions developed by Hofstede (2013) are derived using a factor analysis of a large scale data from 72 countries. The five dimensions thus developed measure the similarities and differences between national cultures. Subsequent research has reaffirmed the validity of these measures (Merritt, 2000). Other measures of national culture were developed by GLOBE project (Javidan and House, 2001), Trompenaars and Hampden-Turner (1998), and Schwartz (1994). However, despite limitations, Hofstede's measures are widely accepted to be valid for business applications (Magnusson et al., 2008). See Wiengarten et al. (2011) for a description of other measures and applicability of Hofstede's measures.

For both empirical and practical reasons, international management research views culture at the national level (Javidan and House, 2001; Trompenaars and Hampden-Turner, 1998; and Hofstede, 2013). Studies have shown that national culture impacts business decisions. For example, decisions in Western companies are sometimes focused on short-term returns, while in many Asian companies decisions are motivated by long term effects. Other important differences include short-term employment and individual responsibility and decision-making in American companies. Many Asian companies have lifetime employment, consensual decision-making, and collective responsibility (de Koster and Shinohara, 2006). Literature on national culture demonstrates difference between countries and offer explanations to account for difference in business strategies, such as international expansion, low cost versus differentiation, compensation schemes, and choice of financial structure (Pagell et al., 2005). Dunning and Pearce (1982) and Porter (1990) argue that home country of the company and physical location of facilities and personnel affect business decisions. So as to understand the business impact of national culture, Katz et al. (1999) and Nakata and Sivakumar (1996) call for studying the association of national culture and functional decisions such as in the area of operations management.

There is limited research on the role of national culture on supply chain management (Mello and Stank, 2005). Pagell et al. (2005) show that decisions such as export, sales forecasts, number of outsource relationships, and make or buy decisions differ based on the country in which the company is located. Mello and Stank (2005) develop a cultural framework and propositions that relate culture to supply chain management behaviors. They argue that cultural orientation is critical to successful implementation of supply chain management practices. Using Korean context, Ryu et al. (2006) study the effect of collectivism on long term orientation in business decisions. They conclude that companies in countries with collective culture (such as Korea) are better at managing long-term supplier relationships when compared to companies located in Western countries that have individualistic culture.

Roh et al. (2008) attribute cultural orientations for difference in productivity gap between American and Japanese companies. Studying manufacturing data from six countries, Naor et al. (2008) conclude that difference in manufacturing performance across countries could be explained by the organizational culture. Wiengarten et al. (2011) study the moderating influence of Hofstede's national cultural dimensions on investment in manufacturing facilities and quality practices. They found that Individualism moderates both facilities and quality investment; while Masculinity and Uncertainty Avoidance moderate only the quality practices. McGinnis and Spillan (2012) attribute culture for differences in logistics strategies between the US and Guatemala. Other research has shown the association between national culture and total quality management (Katz et al. 1998), innovation (Panida et al., 2011), supplier selection (Carter et al., 2010), product characteristics (Desislava, 2010), and product development (Nakata and Sivakumar, 1996). Kaasa and Vadi (2010) conclude that innovativeness is higher in companies located in countries with high Power Distance, Uncertainty Avoidance, Collectivism, and low Masculinity.

Cultural orientation is particularly important when making supply chain disruptions decisions (Dowty and Wallace, 2010). They use cultural biases to characterize interactions among organizations during humanitarian supply chain disasters. The four cultural biases identified by Dowty and Wallace (2010) are hierarchist, individualist, fatalist, and egalitarian. Management effectiveness and interactions between companies are found to be influenced by these cultural biases. Jia and Rutherford (2010) address the issue of supply chain relational risk associated with cultural differences between companies from China and the West. They suggest that companies must adapt according to local culture to be successful.

CONCEPTUAL MODEL AND HYPOTHESES DEVELOPMENT

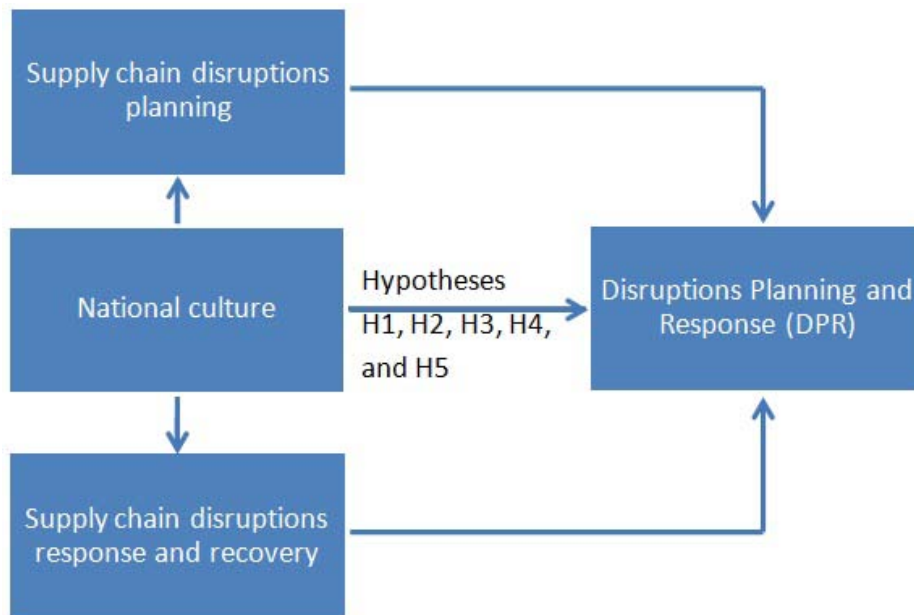
Classical operations and supply chain management literature sometimes assumes that managers are rational decision-makers and their decisions are purely based on optimizing a set of objectives. This approach, however, fails to account for the difference in decisions made by managers in different countries when faced with similar issues. Culture affects the way managers think, communicate, and evaluate various options. This in turn impacts business decisions they make (Flaherty, 1996). Social and

