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Summer 6-30-2018

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Fengfeng Lou

School of Management, Zhejiang University, Hangzhou, 310058, China

Wenguang Qu

School of Management, Zhejiang University, Hangzhou, 310058, China

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Recommended Citation

Lou, Fengfeng and Qu, Wenguang, "The Impacts of Open and Proprietary IT on Vertical Firm Boundaries" (2018). *WHICEB 2018 Proceedings*. 3.

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The Impacts of Open and Proprietary IT on Vertical Firm Boundaries

Fengfeng Lou¹, Wen Guang Qu^{2}*

¹ School of Management, Zhejiang University, Hangzhou, 310058, China

² School of Management, Zhejiang University, Hangzhou, 310058, China

Abstract: Extensive researches have studied the relationship between IT and vertical firm boundaries, but few has distinguished between different types of IT. This study divides IT into two categories, open IT and proprietary IT and proposes that the impacts of open IT and proprietary IT on vertical firm boundaries are different. Moreover, we also hypothesize that industry dynamism has moderating effects on these relationships. We use the panel data from U.S. Bureau of Economic Analysis (BEA) to test these hypotheses. The results show that open IT has a negative effect on vertical scope of firms while proprietary IT has a positive effect on vertical scope. Furthermore, with the increase of industry dynamism, open IT has a further negative effect on vertical scope while proprietary IT has a further positive effect on vertical scope. This study suggests that different types of IT have different impacts on vertical firm boundaries, which provides implications for both research and practice.

Keywords: vertical boundaries, open IT, proprietary IT, industry dynamism, vertical scope

1. INTRODUCTION

As firms have increasingly invested in information technology (IT) resources over the past few decades^[1], more and more researchers are interested in studying how IT can affect the structure of firms^[2]. Previous literature has shown that IT makes significant impacts on vertical firm boundaries^[3, 4]. However, while some scholars claim that IT reduces the vertical scope of firms^[4, 5], others state that IT has the ability to extend a firm's vertical scope^[3, 6].

Although there are many studies focusing on the impacts of IT on vertical firm boundaries, they all focus on overall IT. Few studies on this issue have distinguished between different types of IT. To advance our understanding on the issue, we divide IT into two distinct types, open IT and proprietary IT. The main purpose of our research is to empirically examine the effects of different types of IT on vertical firm boundaries. We used annual industry-level data from U.S. Bureau of Economic Analysis (BEA) and conducted an empirical analysis. Overall, we find evidence showing that open IT and proprietary IT have opposite effects on vertical scope of firms. Specifically, the results suggest that open IT has a negative relationship with vertical scope while proprietary IT is positively associated with the vertical scope. Moreover, we find significant moderating effects of industry dynamism on these relationships. Compared to in stable industries, both the negative effect of open IT and positive effect of proprietary IT become stronger in dynamic industries.

This study contributes to the research by showing the different effects of two distinct types of IT, Open IT and Proprietary IT, on vertical firm boundaries and the moderating effects of industry dynamism on these relationships.

The rest of the paper is organized as follows. First, we review the literature about the impacts of IT on vertical firm boundaries. Second, based on prior research on open and proprietary IT and industry dynamism, we propose hypotheses regarding the impacts of different types of IT on vertical firm boundaries and the moderating effects of industry dynamism. Then we conduct an empirical test on these hypotheses based on the annual industry-level data from BEA. Finally, the paper ends with a discussion of findings and implications for research and practice.

* Corresponding author. Email: quwg@zju.edu.cn(Wen Guang Qu) , lffsghr@163.com(Fengfeng Lou)

2. LITERATURE REVIEW

Many studies have suggested that IT may have an important impact on vertical firm boundaries by influencing firms' make vs buy decisions on the materials or services for producing their final products^[1,4,7]. By analyzing the rich literature on the impacts of IT on vertical firm boundaries, we find that there are different arguments and evidences for the impacts of IT on vertical firm boundaries. The literature could be classified into two groups.

The first group thinks an enterprise will tend to depend more on markets after using IT because IT has the ability to reduce coordination cost^[1]. Thus, a firm's wider use of IT is associated with the reduction of vertical scope. For instance, Brynjolfsson et al. (1994) predicted that increasing use of IT leads firms to narrow down their vertical scope. Their empirical analyses also showed that following investment in IT, firms would seek to coordinate more with markets and IT also leads to smaller size^[4]. Chen and Kamal (2016) claimed that when production processes are easily codified electronically, IT will increase external transactions relative to internal transactions in MNEs (multinational enterprises), and reduce firm scope^[7]. Hitt (1999) provided evidence linking IT to the reduction of vertical integration of firms, because the effect of IT on external coordination costs is stronger than on internal coordination costs^[5].

