

# Dimensions of National Culture and Corporate Adoption of IT Infrastructure

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**Abstract**—Corporate adoption of information technology (IT) infrastructure is a critical management issue that may be affected by national culture. Prior research has shown that dimensions of national culture affect development of national IT infrastructure as well as adoption and impact of IT applications. This study explores the impact of two dimensions of national culture (uncertainty avoidance and power distance) on the adoption of a type of IT infrastructure (frame relay). A multinational survey was carried out, and it yielded useable responses from 153 businesses from 24 countries. The results demonstrated that businesses from higher uncertainty avoidance countries were less likely to adopt frame relay. A one-point increase in Hofstede's [15] uncertainty avoidance index for the country of incorporation was associated with a 3% lower likelihood of adopting frame relay. Power distance was not significantly correlated with adoption of frame relay. These results highlight the relevance of dimensions of national culture as factors affecting corporate adoption of IT infrastructure. Implications for practice and further research are presented.

**Index Terms**—Frame relay, information technology (IT) infrastructure, national culture, power distance, uncertainty avoidance.

## I. INTRODUCTION

GLOBAL increases in incomes, falling barriers to trade and investment, and reductions in transportation and communication costs are driving rapid growth of international trade and investment. Information technology (IT) plays a critical role in this growth of international trade and investment. With IT, foreign exchange traders can almost instantaneously arbitrage differentials in exchange rates between Tokyo and London, a corporate headquarters in the United States can monitor production in a Brazilian plant in real time, and an Australian retailer can reorder supplies from a Chinese manufacturer with minimal effort. Owing to the key role of IT in international trade and investment, it is important for international service providers and corporate managers to understand how national differences may affect corporate adoption and application of IT [1], [17].

Swanson [35] grouped corporate IT innovations under three cores: applications that are confined within the IT function, applications that extend beyond the IT function to the administrative core, and applications that extend beyond the IT function to

the business core. Grover *et al.* [13] emphasized the importance of a fourth core: IT infrastructure that cuts across Swanson's [35] three application cores. IT infrastructure forms the backbone on which IT applications (e.g., e-mail and video-conferencing) supporting international trade and investment are built. Prior scholarship on the impact of national culture on corporate adoption of IT has emphasized the three application cores and not considered IT infrastructure. Previous research into corporate adoption of IT infrastructure has focused on the effects of organizational differences like environmental uncertainty, size, slack, and centralization (e.g., [14] and [21]). These studies, however, have considered only U.S. companies and have not accounted for the effects of national differences.

Countries differ on a number of factors that would affect the costs and benefits of IT adoption. One factor is national policy. For example, new IT should diffuse more quickly in a country where the government provides tax incentives for IT expenditure. Another factor is resource availability. For instance, new IT should be accepted more readily in countries where there is a large supply of IT skilled workers and where suppliers of IT equipment and services abound. There is one other important factor on which countries clearly do vary. This factor is national culture. Despite its importance [16], its impact on IT adoption is poorly understood due to a lack of research.<sup>1</sup>

The preceding discussion raises an interesting issue. Strong international trade and investment gives rise to global businesses. Global businesses rely on IT infrastructure (which supports IT applications) to function effectively. And due to cultural differences, these businesses are likely to differ in terms of their inclination to adopt IT infrastructure. To facilitate global businesses, international service providers and corporate managers need to know precisely how cultural differences may affect corporate adoption of IT infrastructure. Yet, there is a clear lack of research in this area. To inform and equip international service providers and corporate managers on the effective management of global businesses, this study investigates how national culture may impact corporate adoption of IT infrastructure.

## II. LITERATURE AND HYPOTHESES

### A. National Culture

In a classic study involving 116 000 subjects from 50 countries or regions, Hofstede [15] identified four main dimensions

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<sup>1</sup>Research into organizational adoption of IT in general has not considered national or cultural factors (e.g., [4], [11], [13], and [35]).

of national culture: uncertainty avoidance, power distance, individualism–collectivism, and masculinity–femininity.<sup>2</sup> Uncertainty avoidance is the extent to which members of a culture feel threatened by uncertain or unknown situations. Power distance is the extent to which members of a culture expect and accept that power is distributed unequally. Individualism describes cultures in which task prevails over relationship, whereas collectivism describes cultures in which relationship prevails over task. Masculinity describes cultures in which social gender roles are distinct, whereas femininity describes cultures in which social gender roles overlap. These four dimensions of national culture have been the bases for numerous empirical studies in a variety of disciplines [33]. Several studies have confirmed the validity of these four dimensions of national culture (e.g., [30] and [31]).