cultural preferences are also shown to have an impact on supply chain decisions (Dowty and Wallace, 2010). International management researchers attribute cross-national management differences to national culture (Hofstede, 1980).

Research Model

International operations management decisions are affected by national culture (Pagell et al. 2005). Using this argument we develop a conceptual model presented in Figure 1. The model is designed to understand the management of supply chain disruptions in terms of cultural antecedents that may explain the difference between countries. The model is based on postulation that observed national differences in DPR could be attributed to cultural values that may vary from one nation to another. Since supply chain and operations management decisions are affected by national culture, disruption planning is expected to vary between different countries. Using these arguments we can argue a link in the conceptual model: National culture has an effect on supply chain disruption planning.

**FIGURE 1
CONCEPTUAL RESEARCH MODEL**



Popular proactive risk mitigation strategies involve inventory buffer, diversified suppliers, and stronger relations in supply chain. Well cited and studied response strategies involve alternate/standby suppliers and demand management (Tomlin and Wang, 2010). A better proactive risk mitigation strategy is likely to result in better response and recovery (van Wassenhove, 2006). However, a poorly planned and executed response and recovery could diminish the effectiveness of proactive mitigation strategies. Since culture impacts business decisions and their execution, the strategies adopted to respond to a disruption could also vary between countries. For example, Aisin Seiki response was effective primarily because of the manner in which associated companies and competitors reacted to the disruption. Therefore we can argue that national culture affects supply chain response and recovery. In summary, supply chain disruption planning, and response and recovery could determine the consequences of disruptions for a company. In our model, culture could be considered as an independent variable that explains variations between countries in disruption planning; while culture moderates the effectiveness of DPR through response and recovery strategies.

Hypotheses

Our hypotheses relate national culture to effectiveness of supply chain disruption management. We present hypotheses related to each of the five cultural dimensions of Hofstede. An additional hypothesis is proposed to understand disruption management in varying economic conditions of countries.

The first dimension of national culture, Uncertainty Avoidance, represents the degree to which a society feels uncomfortable with uncertainty and ambiguity. Individuals, organizations, and societies plan for uncertainty in different ways. Some of these differences occur across countries in the form of different laws, rules, regulations, and use of technology (Pagell et al., 2005). According to Hofstede (2013), “Countries exhibiting strong Uncertainty Avoidance Index maintain rigid codes of belief and behaviour and are intolerant of unorthodox behaviour and ideas. Weak Uncertainty Avoidance Index societies maintain a more relaxed attitude in which practice counts more than principles.” High Uncertainty Avoidance implies low tolerance to ambiguity. Therefore, we expect that companies in countries with high Uncertainty Avoidance would plan actions and strategies so as to avoid or mitigate the risk of supply chain disruptions. In contrast, countries with low Uncertainty Avoidance are willing to tolerate high risk and uncertainty.

H1: Companies from countries with high Uncertainty Avoidance exhibit effective DPR.

Long-term Orientation dimension, also known as Confucian Dynamism, is related to societies with propensity to save for future, which is reflected in their decisions about savings, investment, and perseverance in achieving results. Long-term Orientation is positively associated with savings, insurance, and economic growth (Hofstede and Bond, 1988; Park and Lemaire, 2011). Short-term Orientation generally focuses on achieving quick results. Investments in low probability events such as supply chain disruptions could be economically justified when considering long term objectives (Stecke and Kumar, 2009). The rewards for investment in disruptions mitigation are expected to occur in long-term rather than short-term. Future rewards as a virtue of Long-term Oriented cultures make them suitable for disruption management.

H2: Companies from countries with high Long-term Orientation exhibit effective DPR.

Individualistic societies are characterized by “preference for a loosely-knit social framework in which individuals are expected to take care of themselves and their immediate families only” (Hofstede, 2013). Opposite of Individualism, Collectivism displays a preference for social relationships that are tightly-knit with members of the community expected to look after each other. Individualism emphasizes individual responsibility and actions. The rewards and penalties are also attributed to individuals. The dimension affects the manner in which society functions. Decisions regarding education, religion, and politics are also affected (Pagell et al., 2005).