Contrary to above findings, however, the second group of studies indicates that there is a positive relationship between IT and vertical scope of firms. For instance, Chen and Kamal (2016) provided evidence that the complex IT should facilitate MNEs (multinational enterprises) to produce in house, expanding vertical scope^[7]. Afuah (2003) revealed that IT may expand some vertical scope of firms by enabling some external activities to be performed in house^[3]. Similarly, Ray et al (2009) showed that IT is positively related to firms' vertical integration in concentrated and predictable environments because firms can use IT to coordinate more activities in house for higher revenue^[6].

Overall, the findings are inconsistent in the literature. We believe that there may be an issue in prior researches that they only focus on overall IT. Because different types of IT have different characteristics^[8-10], they may have different impacts on vertical firm boundaries. Therefore, to augment our understandings, this study distinguishes between open IT and proprietary IT and suggests that they affect vertical firm boundaries differently.

3. HYPOTHESES

IT can be categorized into two types, open IT and proprietary IT^[8-10].

Open IT is defined as one which uses public communication platforms and software, available to the public (e.g., RosettaNet and ebXML)^[9]. Plenty of benefits of open IT have been revealed by prior researches, which contains supply chain flexibility and operational cost savings^[11]. For instance, Malhotra et al. (2007) indicated that open IT enables firms to exchange information with many extended enterprise partners and heralds flexibility of business process connectivity across enterprises^[11].

On the contrary, when IT is developed and available only to a specific enterprise, requiring a private platform and software to communicate, it is considered as proprietary IT (e.g., the early ASAP system characterized as a dedicated system with proprietary protocols)^[9]. There are also numerous benefits of proprietary IT documented in the literature, including partnership relationship and competitive advantages^[8,12]. For instance, Subramani (2004) provided empirical evidence that proprietary IT use can lead to closer cooperative relationships, which contributes to partnership relationship in buyer-supplier exchanges^[12].

3.1 Open IT and vertical firm boundaries

The impacts of open IT on vertical firm boundaries can be analyzed from the angles of transaction costs and firm flexibility.

Due to its standardization and openness, open IT enables firms to adapt to most enterprise information systems, which is convenient for inter-firm information exchange and communication. Well-functioning IT systems on both sides allow firms to share product information easily with external suppliers and reduce coordination costs^[6]. Lower coordination costs contribute to better cooperative relationship and maintain business cooperation between firms and external suppliers. Besides coordination costs, transaction costs contain costs of finding, contracting with suppliers, and resolving disputes in the business process^[6]. Open IT can help firms reduce such costs in the procurement process. Thus open IT can make firms lower transaction costs involved in procuring from suppliers. With lower transaction costs, firms prefer to procure from external suppliers and reduce their own vertical scope.

In the present competitive environment, an enterprise should retain the flexibility of changing strategies frequently to respond to market changes^[6]. Firms which use open IT usually have plenty of suitable suppliers to cooperate. So they are free to choose the most appropriate one from many potential suitable supplier partners to cooperate with, without worrying about being restricted by committed relationship. As a result, those firms that apply open IT prefer to procure outside.

Open IT can help firms reduce external transaction costs and improve enterprise flexibility when they procure from external suppliers. Thus, firms using open IT would prefer external procurement rather than internal production, which leads them to reduce their vertical scope.

Hypothesis 1: The use of open IT is negatively associated with the vertical scope of firms.

3.2 Proprietary IT and vertical firm boundaries

Usually, firms based on proprietary IT typically require extra costs like high relationship-specific investments to build committed partnership if they need to cooperate with external suppliers^[10]. Undoubtedly, this would increase coordination costs of both parties to the transaction and the switching costs of firms if they want to shift from one supplier to another. High switching costs result in the loss of flexibility when the focal firm changes suppliers. Moreover, cooperation between the focal firm and the external supplier often involves opportunistic risks^[13]. Once the supplier partner performing opportunistic behaviors, the focal firm needs to seek for another supplier partner to avoid risks but pays high switching costs in the meantime.

In addition, for firms that use proprietary IT, proprietary IT has significant effects on both internal and external costs. Coordination costs can be further divided into two distinct parts, internal coordination costs and external coordination costs^[4]. Since proprietary IT adapts to internal business procedure and characteristics of an enterprise, it becomes much easier and more convenient for the enterprise to coordinate internally and lower internal coordination costs. When IT reduces internal coordination costs more than external coordination costs, firms are expected to choose internal production decision^[4]. Besides, it will be hard and costly for the focal firm to find a suitable supplier because of the unique characteristic of proprietary IT. To avoid high costs, firms using proprietary IT prefer to produce internally rather than procure from external suppliers, which expands their vertical scope.