A growing number of IT empirical studies have also used these dimensions to account for the results observed. Straub [34] reported significant differences between American and Japanese knowledge workers in their perception of usefulness and actual use of e-mail and fax. He attributed this disparity to differences in uncertainty avoidance. Watson *et al.* [41] and Tan *et al.* [36] argued that national culture could affect the outcome of using computer-mediated communication. Through two studies that compared Singapore with U.S. groups, they reported that power distance moderated the impact of computer-mediated communication on status influence [38], whereas individualism–collectivism moderated the impact of computer-mediated communication on majority influence [37]. In a study comparing Mexico with U.S. groups, Meijas *et al.* [25] showed that national culture affected the outcome of using a group support system. Martinsons and Westwood [24] elaborated on the mechanisms through which national culture might shape the use of IT applications. Collectively, these studies suggest that dimensions of national culture can affect how people actually use IT applications.

Ein-Dor *et al.* [8] discussed the effects of national culture on the implementation of international IT applications. Martinsons and Revenaugh [23] proposed a number of ways through which the four dimensions of national culture might affect the planning and implementation of IT applications. Shore and Venkatachalam [32] argued that analysis and design of software could be sensitive to differences in power distance and uncertainty avoidance. In a study involving three national cultures (Singapore, The Netherlands, and Finland), Keil *et al.* [19] reported that uncertainty avoidance affected decision making during software project management. Together, these studies suggest that dimensions of national culture can affect the implementation of IT applications. Beyond the use and implementation of IT applications, Burn *et al.* [3] suggested that the information society as a whole might partly be shaped by national culture. The successful use of Hofstede's [15] work by many scholars to account

for their empirical results suggests that these four dimensions of national culture are valid and relevant to IT research today.

Although all of these four dimensions of national culture may be important to IT research conducted at the level of individuals, Hofstede [16] argued that uncertainty avoidance and power distance should be especially relevant for research carried out at the level of organizations. This was because uncertainty avoidance and power distance could jointly determine key aspects of corporate behavior, such as distribution of decision authority, establishment of rules and methods, and management of risks and ambiguity [16]. For these reasons, Shore and Venkatachalam [32] concentrated on uncertainty avoidance and power distance in their study conducted at the level of organizations. In a rare study that investigated the relationship between national culture and national IT infrastructure, Garfield and Watson [10] accounted for differences observed in national IT infrastructure of eight countries using uncertainty avoidance and power distance. Because this study involves IT infrastructure and corporate decisions, we focus on the two most relevant dimensions of national culture: uncertainty avoidance and power distance.

### B. IT Infrastructure

Global businesses depend on telecommunications for effective day-to-day operations. Telecommunications provide these businesses with voice and data connectivity across locations spanning large distances. But telecommunications is possible only with the underlying IT infrastructure that transports the voice and data. International service providers offer several types of underlying IT infrastructure to meet corporate demands: private leased circuits, ISDN, X.25, and frame relay.

Private leased circuits and ISDN provide exclusive telecommunications channels for businesses. By contrast, X.25 and frame relay are protocols for packet-switching across shared telecommunications channels. As the older technology, X.25 has two major technical limitations. Its maximum bandwidth is 64 kbps, and it cannot accommodate voice transmission. Frame relay offers a much higher bandwidth of up to 6 Mbps, and it can carry voice as well as data transmission. Panko [28] provides more insights into these comparisons.

There are significant differences among the pricing structure of the various types of IT infrastructure. Private leased circuits and ISDN are priced on the basis of a fixed monthly charge that depends on the bandwidth. X.25 is typically priced on the basis of usage as measured by quantity of data and duration of transmission. As discussed below, the pricing structure of frame relay is unique.

Frame relay [12] was introduced in the United States in March 1991 and in Finland later that year. It was introduced in Japan in early 1993. Corporate telecommunications are characterized by an episodic need for high bandwidth with low latency. Frame relay was designed to meet this need. Typically, the user pays a fixed monthly charge for voice and data transmission at a committed bandwidth while being allowed transmission at double the committed bandwidth or higher with no guarantee of service. By contrast, private leased circuits are priced on the basis of a fixed bandwidth with no allowance for higher bandwidth. Moreover, international service providers generally set lower prices for frame relay than for private leased

<sup>2</sup>Hofstede's [15] indexes for these four dimensions of national culture have some limitations. Specifically, these indexes were based on responses of employees from one organization (i.e., IBM). Also, certain items in the instrument were not face valid. However, the addition of other items based on Hofstede's [15] four dimensions of national culture can resolve the problem of face validity [9].