Businesses are also affected. For example, in an Individualistic country, a company leader’s personal character is more effective in forming “leadership impressions” (Ensari and Murphy, 2003). In contrast, in Collectivistic countries, company performance is more effective in establishing leadership attributes. In collective cultures, people plan and avoid conflicts. They may also take actions to use “face-saving” techniques (Hofstede et al., 2010). In contrast, members of Individualistic cultures tend to use confrontational strategies when dealing with conflicts. Using these arguments we present our next hypothesis.

H3: Companies from countries with low Individualism exhibit effective DPR.

Power Distance measures the extent to which power is distributed in members of a society. The measure also covers the degree of acceptance of the power differential among people. In high Power Distance countries a hierarchical order of power exists and is not questioned by the members. In low Power Distance countries, members strive for equality in decision-making and demand justification for

inequalities. Low Power Distance could also lead to mistrust between levels of hierarchy; whereas high Power Distance leads to internal harmony. These arguments imply that decisions made by leaders (upper levels in hierarchy) would be accepted without questions by members in a country with high Power Distance. This may lead to harmony and order during disruptions. In contrast, in countries with low Power Distance, decisions made by leaders may not be followed, leading to chaos.

In countries such as Japan, which has high Power Distance, decisions to resolve conflicts are deterred to those with high status power (Tinsley, 1998). Similarly, Tinsley and Brett (2001) found that to manage conflicts, managers in the US (low Power Distance) are more likely to discuss issues and make decisions in personal interests. On the other hand, in Hong Kong (high Power Distance) managers tend to make decisions in collective interest and are more likely to relegate them to higher management. A great leader is important in resolving supply chain disruptions that are severe and unfamiliar (Carey, 2011). Owing to these arguments, we hypothesize that high Power Distance would help during disruptions.

H4: Companies from countries with high Power Distance exhibit effective DPR.

A Masculine society values achievement, heroism, aggressiveness, assertiveness, dominance, and material reward. The opposite, Femininity, show preference for cooperation, modesty, caring, and quality of life. Masculinity harbors competition. In Masculine societies economic growth is the priority while Feminist societies prioritize environment protection. Also conflicts are resolved through force in Masculine societies. In contrast, Feminist societies use negotiation to resolve conflicts. Failure is considered a disaster in Masculine cultures (Hofstede, 2013). Attributing to priorities for economic growth and success, we expect Masculine countries to be better at managing disruptions when compared to Feminist countries.

H5: Companies from countries with high Masculinity exhibit effective DPR.

Planning for disruptions require economic resources. Investment in disruption management is expected to yield returns in a long-term. However, poor countries may not have surplus resources to be invested in long-term goals. For such countries, investments in disruption management may require diverting resources that may otherwise be used to create potential economic returns in short-term. For example, despite having economics problems because of terrorist attacks, many poor countries choose not to invest in terrorism prevention efforts (Kumar and Liu, 2013). We hypothesize that companies in rich countries may have more resources to invest in disruptions mitigation and thus perform better when encountering a supply chain disruption.

H6: Companies from high Economic Status countries exhibit effective DPR.

Our hypotheses presented in this section argue that national culture has independent and moderating influence on disruption planning and response. In the next section we present our data collection and statistical analysis.

DATA, ANALYSIS, AND STATISTICAL FINDINGS

Data Collection

We are interested in explaining a macro-level theory relating the influence of national culture on supply chain DPR. Primarily by using surveys and case studies, extant literature has shown that national culture interacts with various aspects of business operations and decision-making. Testing the hypotheses developed in the previous section requires surveying DPR for a large number of companies in different countries. Such surveys are regularly conducted, in some cases annually, by various organizations in different parts of the world. The objective of these surveys is to identify the state of disruptions preparedness, response, and recovery in a country or a set of countries. Some of these organizations

include Continuity Central, EMC Corporation, and Chartered Management Institute. These organizations publically report their findings, sometimes in the form of a summary. To test our hypotheses, we compiled data available from these publically available sources and performed a secondary data analysis.

We specifically chose surveys that focused on medium and small size local companies in a country. The objective was to eliminate large companies that may have cultural influence from multiple countries. Our compiled data from various survey companies resulted in 140 observations from 22 countries. Many survey organizations report their findings in the form of a summary statistic, often an average DPR score or a frequency distribution of DPR. This resulted in each *observation* representing an average DPR score for a certain number of companies. Therefore, our 140 observations correspond to a survey of over 7000 companies. The countries represented on the data are shown in Table 1. The data has representation from all five continents with the largest number of countries from Asia followed by Europe. The diverse countries increase the scope of our results.

**TABLE 1
COUNTRIES REPRESENTED IN DATASET**

Count	Country	Count	Country
1	Australia	12	Morocco
2	Canada	13	Philippines
3	China	14	Qatar
4	France	15	Russia
5	Germany	16	Saudi Arabia
6	India	17	Singapore
7	Indonesia	18	Thailand
8	Italy	19	Turkey
9	Japan	20	UAE
10	Korea	21	UK
11	Malaysia	22	US

Table 2 presents a sample of our compiled data. DPR is measured on a scale of 1 to 10, with 10 being the best. Survey organizations sometimes used a different scale to measure DPR. For example, in some cases these were an ordinal three or five-point scale, in other cases a decimal scale was used. There were some instances where only qualitative statements about disruptions preparedness were reported. To avoid bias in converting from survey scales to our scale, a three person average was used. Of these, two were senior supply chain management major students while the third was one of the authors of this paper. The scores for five national cultural dimensions were obtained from Hofstede (2013). As can be seen in Table 2, each observation represents an aggregate of a group of companies, with the group size reported in the column entitled Count.

