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2006

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Recommended Citation
Li-li, Cui; Cheng, Zhang; Lihua, Huang; and Chenghong, Zhang, "Examining Drivers and Impacts of Informatization in Shanghai Manufacturing Firms" (2006). *PACIS 2006 Proceedings*. 107.
http://aisel.aisnet.org/pacis2006/107

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Examining Drivers and Impacts of Informatization in Shanghai Manufacturing Firms

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Abstract

With careful theoretical development and empirical data examination, this paper investigates several key factors that influence the IT usage in Shanghai firms: technology resource, human resource and environment resource. On the basis of the resource-based view and the process model, the study imports government regulation policies, as well as e-government actions, as environmental resource to affect firms' IT usage. By surveying 398 manufacturing firms in Shanghai and statistically analyzing the field data using structural equation modeling technique, the study contributes several insights to the IT usage in Chinese firms. First of all, this study sheds lights on the value creation process of firms' informatization in Shanghai manufacturing industry and validates the route from IT investment to value realization. Second, the findings suggest that government promotion policies have significant impacts on manufacturing firms' technology infrastructure and IT management decision. However, there is no evidence showing the government impact on firms' IT usage level.

Keyword: Informatization, resource-based view, process model

1. Introduction

With the development of information technology (IT), more and more Chinese firms heavily invest in IT since early 1990s. The nationwide IT adoption phase is called the informatization in China and keeps speeding up in the decade. Report from International Statistical Information Center (ISIC) of China Statistics Bureau shows that China's informatization level, annually increased 20.1% between 1995 and 1998 (ISIC, 2000), and 30.5% between 1999 and 2001 (ISIC, 2004). Among all provinces and big cities, Shanghai ranks number one in information resource, IT infrastructure and IT application, with a 33% growth rate of her informatization level (ISIC, 2004).

To better understand the value creation process of firms' informatization in fast developing countries like China and the critical factors that may significantly influence firms' performance, we developed a research model based on process-oriented model (Soh and Markus, 1995) and resource-based view (RBV) of IT value in organizations (Melville, et al., 2004). With survey data collected from 398 Shanghai firms in machinery manufacturing industry and electronic & telecommunication equipment manufacturing industry, the study provides insightful managerial implications to Chinese manufacturing industry by exploring the following research issues: how manufacturing firms could sustain their competence advantages and improve their operation efficiency by investing IT, what technological, organizational and governmental factors are important factors to deploy IT, and whether there is a general conclusion about IT value creation process across different manufacturing sub-industries in Chinese developed cities like Shanghai.

2. Literature Review

In management science and information system literatures, many studies have done to explore the factors that drive the business value of IT. The research relating to this study can be categorized into 3 streams. Of them, two streams form the theoretical backbone of the model developed in this study. One is the process-oriented model (Soh and Markus, 1995), which is used to explain the process from IT use to value creation. The other is resource-based theory (Barney, 1991), which is used to define specific firm resources that contribute to IT usage and lead to IT value creation. Another stream contains studies that analyzed environment factors affecting Chinese firms' informatization.

2.1 Process-Oriented Model

The process-oriented model is a framework to explain how IT creates business value (Soh and Markus, 1995). With the help of process model, firms can identify IT impacts on business and make right decision on IT-enabled management improvement (Barua, et al., 1995; Hammer and Champy, 1993). According to prior research (Cooper and Zmud, 1990; DeLone and McLean, 1992; DeLone and McLean, 2003), the process briefly includes the following phases: appropriate resources are deployed to build up IT Infrastructure, then IT applications are developed and adopted by firms, and finally IT value is created and realized. On this topic, Barua, et al. (1995) analyzed how an intermediate process of usage linked IT and its impact on firm performance. Soh and Markus (1995) developed a conceptual framework to describe the causal relationship among IT investment, IT assets, IT impacts and firm performance. Following Soh and Markus's logic, Zhu and Xu, (2004)

further developed an e-business value creation model consisting of three stages: investment, usage and value. This paper will base on this three stages' value creation model and consider the sequence process of IT value creation, which include: investment, infrastructure construction, usage and value.