TABLE I  
PRICING OF FRAME RELAY VERSUS PRIVATE LEASED CIRCUITS

To New York from	Frame relay	Private leased circuit	% Price difference in favor of frame relay
Hong Kong (HK Telecom)	\$3,590	\$4,445	24%
Japan (KDD)	\$2,827	\$5,462	93%
Korea (Korea Telecom)	\$1,970	\$5,030	155%
Singapore (Singapore Telecom)	\$2,893	\$4,101	42%
Taiwan (ChungHwa Telecom)	\$2,096	\$3,989	90%

Source: *Asia Pacific Telecommunications Index Report* [2]

Note: Prices are based on that charged by the main international service provider in the respective country for 64 kbps bandwidth from each business city to New York by frame relay and private leased circuits. These prices have been converted to U.S. dollars based on an average of the exchange rates over the period June 1996 to May 1997. The names of the international service providers are in parentheses.

TABLE II  
CORPORATE TELECOMMUNICATIONS PLANNING

	1995	1996	1997
Currently using frame relay	11%	14%	12%
Plan to use frame relay within 12 months	21%	30%	22%
Currently using private leased circuits			29%
Plan to use private leased circuits within 12 months			17%
Currently using X.25	34%	29%	14%
Plan to use X.25 within 12 months	17%	14%	7%
Currently using ISDN	32%	33%	25%
Plan to use ISDN within 12 months	34%	35%	22%
Number of respondents	348	343	332

Source: *Data Communications* [5]–[7]

Note: The 1997 survey asked respondents about usage of international services while the 1995 and 1996 surveys asked respondents about services in general. Hence, the 1997 responses are not strictly comparable with the 1995 and 1996 responses.

circuits with equivalent guaranteed bandwidth (see Table I). Consequently, frame relay is significantly cheaper than are private leased circuits. As Panko [28, p. 177] observed, "Many firms are now ripping out their meshes of leased lines ... and replacing them with frame relay."

In an earlier study on corporate adoption of IT infrastructure, Lai and Guynes [21] focused on ISDN. ISDN does not offer any clear advantage as a general broadband telecommunications channel. Instead, it is often used for specific applications, such as video-conferencing and as a back-up for private leased circuits or frame relay [5]. In recent years, *Data Communications* has systematically surveyed corporate network managers for their usage of various IT infrastructure [5]–[7]. As shown in Table II, corporate network managers are rapidly abandoning private leased circuits and X.25, while the demand for ISDN has peaked and has begun to decline. By contrast, the demand for frame relay is growing fast. Because frame relay is fast becoming the choice among corporate network managers, we consider it more relevant to focus this research on frame relay.

### C. Research Hypotheses

As discussed above, corporate decisions tend to be most affected by the uncertainty avoidance and power distance dimensions of national culture. And frame relay is rapidly gaining

in popularity as the choice IT infrastructure for telecommunications. Therefore, the hypotheses in this study focus on how uncertainty avoidance and power distance may affect corporate adoption of frame relay. National culture can affect corporate decisions in two important ways [16], [32], [39]. First, large businesses that operate internationally tend to have established decision rules that reflect the national culture of the country of incorporation. Second, these businesses are likely to have a significant proportion of senior executives from the country of incorporation. These senior executives often make critical decisions based on the norms of their national culture.

Among the four dimensions of national culture, Straub [34] identified uncertainty avoidance as having the most direct bearing on preference for and use of communications media. Shore and Venkatachalam [32] reported that in higher uncertainty avoidance countries, the introduction of new IT applications raised the anxiety level of management (who tended to be more risk averse). However, in lower uncertainty avoidance countries, management (who tended to be more risk seeking) was more willing to try out new IT applications. Garfield and Watson [10] provided some evidence to suggest that such observations might also apply to IT infrastructure. Higher uncertainty avoidance countries were found to have national IT infrastructure characterized by cautious government control. New components of IT infrastructure tended to be

embraced carefully and slowly. But lower uncertainty avoidance countries were found to have national IT infrastructure dictated by the competitive environment. New components of IT infrastructure could emerge freely if there were demands. Given that corporate decisions on adoption of IT infrastructure may be guided by national culture and constrained by national IT infrastructure, we hypothesize that uncertainty avoidance will be inversely related to corporate adoption of frame relay.

**H1:** Businesses incorporated in higher uncertainty avoidance countries will be less likely to adopt frame relay.

Higher power distance countries are likely to have organizations with a centralized decision structure, whereas lower power distance countries tend to have organizations with a distributed decision structure [16]. Shore and Venkatachalam [32] found that new IT applications were usually evaluated more cautiously in organizations with a centralized decision structure because these IT applications might disrupt defined lines of authority. In organizations with a distributed decision structure, new IT applications were more readily embraced because these IT applications might facilitate joint decisions among distant executives. Garfield and Watson [10] found that the development of a national IT infrastructure was regulated by the authorities in higher power distance countries but was more spontaneous in lower power distance countries. Again, given that corporate decisions on adoption of IT infrastructure may be guided by national culture and dictated by national IT infrastructure, we hypothesize that power distance will be inversely related to corporate adoption of frame relay. In a study on ISDN (a type of IT infrastructure), Lai and Guynes [21] arrived at a similar conclusion that organizations with a centralized decision structure were less likely to adopt ISDN.