TABLE 2
SAMPLE DATA

Country	Power Distance	Individualism	Masculinity	Uncertainty Avoidance	Long-term Orientation	Economic Status	Count	Average DPR*
Australia	36	90	61	51	31	1	200	1
Australia	36	90	61	51	31	1	200	5
Canada	39	80	52	48	23	1	85	10
Canada	39	80	52	48	23	1	15	1
Canada	39	80	52	48	23	1	20	7
China	80	20	66	30	118	0	30	6
France	68	20	43	86	39	1	155	5
France	68	20	43	86	39	1	85	7
Germany	35	67	66	65	31	1	210	10
Germany	35	67	66	65	31	1	40	1

* Average DPR is measured on a scale of 1 to 10; 10 is best.

The count of companies for each country varies in the data compilation, rendering the data biased towards some countries. To avoid over- or under-representation, we use a probabilistic data sampling method. The selection probability is inversely proportional to the number of data points available for a country. This probability was adjusted so as to get approximately one-hundred company data for each country. The final resulting data is a subset of the original compilation and contained 140 observations representing 22 countries and approximately 100 data points (companies) for each country. In all, 2258 companies were represented in the final dataset. Among 22 countries in the dataset, 15 had all five Hofstede dimensions available while for the rest 7 countries, Long-term Orientation dimension was not available.

For the economic status of a country we use a proxy variable generated using data from International Monetary Fund (IMF). All developed countries were assigned a value of 1; others 0. The IMF uses the criteria related to gross domestic product, the per capita income, level of industrialization, amount of widespread infrastructure, and general standard of living to assess the economic status of a country. As indicated in hypothesis for economic status, we expect developed countries to have a better DPR.

Analyses and Statistical Findings

Testing the hypotheses requires regressing each of the six independent variables independently on the dependent variable DPR. However, we do not observe the DPR scores for each company. Instead, our data includes a mean DPR for a certain number of companies. This implies that, if a Generalized Least Square regression is performed, the variance of errors is not constant. The data exhibits heteroskedasticity. Thus the estimations obtained from a Generalized Least Square regression procedure will be inefficient. The independent variable coefficient estimates in such a regression procedure could still be unbiased. However, the standard error coefficients could be biased, resulting in incorrect statistics and wrong conclusions (Dickens, 1990). In practice many researchers use Ordinary Least Square even when heteroskedasticity is suspected. However, in such cases standard error and test statistics must be adjusted so that they are valid for arbitrary heteroskedasticity (Wooldridge, 2002).

To overcome the issue of heteroskedasticity and produce best unbiased linear estimators for each of the independent variables, we perform a Generalized Weighted Least Square regression. This method is more robust as compared to Ordinary Least Square (Wooldridge, 2002). Generalized weighted Least Square method eliminates heteroskedasticity from grouped data with known group sizes (Dickens, 1990). The *weight* for each observation is dependent on the count of companies it represents. Therefore, the structural equation model for testing hypotheses is as follows.

$$\begin{aligned} \sqrt{N_i} \overline{DPR}_i &= \alpha_1 \sqrt{N_i} + \beta_1 \sqrt{N_i} \overline{Uncertainty\ Avoidance}_i + \sqrt{N_i} \overline{\varepsilon}_i, \\ \sqrt{N_i} \overline{DPR}_i &= \alpha_2 \sqrt{N_i} + \beta_2 \sqrt{N_i} \overline{Long-term\ Orientation}_i + \sqrt{N_i} \overline{\varepsilon}_i, \\ \sqrt{N_i} \overline{DPR}_i &= \alpha_3 \sqrt{N_i} + \beta_3 \sqrt{N_i} \overline{Individualism}_i + \sqrt{N_i} \overline{\varepsilon}_i, \\ \sqrt{N_i} \overline{DPR}_i &= \alpha_4 \sqrt{N_i} + \beta_4 \sqrt{N_i} \overline{Power\ Distance}_i + \sqrt{N_i} \overline{\varepsilon}_i, \\ \sqrt{N_i} \overline{DPR}_i &= \alpha_5 \sqrt{N_i} + \beta_5 \sqrt{N_i} \overline{Masculinity}_i + \sqrt{N_i} \overline{\varepsilon}_i, \\ \sqrt{N_i} \overline{DPR}_i &= \alpha_6 \sqrt{N_i} + \beta_6 \sqrt{N_i} \overline{Economic\ Status}_i + \sqrt{N_i} \overline{\varepsilon}_i, \end{aligned}$$

In the above models, error term $\sqrt{N_i} \overline{\varepsilon}_i$ has a constant variance. i is the observation count. N_i is the group size or the frequency of each observation in the dataset. \overline{DPR}_i is the observed variable, which could be considered as a mean planning and response for a group represented by N_i companies in a specific country.