2.2. Resource Based View (RBV)

The resource based view emphasizes firm resources, which are valuable, rare and hardly to be substituted, as a basis for competitive advantages (Barney, 1991; Melville, et al., 2004). In IT context, RBV can be used to understand the link between IT resource and competitive advantages, i.e. how IT becomes a firm's resource and contributes to business value. In information system literatures, it is commonly agreed that the sustainable business value of IT resources comes from its appropriate usage and integration with firms' business.

IT-related resources are defined and categorized diversely. Mata, et al. (1995) defined four types of IT resources: capital, proprietary technology, technical IT skills and managerial IT skills, in which the managerial skill is empirically proved to be sustainable. Powell and Dent-Micallef (1997) divided IT resources into human resources, business resources, and technology resources. Bharadwaj, et al. (1998) suggested a six-dimension measure on IT capability and resources: IT/business partnerships, external IT linkages, business IT strategic thinking, IT business process integration, IT management, and IT infrastructure. Bharadwaj (2000) classified IT resources into IT infrastructure, human IT resources and IT-enabled intangibles. Melville, et al. (2004) described two types of IT resources: technological IT resource and human IT resource.

The external environment, such as trading partners, government and socio-political conditions, also plays an important role in IT business value generation (Melville, et al., 2004), but rarely incorporated into models (Chatfield and Yetton, 2000; Jarvenpaa and Leidner, 1998).

Overall, RBV provides a theoretical basis for understanding the role of IT usage in firm (Zhu and Kraemer, 2005) and for evaluating business value of IS resources (Wade and Hulland, 2004), which reveals RBV make a good fit with process model in learning certain factors in IT value creation process. In this study, four widely-used resource types are investigated in Shanghai manufacturing firms' Informatization: finance resource, technology resource, human resource, and environment resource.

2.3. China Informatization and Her Manufacturing Industry

With her persistent booming economy, China, as the biggest developing country, gains increasing interest in recent years (Pyke, et al., 2000). However, due to immature market, different culture and other reasons, China has significantly different characteristics from Western industrial countries (Boisot and Child, 1999).

In literatures, several studies attempt to understand management and IT issues in Chinese context. For example, some studies found that different ownership strongly influences firms' IT implementation (Reimers, 2002). Culture, philosophy and behavior differences are also found to have impacts on firms' IT adoption (Davison, 2002; Martinsons and Westwood, 1997). Zuo and Mao (2005) empirically investigated the state and impact of CIOs in China. The result showed that CIO mechanism in Chinese firms is not completely built up yet. Tan and Ouyang (2004) examined the diffusion and impacts of e-

commerce in China. They found that the e-commerce infrastructure is not completed in China yet. The e-commerce barriers include legal, cultural and governmental issues. Xu, et al. (2004) further confirmed that government regulation plays a more important role in China than in the state. Therefore, in this study, we consider government regulation policies as an important environment factor that may influence firms' IT usage and value creation process.

Manufacturing industry is one of the most representative industries in China. According to the data from China Statistic Bureau, in 2003, the added value of manufacturing industry reached 520 billion US dollars, which accounted for 36.8% of China GDP. The number of employees in the industry was 83.07 million, accounting for 11.3% of total employed population. In Shanghai, manufacturing industry contributes to more than half of the city's GDP in recent years.

3. The Research Model and Hypotheses

With theoretical support by the process model and RBV, we developed a research model shown in Figure 1. First, the model describes an IT value creation process from investment to value realization (Soh and Markus, 1995; Zhu and Xu, 2004).For most Shanghai manufacturing firms, framing physical IT infrastructure is their main work in the initial period of informatization. So forming IT infrastructure is also an important stage that must be considered in the sequent process of IT value creation. Four major types of resources, i.e. finance, technology, human and environment (Melville, et al., 2004; Tan and Ouyang, 2004; Wade and Hulland, 2004; Xu, et al., 2004), are proposed in the model to analyze their impact on IT usage. In order to focus on the impact of government policy on firms' informatization, we will consider government policies as the only environment factor in the model. Finally, we consider the possible relationships between environment resource and firms' IT resources to discover how government policies may influence firms' IT technology and management decision, respectively.