**H2:** Businesses incorporated in higher power distance countries will be less likely to adopt frame relay.

Given that the United States and Japan are big economic powers that have given rise to global businesses, which rely very much on telecommunications for effective operations, it is interesting to compare U.S. with Japanese businesses. Straub [34] reported that Japanese knowledge workers are slower to adopt e-mail than are American knowledge workers. This result can be explained using Hofstede's [15] work, which shows that Japan and the United States have uncertainty avoidance indexes of 92 and 46, respectively. Hofstede's [15] work also reveals that Japan and the United States have power distance indexes of 54 and 40, respectively. Considering both **H1** and **H2**, we predict that Japanese businesses will be less likely to adopt frame relay than will U.S. businesses.

**H3:** Businesses incorporated in Japan will be less likely to adopt frame relay than will businesses incorporated in the United States.

Although the main interest for this study lies in national culture, we have also considered organizational size because this is an important moderating variable. Previous studies, which measured organizational size using total assets or annual revenue, have consistently shown that organizational size is positively correlated with adoption of new IT applications (e.g., [14], [29], and [35]). This is because larger organizations can afford to devote more resources to facilitate adoption of IT applications. We

predict that this relationship will also hold for corporate adoption of IT infrastructure (including frame relay).

**H4:** Larger businesses will be more likely to adopt frame relay.

### III. RESEARCH METHODOLOGY

#### A. Data Collection

The data for this study were gathered through a survey administered by the Center for Telemedia Strategy at the National University of Singapore. A key role of this Center was to construct the Asia Pacific Telecommunications Index, a rating of quality and cost of telecommunications services and regulation in ten regional economies in the Asia Pacific. Based on interviews with several regional network managers from selected multinational businesses, the Center developed a questionnaire that elicited details (e.g., percentage of expenditure and rating of service quality) on corporate adoption of IT infrastructure (e.g., private leased circuits, ISDN, X.25, and frame relay).

This questionnaire was mailed to 2374 businesses selected from *Moody's Global Company Data* [26], an annual CD-ROM service that provides basic information about 50 000 businesses worldwide. The target businesses were the 2374 largest by annual revenue that met three criteria. First, its record included the name and mailing address of a senior executive to whom the questionnaire could be addressed. Second, its record included information on its revenue. Third, it was not a subsidiary of another business in the sample. Together with a letter providing information about the study and a return envelope with postage paid, the questionnaire was addressed to a senior executive of each business (e.g., Chairman, President, Chief Executive Officer, or Director). The letter requested that the questionnaire be directed to the officer in charge of Asia Pacific telecommunications. The questionnaire did not ask for the identity of the respondent. To encourage returns, the Center promised to make a contribution to a charity named by each respondent.

This exercise was conducted in two waves. In the first wave, the questionnaires were mailed to the entire list of 2374 businesses. This elicited 125 responses. To economize on postage, the second wave focused on the largest 500 of our target list of businesses by annual revenue that had not responded to the first wave. This drew a further 37 responses. As expected, respondents to the second wave represented larger businesses (in terms of annual revenue) than did respondents to the first wave. The overall response rate was 7%, which was reasonable, considering that many businesses did not have operations in Asia Pacific and the questionnaire was reasonably long and complex.

#### B. Descriptive Statistics

For each responding business, information on its total assets, annual revenue, and country of incorporation was extracted from *Moody's Global Company Data* [26]. Among the 162 responding businesses, the total assets for nine businesses were unavailable. Therefore, data from the remaining 153 businesses (incorporated in 24 countries) were used for statistical analyses. Table III presents summary statistics for this sample of 153 businesses. These businesses were generally very large, with average total assets of \$25.8 billion and average annual revenue of

TABLE III  
SUMMARY STATISTICS FOR THE SAMPLE

	Mean	Std. dev.	Min.	Max.	Source of data
Total assets (US\$ billion)	25.8	43.1	0.0*	243.3	MGCD [26]
Annual revenue (US\$ billion)	12.2	20.4	0.9	137.1	MGCD [26]
Incorporated in Asia Pacific	37%				MGCD [26]
Incorporated in Europe	22%				MGCD [26]
Incorporated in North America	39%				MGCD [26]
Incorporated in South America	2%				MGCD [26]
Adopted frame relay	44%				APTI Report [2]
Uncertainty avoidance index	64.2	21.2	8	94	Hofstede [16]
Power distance index	47.1	13.6	11	94	Hofstede [16]
Individualism-collectivism index	66.6	23.0	17	91	Hofstede [16]
Masculinity-femininity index	65.2	23.0	5	95	Hofstede [16]
Frame relay availability	10.5	2.3	1	12	DC [6]
Teledensity	520.8	144.7	25.5	682.1	YOS [42]
Internet density	20.5	17.0	0.01	61.2	YOS [42]