In the above regression models we explore a causal relationship between the explanatory variables and DPR for a country. As argued in the hypotheses development section, the culture and economic status influences DPR but not vice a versa. We also expect the independent variables to be exogenous in regression equations.

Table 3 present the statistical findings of the regression model for each of the six independent variables. The predicted sign of independent variables from our hypotheses are also shown in the table. We find that all five cultural variables have positive coefficients that are significant at 1%. The economic variable coefficient is also positive and is significant at 5% level. Reported R-Square values show the variance in DPR explained by each of the six independent variables.

TABLE 3
STATISTICAL RESULTS TO TEST HYPOTHESES

Independent Variable	Predicted Sign	Observed Sign	Coefficient Estimate	Significance Level	R-Square
Uncertainty Avoidance	+	+	0.080	1%	30.88%
Long-term Orientation	+	+	0.071	1%	25.78%
Individualism	-	+	0.034	1%	4.88%
Power Distance	+	+	0.073	1%	30.52%
Masculinity	+	+	0.105	1%	28.85%
Economic Status	+	+	1.396	5%	2.70%

The results indicate that cultural factors as defined by Hofstede dimensions have a direct influence on DPR. National culture explains the DPR variability observed in different countries. Note that DPR is measured on a scale of 1 to 10, while cultural dimensions could take values from 1 to 100. The exception is Long-term Orientation, which are a little over 100 for some Asian countries. The cultural dimension values used in this study are as per Hofstede (2013). The scales and the coefficient estimates from Table 3 allow us to interpret the significance and impact of cultural factors on DPR. For example, a 12-point

difference in Uncertainty Avoidance index implies approximately 1-point difference in DPR, with higher Uncertainty Avoidance index country exhibiting better DPR. Japan has an Uncertainty Avoidance index of 92, while the same index for the US is 46. This is a difference of 46 points. Therefore, considering the impact of Uncertainty Avoidance alone, Japanese companies are expected to have about 3.7 points (out of a 10) advantage in DPR over the companies from the US. Similarly, when comparing countries, a country with 10 point higher Long-term Orientation, Individualism, Power Distance, and Masculinity could expect to have a DPR higher by 7.1%, 3.4%, 7.3%, and 10.5%, respectively. Economically superior countries are likely to have better DPR.

Counter to our hypothesis, the independent variable Individualism displayed a positive coefficient. The coefficient is smallest among the six independent variables. This indicates that, although positive, Individualism has the least effect on DPR. Note that we predicted that low Individualism should benefit in DPR. Despite the arguments presented to support the hypothesis, there is some support in literature to support our statistical results. The social preference of a Collectivistic (opposite of Individualistic) society and their primary focus on community and family motivated our hypothesis. However, Individualistic societies are characterized by success, leadership, and non-reliance on others for support. These characteristics may motivate managers in Individualistic countries to plan for disruptions. Such actions would reduce the reliance on others and may show leadership abilities in decision-makers. There is a strong correlation between Individualism and economic development, modernization, and wealth (Hofstede, 2001).

Smith et al. (1996) found that Western managers use their leadership abilities and make decisions based on their experiences. In contrast, Chinese managers rely more on rules and regulations. Also Sagie et al. (1996) show that achievement tendency is higher for managers in US, as compared to managers in Japan and Hungary which have Collectivistic orientation. In individualistic cultures completing a task is more important when compared to maintaining personal relationships. Collective societies give preference to social links over tasks (Hofstede et al., 2010). These arguments indicate that Individualism may help in DPR.

NATIONAL CULTURE AS PREDICTOR OF SUPPLY CHAIN DISRUPTION PLANNING AND RESPONSE

Since our statistical results show that all dimensions of national culture affect a company's disruptions preparation and response, a logical next question would be: Could we use the dimensions of national culture to predict a country's supply chain DPR? Hofstede dimensions have strong predictive power and have been used in many business applications to make predictions about applicability of human resource policies, advertising strategies, negotiation practices, consumer preference, and financial structure. See Hofstede (2013, 2001) for details and other examples. To achieve this we build on the model from previous section. A Generalized Weighted Least Square regression was performed using the following model.

$$\begin{aligned} \sqrt{N_i} \overline{DisPR}_i = & \alpha \sqrt{N_i} + \beta_1 \sqrt{N_i} \overline{Power\ Distance}_i + \beta_2 \sqrt{N_i} \overline{Uncertainty\ Avoidance}_i \\ & + \beta_3 \sqrt{N_i} \overline{Masculinity}_i + \beta_4 \sqrt{N_i} \overline{Individualism}_i \\ & + \beta_5 \sqrt{N_i} \overline{Long-term\ Orientation}_i + \beta_6 \sqrt{N_i} \overline{Economic\ Status}_i + \sqrt{N_i} \overline{\varepsilon}_i \end{aligned}$$

The results of regression model are reported in Table 4. Only Uncertainty Avoidance, Long-term Orientation, and Power Distance exhibit significance in affecting the dependent variable DPR. Individualism, Masculinity, and Economic Status do not seem to contribute in explaining the disruptions preparation and response. The R-Square values are also reported in Table 4. F-statistic for the model is significant at .01%. The results suggest a significant multicollinearity between the independent variables. For example, for the 22 countries in our data, Power Distance and Individualism has a correlation coefficient of over -0.80. Other research has also reported such issues resulting from strong correlation

between various Hofstede dimensions of national culture (Hofstede, 2001). There could be redundancy among the six independent variables when used for predicting our dependent variable. Perhaps multiple of the culture dimensions are measuring the same constructs.