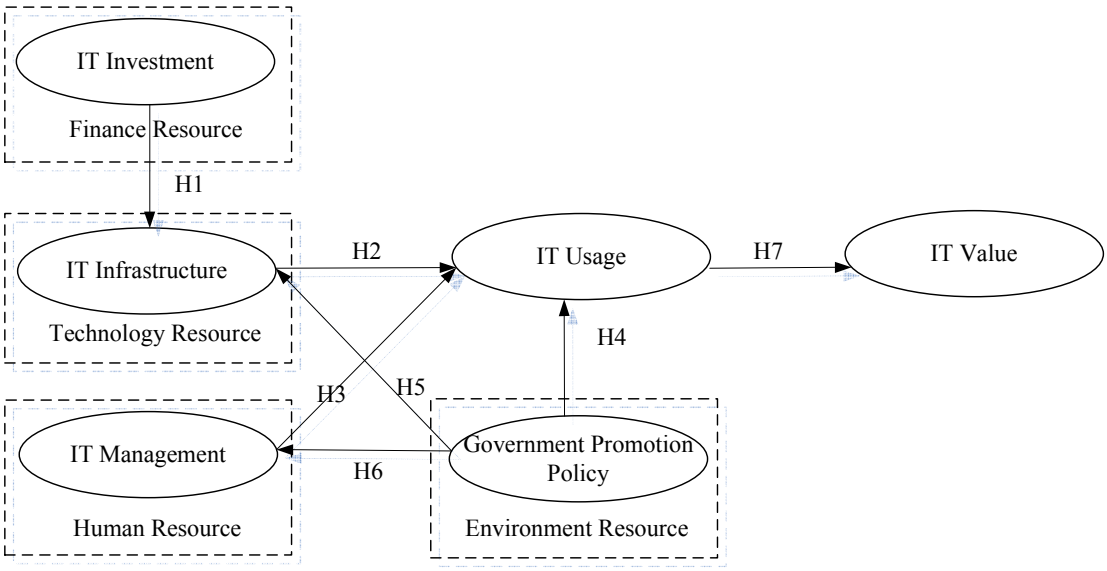

Figure 1: the research model

In recent years, many Chinese firms follow a leap-frog approach to significantly upgrade their IT infrastructure for business (Guo and Chen, 2005; Tan and Ouyang, 2004).

Constructing and using IT systems requires enough investment in hardware and software. Adequate investment will promise firms to improve and maintain their IT equipments, networks and software applications. Consequently, IT investment (ITIV), as a finance resource, will help firms to build a better IT infrastructure (ITIF) and to enable a greater usage (ITUS). According to the situation that little investment was used in improving IT related management skills in China enterprises, we will ignore the link between investment and IT management in this paper. Therefore we propose:

H1: firms' IT investment affects firms' IT infrastructure construction

IT infrastructure is a collection of physical technology resources, including shared technology and technology services across the organization (Melville, et al., 2004), which facilitate firms' connectivity and operations. Prior research showed that IT infrastructure investment accounted for over 58% of firms' IT budget and the percentage grew at 11% a year (BroadBent and Weill, 1997). Depending on its use, IT infrastructure can be an importance source of firms' business value (Kumar, 2004). Therefore we propose:

H2: Firms' IT infrastructure status affects firms' IT usage

Another type of resource is IT management capability (ITMC) or human component of IT resource in firms, which denotes firms' technical and managerial knowledge (Byrd and Turner, 2000; Melville, et al., 2004) on IT. Compared with physical IT infrastructure, IT management is a set of 'soft' abilities that help firms to deploy IT in an effective manner (Lee, et al., 1995; Swanson, 1994). In order to utilize IT physical asset economically, firms need to pursue a fit between IT functionalities and business strategies (Grabowski and Lee, 1993; McLaren and Head, 2004) and manage IT infrastructures to improve organization performance (Markus and Soh, 1993). Therefore we propose:

H3: Firms' IT management affects firms' IT usage

Prior research shows that non-technical environmental factors are important factors that affect innovation adoption (Kraemer, et al., 2002; Tornatzky and Fleischer, 1990). While firms in e-commerce survey studies frequently cite environment issues, like security, credibility system and legal issues, as their major concerns, they synchronously point out that incentives provided by government are key drivers for their new IT and e-Commerce usage (Tan and Ouyang, 2004; Xu, et al., 2004). The results denote that government regulation (GRP) and IT-related promotion policies can affect firms' IT configuration and improve their IT usage. Thus, we propose:

H4: Government IT promotion policies improve firms' IT usage

Governments have various ways to regulate and promote firms' IT usage, including promoting IT knowledge, helping firm to assess their informatization needs, adopting online reporting system, providing e-procurement service and many other ways. Previous research, such as Tan and Ouyang (2004); Xu, et al. (2004), has noticed the importance of government regulation. Considering relatively immature markets and information asymmetry in China, government promotion policies are like to have broad impacts on Chinese local firms' behaviors, including their IT decision, management and usage. Furthermore, Chinese firms are more used to adapting themselves to government policies, given the history of frequent government interventions in China. Therefore, government regulation affects not only firms' IT usage, but also their IT configuration and management. Therefore, we propose:

H5: Government IT promotion policies improve firms' IT infrastructure construction

H6: Government IT promotion policies improve firms' IT management

IT value (ITVA) is commonly used to refer IT impact on organization performances (Melville, et al., 2004), including operational efficiency improvement, competitive advantage and other measures of performance (DeLone and McLean, 2003). With significant investment in IT resources, understanding the relationship between IT investment and IT value continues to interest governments, enterprises and researchers, particularly in today's fast-changing economic environments (Brynjolfsson and Yang, 1996; Zhu and Xu, 2004). Although literatures show that IS resources have value, at least moderate value, to firms (Wade and Hulland, 2004), IT resources rarely contribute directly to firms' performance improvement, but realize their value after appropriate usage (Lucas, 1993; Soh and Markus, 1995). Therefore, we propose:
H7: Firms' IT usage help to contribute to firms' IT value creation

4. Methodology

4.1 Data and Method

A questionnaire survey method was adopted for the study. The survey was held by Shanghai Municipal Internet Economy Consulting Center (SIECC) and a world's reputable consultant firm that is doing research and analysis on global information technology industry.

The sample frame was manufacturing enterprises from two main sub sections in Shanghai manufacturing industry: machinery manufacturing and electronic & telecommunication equipment manufacturing. A random sampling process was followed in selecting the sample enterprises from a full list of all enterprises in the industry. A pre-screening process via telephone was followed to determine the suitability of the representative interviewee for the selected enterprise to answer the survey questionnaire. Overall, qualified interviewees were firms' senior executives who took charge of information technology or head of their IT department.

Of the 744 selected representative interviewees, face-to-face interviews followed immediately. All data used in this study is collected through field interview, which went on for 8 weeks in 2003. The response rate is 62%. A total of 459 completed questionnaires were secured. Among them, 398 questionnaires were valid. Characteristics of the sample are shown in Table 1. Distribution of firms' annual revenue and size shows a suitable portion of small, medium and large firms. The distribution of existence years shows a good cover of the whole process of informatization.

Industry	**# (%)**	**Annual Revenue (million)**	**%**
Machinery manufacturing	295 (74)	<5	24.4
Electronic and telecommunication equipment manufacturing	103 (26)	5-10	16.4
Number of Employees	**%**	10-50	31.8
<10	5.3	50-100	9.1
10-50	29.0	100-500	13.2
50-100	24.3	>500	5.1
100-500	29.5	**Existence Years**	**%**
500-1000	8.4	<5	9.8
>1000	3.5	5-10	31.6
		10-15	30.1

15-20	11.8
>20	16.7

Table 1: Sample Characteristics (N=398)

We used partial least squares (PLS) approach (Haenlein and Kaplan, 2004; Lohmoller, 1989) to examine the hypotheses. The software we used was PLS-Graph (Chin, 2001).

4.2. Measures and Validity

Most of the constructs in the study were measured through the measurements adapted from research literatures. Others were final discussion result from professionals in SIECC and the consultant firms. Items were either measured by ratio scale, such as IT investment, or ordinal scale, such as importance of IT usage, or nominal scale, such as specific promotion policy. The content validity of the measures was examined by pretests with SIECC professionals and a few firms' IT managers.

Three items for measuring IT Infrastructure were derived from Byrd and Turner (2000); Duncan (1995). They were used to measure firms' IT hardware, software, and network status. To measure IT investment, item used were annual IT input by the firm (Zhu and Xu, 2004) and portion of hardware input of annual IT investment. Since the portion of software is one minus hardware portion, we did not include it in. To measure IT management, we considered the practice of IT-related planning, evaluation and management activities in firms (Byrd and Turner, 2000).