\*US\$1 million

Note: MGCD refers to *Moody's Global Company Data*, APTI Report refers to *Asia Pacific Telecommunications Index Report*, DC refers to *Data Communications*, and YOS refers to *Year-book of Statistics: Telecommunication Services Chronological Time Series 1988-1997*.

TABLE IV  
DISTRIBUTION OF SAMPLE BY COUNTRY OF INCORPORATION

Country or region	Uncertainty avoidance index	Adopters of frame relay	Non-Adopters of frame relay	% Adopters
Singapore	8	1	0	100%
Denmark	23	1	1	50%
Sweden	29	2	0	100%
Philippines	44	1	2	33%
United States	46	32	20	62%
Canada	48	2	4	33%
Norway	50	2	0	100%
Australia	51	2	2	50%
Netherlands	53	0	2	0%
Switzerland	58	2	1	67%
Finland	59	3	2	60%
Thailand	64	1	2	33%
Germany	65	2	5	29%
Saudi Arabia	68	0	1	0%
Taiwan	69	2	1	67%
Austria	70	0	1	0%
Italy	75	0	2	0%
Brazil	76	0	2	0%
Mexico	82	1	1	50%
Chile	86	0	1	0%
France	86	1	4	20%
Spain	86	0	1	0%
Japan	92	12	30	29%
Belgium	94	0	1	0%
Total		67	86	44%

\$12.2 billion. These businesses were involved in a broad spectrum of industries, with 60% in manufacturing and finance.

Table IV reports the distribution of the sample by country of incorporation. Ninety-four (61%) of these businesses were incorporated in either Japan or the United States. This dominance of Japanese and U.S. businesses was a potential source of bias. Also, 13 of the 24 countries represented had fewer than three

businesses in the sample. This was another potential source of bias. Both of these potential sources of bias were addressed through empirical tests (see Section IV-A).

### C. Statistical Model

The four hypotheses were tested by means of a logit discrete choice model [4]. The dependent variable was the adoption of

TABLE V  
RESULTS OF TESTING HYPOTHESES

Independent variables	(A) Basic logit model	(B) Omitting Japanese and US businesses	(C) Omitting countries with fewer than three businesses	(D) Japanese versus US businesses
Constant	1.85*** (0.68)	2.62** (1.25)	1.84** (0.79)	0.35 (0.31)
Total assets	0.0038 (0.0046)	0.0086 (0.0069)	0.0027 (0.0046)	0.0035 (0.0045)
Annual revenue	0.0055 (0.0101)	-0.0550 (0.0453)	0.0053 (0.0101)	0.0028 (0.0101)
Uncertainty avoidance index	-0.0304*** (0.0098)	-0.0417** (0.0195)	-0.0250** (0.0106)	
Power distance index	-0.0075 (0.0145)	-0.0101 (0.0155)	-0.0126 (0.0179)	
Japan				-1.40*** (0.45)
Rest of the world				-0.91** (0.39)
Number of observations	153	59	133	153
-2 log likelihood	192.2	68.9	171.4	196.9
$\chi^2$	17.57	10.04	11.72	12.80

\*\*\*significant at 99% level ( $p < 0.01$ )

\*\*significant at 95% level ( $p < 0.05$ )

\*significant at 90% level ( $p < 0.10$ )

Note: All numbers in parenthesis are standard errors.

frame relay. This variable was given a value of 1 if a business had adopted frame relay, and a value of 0 was assigned otherwise. A business was considered to have adopted frame relay if it provided an affirmative response to any question regarding frame relay or it reported a positive percentage expenditure on frame relay. Of the 153 businesses in the sample, 67 (44%) had adopted frame relay (see Table IV).

Key independent variables pertained to national culture and organizational size. To test **H1** and **H2**, Hofstede's [15] uncertainty avoidance and power distance indexes for the country of incorporation of responding businesses were used. To test **H3**, dummy variables were coded for responding businesses that had been incorporated in Japan and the rest of the world, leaving those that had been incorporated in the United States as the default case. To test **H4**, organizational size was represented using both total assets and annual revenue, as in many other earlier studies.