TABLE 4
PARAMETER ESTIMATES AND SIGNIFICANCE FOR PREDICTOR EQUATION USING ALL SIX INDEPENDENT VARIABLES

Independent Variable	Coefficient Estimate	Significance Level
Intercept	-6.21	10%
Uncertainty Avoidance	0.052	1%
Long-term Orientation	0.031	5%
Individualism	0.023	Not Significant
Power Distance	0.046	1%
Masculinity	-0.011	Not Significant
Economic Status	0.188	Not Significant
Model R-Square	52.40%	
Model Adj. R-Square	49.39%	

Note that despite issues about significance of individual culture dimensions, multicollinearity does not limit prediction power of the models. However, to create a parsimonious model and understand the latent constructs relevant for our application, we perform a Factor analysis on the data. With the analysis, we expect a reduction in number of cultural variables. The reduced number of variables could then be used to predict supply chain DPR for a country.

A scree plot of eigenvalues indicates that three factors may be relevant as these factors satisfy the Kaiser criterion. The plot exhibits clear break between third and fourth factors. The plot is not reported for brevity. A rotated factor pattern is reported in Table 5. Factor rotation was obtained using varimax rotation method, which is an orthogonal rotation method. The rotation ensures that the resulting factors are orthogonal, i.e., they are uncorrelated. The rotated factor pattern represents a clearer loading of the independent variable. Un-rotated factor pattern is not presented for brevity.

TABLE 5
ROTATED FACTOR PATTERN

Independent Variable	Factor 1	Factor 2	Factor 3
Uncertainty Avoidance	-0.0057	0.0213	0.9207
Long-term Orientation	0.7848	0.3043	0.1452
Individualism	-0.8519	0.4335	-0.1383
Power Distance	0.8431	-0.2746	-0.2338
Masculinity	0.5538	0.9547	0.0096
Economic Status	-0.6414	-0.0771	0.4375

*Primary loadings are in bold letters.

The loadings of six independent variables are clear when considering *meaningful loadings* to have a coefficient of at least 0.50. Factor 1 covers all independent culture variables except Uncertainty

Avoidance, which has a clear loading on Factor 3. Economic Status is also covered by Factor 1. Masculinity is represented in Factors 1 and 2 both, however Factor 2 has a clear loading for Masculinity. A significant loading of each culture variable on at least one of the factors may indicate that all of the six independent variables contribute to explaining DPR for companies in a country. The independent variables may have some overlapping in underlying constructs. Each of them, however, has some information relevant for predicting DPR. As indicated by communality estimate of 4.87, over 81% of the total variance is explained by the first three factors. See Table 6.

**TABLE 6
COMMUNALITY ESTIMATES**

Independent Variable	Communality
Uncertainty Avoidance	0.8482
Long-term Orientation	0.7296
Individualism	0.9328
Power Distance	0.8409
Masculinity	0.9145
Economic Status	0.6087
Total	4.8751

In summary, the Factory analysis revealed the following factor loadings.

$$\begin{aligned} \text{Factor 1} &= \{ \text{Long – term Orientation} \cup \text{Individualism} \cup \text{Power Distance} \\ &\quad \cup \text{Economic Status} \cup \text{Masculinity} \} \\ \text{Factor 2} &= \{ \text{Masculinity} \} \\ \text{Factor 3} &= \{ \text{Uncertainty Avoidance} \} \end{aligned}$$

The analysis also revealed the standardized scoring coefficients for each of the three factors. These scoring coefficients could be used to convert the factor loadings to component scores. These component scores are linear combination of optimally-weighted national culture dimensions. The weights are reported in Table 7. The procedure results in three component scores for each country, one corresponding to each factor. These three components are orthogonal to each other. Finally, the three component scores are then used as independent variables to predict the DPR for a country.

**TABLE 7
STANDARDIZED SCORING COEFFICIENTS**

Independent Variable	Factor 1	Factor 2	Factor 3
Uncertainty Avoidance	0.0841	0.0124	0.8299
Long-term Orientation	0.3893	0.3433	0.2013
Individualism	-0.3288	0.2533	-0.2047
Power Distance	0.3101	-0.1224	-0.1326
Masculinity	0.0926	0.7759	-0.0007
Economic Status	-0.2467	-0.1425	0.3364

A regression analysis using the three factor scores indicate that component 1 and 3, corresponding to Factors 1 and 3, are significant at 0.01% in predicting DPR for a country. Intercept term is also significant at the same level. Component 2 was dropped as it is not significant. As all important regression details are discussed here, a table for regression results is not provided for brevity. Note that Factor 2 primarily covered Masculinity. The effect of Masculinity is not entirely eliminated as it has a relatively large loading on Factor 1. See Table 5. Insignificance of Component 2 could be attributed to significant correlations between the dimensions of national culture. The resulting Predictor Equation is

$$\text{DPR Score} = 6.4811 + 0.7776(\text{Component 1}) + 0.9624(\text{Component 3}).$$

The F-statistics for model is significant at 0.01%. As reported in Table 4, the five culture dimensions and the economic status of a country explain about 50% of variability in DPR. The other part of DPR variability could be attributed to numerous factors including organization culture, culture variations within a country, history of disruptions, and regulations.