To measure regulatory environment, the questions about how government actions, including online procurement requirement, incentives, law and legal protection, would affect firms' IT adoption was adapted from prior research (Tan and Ouyang, 2004; Xu, et al., 2004). Other new items, such as establishing evaluation framework, were added after careful discussion among professionals and validated in pretest.

Finally, IT usage included firms' computer usage and application usage, while IT value was its importance to firms' competitive advantage (Melville, et al., 2004; Wade and Hulland, 2004) and adoption by firms (Sambamurthy and Zmud, 1994).

To validate the instruments, we examined internal consistency, convergent validity, and discriminant validity. The composite reliability values for the constructs in the model were all above the suggested threshold of 0.7 (Chin, 1998; Straub, 1989) and thus supported the reliability of the measures. All items had a loading above the suggested of 0.55 by Falk and Miller (1992) . The AVE values for all the constructs were above the limit of 0.50 advised by (Fornell and Larcker (1981). The discriminant validity was examined at both the item and construct level. In every case, the shared variance between two constructs was less than the AVEs.

5. Data Analysis

All hypothesized paths, except the link between government regulation and IT usage, were found significant *($p<0.01$),* as shown in Table 2. These positive and significant results show a clear map of how IT investment, after an appropriate infrastructure and usage, creates value to manufacturing's operation. The three dependent constructs, i.e. IT infrastructure, IT usage and IT value, have R^2 of 0.384, 0.318 and 0.118 respectively, suggesting a good explanation of data variation from RBV perspective.

Hypothesis	Path coefficients
IT Investment -> IT Infrastructure	0.603 ***

IT Infrastructure -> IT Usage	0.424 ***
IT Management -> IT Usage	0.183 ***
Government Promotion -> IT Infrastructure	0.101 ***
Government Promotion -> IT Management	0.188 ***
Government Promotion -> IT Usage	-0.01
IT Usage -> IT Value	0.343 ***

Table 2: Hypotheses result with data from manufacturing industry *(*** $p<0.01$)*

Besides infrastructure, the path coefficient from IT management to the usage is 0.183 *($p<0.01$)*, which suggesting a significant impact of IT management issues on appropriate IT usage in firms. Furthermore, the path from government promotion policy to the infrastructure and IT management, respectively, is also positively significant, suggesting a clear influence of government regulation on firms IT configuration and management. However, the direct impact of government regulation on firms' IT usage is not significant. To test the generality of the model, we split the full sample set into two sub-samples: one is data from machinery manufacturing industry (MM) and the other is data from electronic & telecommunication manufacturing industry (ETM). After examining the internal consistency, convergent validity, and discriminant validity of the model with each sub sample set, we then ran PLS analysis. The result showed that the path coefficients are of the same significance as those in the full-data model, and their values are close to those in the full-data model as well, suggesting a good fit between sub data sets and the full data set. Therefore, our later discussion on the full-data model is quite general.

6. Discussion and Conclusions

To study IT use and value creation process in Chinese manufacturing context, we developed a research model and examined the model with empirical data from Shanghai manufacturing industry. All hypotheses are assessed with full sample and two sub-samples. The empirical analysis reveals several major findings.