#### IV. EMPIRICAL RESULTS

##### A. Testing Hypotheses

Table V presents the main empirical results. Column A reports the results of the basic logit model. The coefficient of uncertainty avoidance index was  $-0.0304$ , which was significant at the 99% level. This result supported **H1**. Businesses incorporated in higher uncertainty avoidance countries were less likely to adopt frame relay. Table IV illustrates this result by showing that a lower uncertainty avoidance index tends to be associated with a bigger percentage of adopters of frame relay and vice

versa. Because  $e^{-0.0304} = 0.97$ , this estimate implied that for every one point increase in uncertainty avoidance index of the country of incorporation, the business would be 3% less likely to adopt frame relay. The coefficient of power distance index was  $-0.0075$ , which was not significant. This result did not support **H2**. The coefficients of total assets and annual revenue were 0.0038 and 0.0055, respectively, both of which were not significant. This result did not support **H4**.

As discussed earlier (see Section III-B), there were two potential sources of bias. The first potential source of bias was the presence of many Japanese and U.S. businesses in the sample. To address this issue, the basic logit model was reestimated using only data from businesses incorporated outside Japan and the United States. The coefficient of uncertainty avoidance index was  $-0.0417$  and significant at the 95% level (see column B of Table V). All other results remained insignificant. The second potential source of bias was the presence of many countries with few businesses in the sample. This issue was addressed by reestimating the basic logit model using only data from countries with three or more businesses in the sample. The coefficient of uncertainty avoidance index was  $-0.0250$  and significant at the 95% level (see column C of Table V). Again, all other results remained insignificant. These results showed that the relationship between uncertainty avoidance index and corporate adoption of frame relay was not affected by both of these potential sources of bias.

Column D of Table V reports the results of a direct comparison between Japanese and U.S. businesses. The coefficient of Japan was  $-1.40$  and significant at the 99% level. Because  $e^{-1.40} = 0.247$ , this estimate implied that a Japanese business

TABLE VI  
RESULTS OF TESTING ALTERNATIVE EXPLANATIONS

Independent variables	(A) Including another two dimensions of national culture	(B) Including frame relay availability	(C) Including teledensity	(D) Including Internet density
Constant	3.29* (1.95)	0.68 (1.55)	-0.49 (1.93)	-0.03 (1.36)
Total assets	0.0041 (0.0047)	0.0037 (0.0046)	0.0032 (0.0046)	0.0044 (0.0046)
Annual revenue	0.0052 (0.0102)	0.0041 (0.0102)	0.0045 (0.0101)	0.0047 (0.0103)
Uncertainty avoidance index	-0.0423** (0.0165)	-0.0352*** (0.0114)	-0.0304*** (0.0100)	-0.0197* (0.0118)
Power distance index	-0.0164 (0.0182)	0.0032 (0.0193)	0.0139 (0.0222)	0.0064 (0.0170)
Individualism-collectivism index	-0.0118 (0.0139)			
Masculinity-femininity index	0.0080 (0.0112)			
Frame relay availability		0.0954 (0.1135)		
Teledensity			0.0026 (0.0020)	
Internet density				0.0264 (0.0167)
Number of observations	153	153	153	153
-2 log likelihood	191.2	191.4	190.4	189.6
$\chi^2$	18.54	18.32	19.32	20.11

\*\*\*significant at 99% level ( $p < 0.01$ )

\*\*significant at 95% level ( $p < 0.05$ )

\*significant at 90% level ( $p < 0.10$ )

Note: All numbers in parenthesis are standard errors.

was 75.3% less likely to adopt frame relay than was a comparable U.S. business. As illustrated in Table IV, 62% of the U.S. businesses in the overall sample were adopters of frame relay, but only 29% of the Japanese businesses were adopters. Given that Japan has higher uncertainty avoidance and power distance indexes than the United States, this result supported **H3**. Collectively, the results in Table V confirmed that regardless of whether difference in uncertainty avoidance were represented by Hofstede's [15] index or a direct Japan versus U.S. comparison, this difference had a significant negative correlation with corporate adoption of frame relay. Differences in power distance and organizational size, however, were not significantly correlated with corporate adoption of frame relay.

### B. Testing Alternative Explanations

Based on the literature review (see Section II-A), two dimensions of national culture (individualism–collectivism and masculinity–femininity) were unlikely to affect corporate adoption of IT infrastructure. Nevertheless, an empirical test was carried out to verify that these two dimensions of national culture were indeed unimportant in the context of this study. This test added the individualism–collectivism and masculinity–femininity indexes [15] as variables to the basic logit model. The coefficient

of uncertainty avoidance index was  $-0.0423$  and significant at the 95% level (see column A of Table VI). The coefficients of individualism–collectivism and masculinity–femininity were not significant. These results reinforced the observation that individualism–collectivism and masculinity–femininity should not affect corporate adoption of IT infrastructure.