Our results indicate that, in estimating DPR, the explanatory power of culture is very high. Covering independent variables that explain only 50% variability implies that the model may not be very effective in predicting DPR for an individual company. The Predictor Equation, however, should be effective in predicting average DPR for a group of companies. Since we are interested in explaining the DPR variability at a country level, we test the effectiveness of Predictor Equation for a group of companies from a country. In other words, we expect our model to be effective in predicting an average score for a group of companies, which belong to a specific country.

For 15 countries, that have all five culture dimensions available, we predicted DPR using Predictor Equation. See Figure 2. Note that Hofstede did not assign Long-term Orientation scores to every country. To compare to our result, in the figure we also show the Observed DPR for each country obtained using the original data of over 7000 companies. The Observed DPR is the average DPR for all companies for each country. Note that this data has a large number of companies that were dropped while a probabilistic sampling was used to balance the number of data points from each country. Figure 2 reports countries ranked by predicted DPR.

**FIGURE 2
PREDICTED VS. OBSERVED DPR**

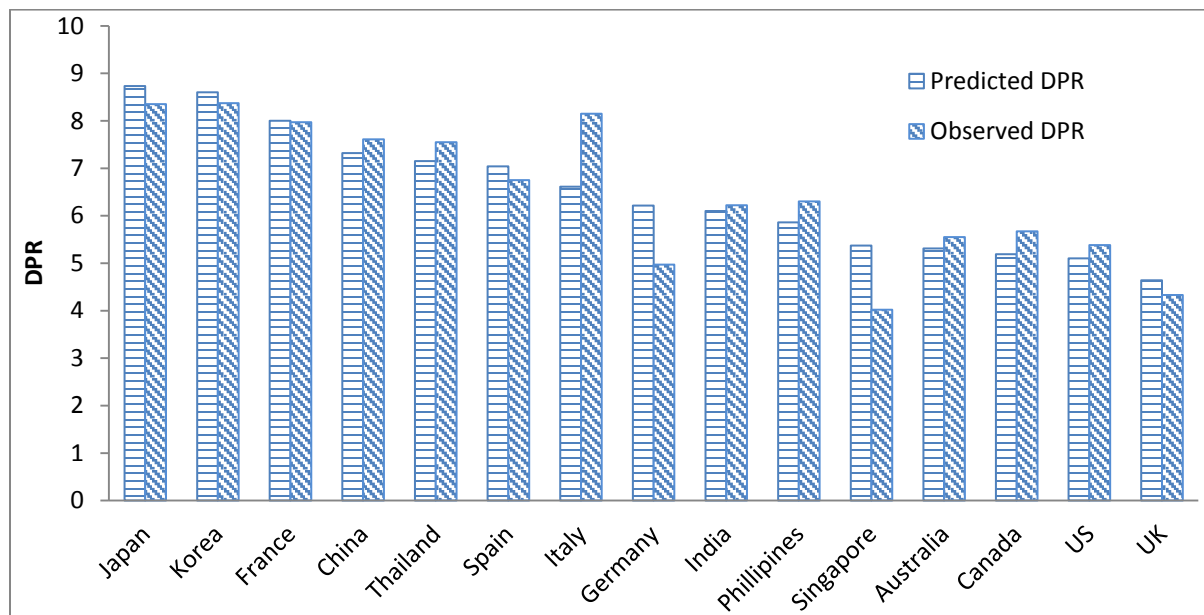


Figure 2 shows that our Predictor Equation is powerful and effective in estimating the DPR for a country. The correlation between Predicted and Observed DPR for the countries was found to be 87.8%. The deviations between two could be attributed to other factors that may affect DPR. The performance of Predictor Equation also indicates the suitability and robustness of our method. In the resulting scores and rankings, as expected, Japan is on the top. The US is ranked at 14th place. The Predictor Equation could be easily used for any country that has all five national culture dimensions available. A similar equation could be developed for countries that do not have Long-term Orientation dimension available.

IMPLICATIONS AND DISCUSSION

Our findings have implications for companies across the globe. Attributing to the national culture, companies in different countries are expected to have variations in disruption planning. The Predicted DPR and relative ranking (Figure 2) provide companies with an assessment of supply chain vulnerability originating from their own location and the countries in which other supply chain partners are located. It could also help them assess their DPR as compared to companies in other countries. Competitors located across borders may use such information to justify investment in disruptions mitigation practices.

Our findings are also useful for multi-national companies engaged in global operations. Companies could use our findings when making supply chain design or reconfiguration decisions. Some such decisions include choosing between business partners that are located in different countries. They could also benefit as our findings could help in identifying the vulnerable stages of a supply chain. The companies could then bolster the supply chain with disruptions mitigation investments in supply chain stages that are located in low DPR countries. Mitigation decisions such as buffer inventory and choice of backup facilities could be influenced by country in which the supply chain partner is located.