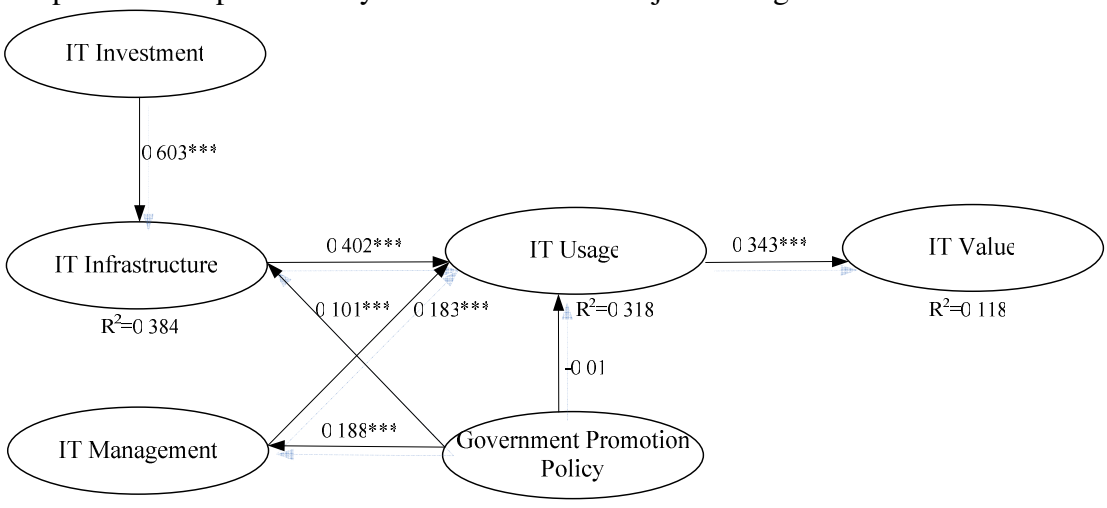

Figure 2: PLS Structural model

Finding 1: As shown in Figure 2, the value creation process of the informatization in Shanghai manufacturing industry starts at firms' IT investment. Through IT infrastructure construction, firms use IT application systems to support their business and management and finally realize the IT value.

More and more Chinese manufacturing firms start their informatization, but little

empirical research has been done to analyze the value creation process of their informatization, its key drivers and performance impacts. With theoretical support from the process model and RBV, the study investigated the key financial, technological, human and governmental factors that affect the value creation process of the informatization in Shanghai manufacturing industry. The model provides a useful theoretical guide to understand the informaization process now happening in Shanghai China and points out the important stage that should draw much attention from researchers, practitioners and Chinese government.

Finding 2: Government promotion policies have significant and positive impacts on manufacturing firms' IT infrastructure construction and management.

Although prior research often cited that the government regulation, as an important environmental factor, would significantly influence firms' operation and decision, few empirically examined the role of government in driving the IT value creation process in Chinese manufacturing firms. By exploring the government regulation power on firms IT infrastructure construction, IT management and IT application usage, this study reveals that government can significantly influence manufacturing firms' IT decision and management.

Because the informatization is emergent as an technological innovation to most of Chinese firms in recent years, firms are lack of knowledge and experience on how to adopt IT well to support their management and business. Therefore, governmental promotion actions can give firms a great chance to learn and act. For example, case studies and IT learning can help firms know more about IT, providing informatization evaluation framework can help firms clarify their direction of informatization, while promoting IT practices and e-government systems can directly motivate firms to initialize their informatization process.

In this empirical study, all the policy impacts have been denoted by the significant path coefficients of the links from government policies to manufacturing firms' IT infrastructure and management. The observation will help the government assess their IT policies. For example, when considering new regulations, the government may find it more effective to help firms improve their IT management knowledge, rather than to intervene their IT usage or direct invest.

Finding 3: Resources like infrastructure and management play an important role on manufacturing firms' IT usage.

In the informatization process, both the Chinese government and firms pay more attention on IT 'hard' investment than on soft investment. Here 'hard' means the IT resources that can be directly measured by capital, such as hardware, software and network, while 'soft' means other IT resources that cannot be measured by capital directly, such as management rules, organization structure and planning. Although research has shown the importance of a good fit between IT physical assets and management resources, there is little empirical data to support this conclusion in Chinese firms. In this study, the management issues are imported into the structural model for examination. The result clearly proves the importance of management factors, besides IT 'hard' factors, on IT usage in Chinese manufacturing firms. Therefore, government and firms should shift more attention to normalizing firm's IT-related management systems and policies, encouraging the practice of IT planning, and the evaluation of IT investment and competence of using IT.

The key limitation of this study is the generality of the conclusions. Although the sampling process and data set is satisfactory, the result is limited in Shanghai manufacturing industry, meaning that conclusions in this study cannot be simply applied to the whole Chinese manufacturing. However, we believe the model will help to understand the developed cities and provinces in China with the same level of informatization and industrialization as Shanghai has, such as Beijing, Tianjin, Guangdong, Zhejiang, Fujian and Liaoning (ISIC, 2004). The implications and conclusions drawn from this study are expected to be general to the regions mentioned above.

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