Other than dimensions of national culture, a number of other factors might provide alternative explanations for corporate adoption of frame relay. One such factor was the availability of frame relay in a country. This alternative explanation was tested by adding, to the basic logit model, a variable that shows the number of international service providers that offer frame relay in the country of incorporation in 1996 [6]. This variable was an indicator of the availability of frame relay in a country. The coefficient of uncertainty avoidance index was  $-0.0352$  and significant at the 99% level (see column B of Table VI). The coefficient of availability of frame relay was not significant. Hence, availability of frame relay was not a good alternative explanation for corporate adoption of frame relay.

Another such factor was the level of telecommunications development (technological sophistication and existing IT infrastructure) in a country.<sup>3</sup> This issue was dealt with in two ways. First, the standard measure of telecommunications development

<sup>3</sup>We are grateful to an anonymous reviewer for suggesting this argument.

in a country is teledensity, defined as the number of main telephone lines per thousand population.<sup>4</sup> A variable representing teledensity in the country of incorporation in 1996 [42] was added to the basic logit model. The coefficient of uncertainty avoidance index was  $-0.0304$  and significant at the 99% level (see column C of Table VI). The coefficient of teledensity was not significant. Hence, teledensity was not a good alternative explanation for corporate adoption of frame relay.

Second, a recently used measure of telecommunications development in a country is Internet density, defined as the number of Internet hosts per thousand population. A variable that represents Internet density in the country of incorporation in 1996 [42] was added to the basic logit model. Column D of Table VI summarizes the results. The coefficient of uncertainty avoidance index was  $-0.0197$  and significant at the 90% level. The coefficient of Internet density was  $0.0264$ , which was significant at the 88% level. This result is discussed below (see Section V-B).

Based on all of the results reported above, we conclude that uncertainty avoidance had a significant negative correlation with corporate adoption of frame relay. This result was consistent across several alternative logit models, which included variables to capture other potential determinants of corporate adoption of frame relay.

## V. IMPLICATIONS

### A. Practical Implications

The results of this study clearly suggest that it is not appropriate to apply the same strategy to promote adoption of IT infrastructure for all businesses. Specifically, when attempting to introduce IT infrastructure into businesses, due attention must be given to the national culture of the country of incorporation. Businesses from lower uncertainty avoidance countries are more ready to adopt IT infrastructure than are businesses from higher uncertainty avoidance countries.

For international service providers, a useful strategy is to target new IT infrastructure at businesses from lower uncertainty avoidance countries. Besides raising the chances of acceptance for new IT infrastructure, this approach may minimize the consequences of risks associated with new IT infrastructure because businesses from lower uncertainty avoidance countries tend to take initial setbacks with innovations more positively and do not give up easily [16]. Success with these early adopters can then enable international service providers to market the IT infrastructure to businesses from higher uncertainty avoidance countries. With such businesses, it is important that international service providers put in greater efforts to mitigate the risks associated with the IT infrastructure. Other than testimonials from successful early adopters, such efforts may include more detailed demonstration and training and credible guarantees of service and support.

Corporate managers seeking to introduce new IT infrastructure into their businesses should also be cognizant of the national culture of the country of incorporation. Managers who

work in businesses from lower uncertainty avoidance countries can employ a more aggressive strategy when introducing new IT infrastructure. Where opportunities exist, they can bring in such IT infrastructure quickly and throughout their businesses to exploit the competitive advantage that comes with the new IT infrastructure [40]. However, managers who work in businesses from higher uncertainty avoidance countries should be more cautious in their attempts to introduce new IT infrastructure. They should put in more efforts to justify adoption of the IT infrastructure. Examples of such efforts include working closely with international service providers for guarantees of service and support, doing case studies of successful adopters, or even assigning people to learn from successful adopters on a temporary basis.

### B. Research Implications

The result of this study was obtained based on a survey originally designed to collect data for regional benchmarking of telecommunications and not to study the adoption of IT infrastructure. Consequently, the original data had to be supplemented with secondary information from a number of other sources (see Table III). Future research can verify our results through full-fledged studies specifically designed for studying the adoption of IT infrastructure. Results from such comprehensive studies can provide a clearer picture of the relationships between the independent and dependent variables [20]. Of course, larger surveys that involve bigger samples from a wider range of countries can certainly help to enhance the generalizability of research findings.