Effective DPR could be ingrained in the culture for certain countries. For companies in these countries, investment in DPR could be the *way of life and business*. Companies in other countries could learn from practices that are adopted in countries better at DPR. For example, formal and informal long-term supplier relationships are common in Japanese companies. Companies benefit as partners and even competitors are willing to help during disruptions (for example, Aisin Seiki). To counter this, many US companies have chosen to have backup suppliers, diversification, and strategic sourcing of material and components. These practices have the potential to provide the DPR effectiveness that Japanese companies enjoy.

Same strategies may not be suitable in different countries. For example, Japanese companies effectively use strategies such as JIT, Lean, and enjoy the efficiency inducing benefits of sole supplier. These practices when applied to the companies in the US may not have the desired outcomes, for example, they may be attributed to increased vulnerability. The increase is caused by higher risk of disruption in the event of a disaster due to “deliberate choices of low inventory and fortification” made for short-term operational benefits (Whitney et al., 2012). The same efficiency inducing practices are effectively used in Japanese companies because of cultural attributes that motivate supply chain disruption planning and limit the risks in the case of a disruption. Imitating the efficiency inducing practices may require understanding the manner in which Japanese companies plan for and manage disruptions. To avoid undesired outcomes, practices such as JIT and Lean should be adopted along with long-term relationships and collaborative planning (Womack et al, 1990).

Despite the benefits, imitation of disruptions mitigation practices from countries with effective DPR may not be welcome by the management in other countries. Popular risk mitigation methods such as buffer inventory and backup suppliers are thought to help during disruptions but at the cost of reduced efficiency during non-disruption periods. The cost disadvantage for mitigation strategies could be more prominent for events that occur with low probability (Tomlin, 2006). The prevalent supply chain literature consider many disruptions mitigation practices to add cost because of increased operational complexity, limited mutual trust between supply chain partners, and loss of value from diversification, such as scale economies (Sheffi, 2007).

Investment in mitigation practices may require economic justification, which sometimes is based on short-term goals. For some companies, national cultural norms, which influence thought process and business decisions, may not be conducive to investment in mitigation practices. These companies may find it difficult to justify investment in mitigation practices. In contrast, companies in countries with culture that supports risk mitigation may find it easier to invest and implement disruptions mitigation practices as such practices may not need stringent cost-benefit validation. Moreover, employee and management are more likely to see such practices favorably. Companies in countries that have low DPR score may need more directed efforts and initiatives to bolster mitigation practices as compared to companies in countries with high DPR score.

CONCLUSIONS AND FUTURE RESEARCH

Appropriate cultural mindset and orientation could enable companies to perform supply chain management activities better than other companies. Cultural understanding could also lead to effective supply chain disruption management. With open economies, global marketplace, and a growing number of companies with international operations, research in the field of international culture could help companies succeed in international market.

Our research contributes to the supply chain disruption management literature by studying the interactions of national culture and effectiveness of companies from various countries in managing disruptions. We find that national culture as defined by Hofstede's dimensions could help explain the apparent differences in disruption management effectiveness of companies from certain countries. Our results are based on a large data from 22 countries that was collected from various survey companies.

Hofstede national culture dimensions as represented by Uncertainty Avoidance, Long-Term Orientation, Individualism, Power Distance, and Masculinity were shown to affect the DPR for companies in different countries. Each of these five dimensions has a significant positive influence on DPR. Companies in countries with high values of Hofstede dimensions could expect to have culture that promotes DPR. The economic status of a country was also shown to be important, with richer countries having a better DPR as compared to poorer countries.

We developed a model that could help predict the aggregate DPR for companies from a country. The prediction model uses information from all five Hofstede dimensions as well as the economic status of a country. The model was found to be effective in predicting DPR for a set of fifteen countries that have all five Hofstede cultural dimensions available. According to the prediction model Japan was placed on top while the US and UK, partly attributing to cultural factors, were placed at the bottom. The model and framework could also be easily used to assess DPR for other countries that we did not include in the analysis.

The results and findings are of significance for supply chain decision-makers. However, our results are limited by data from medium and small size companies. Moreover, the dimensions included in this paper may not completely address the DPR variability between countries. One such factor may be organizational culture. Similar to national culture, organization culture may also affect DPR. Exploring this issue could help companies within a country. Other companies that have presence in multiple countries or have influence from multiple national cultures may benefit from such a study. The effectiveness of DPR may also be affected by non-cultural aspects. Some of these include characteristics of the supply chain design, market attributes, affected product, production methods, specificity in design and production methods (Whitney et al. 2011). Research exploring these aspects could also be useful.

We call for additional research to develop theories that examines how and why culture dimensions affect decisions made by individuals, especially when dealing with supply chain disruptions. Such research could help companies and strategic decision-makers learn from the impact of national culture and adapt the organizational culture to better suit DPR. This is important because without appropriate change in organizational culture the effectiveness of risk mitigation strategies could be limited.

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