The results of data analyses showed that inclusion of Internet density as an independent variable reduced the statistical significance of an uncertainty avoidance index. One possible explanation for this reduction in statistical significance is that the uncertainty avoidance index drives corporate adoption of frame relay as well as the spread of Internet hosts. By being correlated with the uncertainty avoidance index, Internet density would reduce the statistical significance of the uncertainty avoidance index. More generally, these results point to the possibility that the managers who decide on corporate adoption of frame relay may be the same people responsible for evaluating Internet or other IT infrastructure. Further research is needed to test this observation, which has implications for the generalizability of the results of this study.

Consistent with Grover and Goslar [14], this study showed that organizational size, whether measured by total assets or annual revenue, did not affect corporate adoption of frame relay. In contrast, other prior studies have reported a positive relationship between organizational size and corporate adoption of IT infrastructure (e.g., [13], [18], [21], and [22]).<sup>5</sup> This positive relationship has been explained in terms of the large fixed costs required for corporate adoption of IT infrastructure. Larger organizations are more able to absorb the fixed costs than are smaller organizations. In this study, the overall sample consisted of large organizations (see Table III); therefore, the fixed costs might have

<sup>4</sup>This measure had been used in major studies of international competitiveness, such as the *Global Competitiveness Report* (published in Geneva, Switzerland) and the *World Competitiveness Yearbook* (published in Lausanne, Switzerland).

<sup>5</sup>Liberatore and Breem [22] measured organizational size by number of employees. Grover *et al.*, [13] sampled only organizations with more than \$50 million revenue. Lai and Guynes [21] did not provide figures for organizational size.

been immaterial. Future research can investigate this fixed cost effect by comparing corporate adoption of IT infrastructure for a wider range of organizational sizes.

This study focused on the demand rather than on the supply aspect of IT infrastructure. In reality, supply factors do affect corporate adoption of IT infrastructure. Although this study considered a supply factor (availability of IT infrastructure), an important supply factor that has been omitted is the price of IT infrastructure. In future research, it is important to examine variables pertaining to both demand and supply aspects of IT infrastructure to attain a more holistic understanding about corporate adoption of IT infrastructure. Having such a more complete understanding can help international service providers to better map their strategy to promote corporate adoption of IT infrastructure.

Another possible extension for this study is to do a longitudinal survey. Specifically, data on corporate adoption of IT infrastructure can be collected annually over a period of several years. Results from such a study can yield insights on whether the relationships between independent and dependent variables are robust over time. Theoretically, these relationships should hold for several years in the case of new IT infrastructure (but the adoption rates for businesses from both higher and lower uncertainty avoidance countries should increase over time). After some time, when the IT infrastructure is no longer new, all businesses should feel comfortable adopting the IT infrastructure and uncertainty avoidance should no longer be a differentiating factor. This contention can be tested through a longitudinal survey.

### C. Limitations of Results

The practical and research implications discussed above must be interpreted in light of the limitations of this study. A limitation of this study is that it did not distinguish among businesses that had not adopted frame relay because they had considered and rejected it, and businesses that had yet to consider it. Lai and Guynes [21] emphasize the importance of this distinction. Another limitation is that this study involved only large international businesses. Thus, the results may not apply to smaller businesses or local businesses. A third limitation is that our sample was not evenly distributed among the 24 countries. Although such an uneven distribution of businesses among the countries may limit the generalizability of the results, it does not render the results invalid because all the dimensions of national culture were interval variables [27].<sup>6</sup> A fourth limitation is that this study involved only one type of IT infrastructure: frame relay. However, given that the same managers are likely to be responsible for making decisions on corporate adoption of various types of IT infrastructure, it is likely that results of this study would apply beyond frame relay. No theoretical basis suggests that these results would not apply to other types of new IT infrastructure. Nevertheless, uncertainty avoidance may not be a differentiating factor for widely adopted IT infrastructure (see Section V-B).

<sup>6</sup>Uneven distribution of data points for nominal or ordinal variables would have a greater impact on the validity of the results.

## VI. CONCLUSION

Based on data from an international survey, this study clearly showed that uncertainty avoidance index of the country of incorporation was negatively associated with corporate adoption of IT infrastructure. But power distance index of the country of incorporation and organizational size were not associated with corporate adoption of IT infrastructure. With data from a wide range of countries, the conclusion of this study is stronger than the results of prior studies that compared only a few countries. Having so many countries also helped to rule out alternative explanations based on other characteristics of these countries (e.g., national policy and resource availability).

As strong international trade and investment gives rise to global businesses, more and more such businesses would search for IT infrastructure to help them function effectively. The role that IT infrastructure plays in global businesses would continue to increase in importance. Because cultural differences can affect corporate adoption of IT infrastructure, international service providers and corporate managers must understand this relationship to facilitate corporate adoption of IT infrastructure. Although this study provides some useful insights on this relationship, it also highlights the fact that more research attention is warranted in this important area of international IT management.

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