For firms using proprietary IT, it is hard to find a suitable supplier to cooperate with in the market. Furthermore, external procurement will cost a lot and lead to the inflexibility of firms while the internal production has lower costs and risks. Therefore, internal production which expands vertical scope would be the better decision for the firms.

Hypothesis 2: The use of proprietary IT is positively associated with the vertical scope of firms.

3.3 Industry dynamism

Industry dynamism represents the degree of change in industry environmental activities related to an organization's operations^[14]. The change is hard to predict, thus industry dynamism could create uncertainty and make an impact on firms' managerial decision-making^[15]. In this study, it is analyzed and inquired into the different effects of industry dynamism on the relationship between IT and firms' make vs buy decisions after using different type of IT (open IT or proprietary IT).

Accordingly, a firm must have the necessary agility to survive in the dynamic environment. Open IT gives firms the agility to seek and change suitable suppliers easily whenever necessary. Procuring from external suppliers is highly agile for those firms that apply open IT, which is very important for their survival in dynamic environment. Therefore, compared in stable environment, firms with open IT prefer to procure more from outside in dynamic industry environment. This leads to the narrowing of vertical scope of firms.

Within dynamic environment, firms which apply open IT need agility to survive and external procurement offers this agility. Thus, the firms tend to procure from external suppliers and reduce their vertical scope.

Hypothesis 3: The relationship between open IT and vertical scope of firms will become more negative when industry dynamism is higher.

In dynamic industry environment, IT investment decision-making of enterprise is a demanding task because of the importance and irreversibility of IT investment itself^[16]. Overinvestment in IT wastes resources while underinvestment in IT results in critical opportunity costs^[17]. As we know, IT investment is a kind of sunk cost. It is easier for IT investment to lose value in uncertain industry environment contrast to in stable environment. As a result, firms become very cautious in investing in IT resources in uncertain environment. When a firm with proprietary IT chooses to procure from external suppliers, both sides need to increase IT investments for better IT integration and building committed relationship during the cooperation period^[10]. But in dynamic environment, it's hard for the focal firm to find a supplier which is willing to investing in IT resources for the cooperation. Therefore, the firms using proprietary IT are harder to procuring from external suppliers in uncertain environment.

For firms using proprietary IT, it becomes harder to find a suitable supplier to cooperate with in dynamic environment. At the same time, the cost of internal coordination is still at a lower level. Thus, it is better for those firms using proprietary IT to choose internal production rather than external procurement, (i.e., expanding their vertical scope).

Hypothesis 4: The relationship between proprietary IT and vertical scope of firms will become more positive when industry dynamism is higher.

4. METHOD

4.1 Data and variables

To test the hypotheses, we gathered annual industry-level data from U.S. Bureau of Economic Analysis (BEA). The data includes 62 industries at the three-digit North American Industry Classification System (NAICS) level, covering the years from 1998 to 2015. We use the Use Tables from the BEA's Input-Output

Accounts to measure the vertical scope of firms and industry dynamism. For open IT investments and proprietary IT investments, we can use data in the BEA's Fixed Assets Tables to compute them. As previous studies^[18], we assume that the industry average can be considered as the data of a 'representative' firm in the industry. Thus, we can use industry-level data to carry out firm-level research.

4.1.1 Dependent variable

To better analyze the IT impacts on vertical firm boundaries, we decide to take the vertical scope of firms as the dependent variable in empirical test. Since our premise in this study is that firm's internal production and external procurement are substitutive for each other, we can take the ratio of external procurement value to internal production value as a measure of the vertical scope of firms. More precisely, we use the negative value of this ratio to measure the vertical scope, because the ratio represents the level of external procurement of firms compared to internal production. We consider intermediate inputs from the BEA's Use Tables as a measure of external procurement and value added in the Use Tables as a measure of internal production of firms. The denominator is the value of value added and the numerator is the negative value of intermediate inputs. Therefore, the measure of our dependent variable is:

$$VS = -\text{intermediate inputs}/\text{value added} \quad (1)$$

4.1.2 Independent variables

In this study, the use of open IT is measured by the investment on prepackaged software. In the BEA's Fixed Assets Tables, it refers to the stock of prepackaged software. BEA categorized IT software stock into three groups: prepackaged software stock, custom software stock and own account software stock. Prepackaged software is the category of public software, available to the public. A firm using prepackaged software is considered as using open IT. Therefore, we use a firm's investment on prepackaged software to measure its use of open IT.

We measure the use of proprietary IT by the sum of custom software stock and own account software stock in the BEA's Fixed Assets Tables. In the BEA's Fixed Assets Tables, both custom software and own account software are the categories of software which are developed and available only to a specific enterprise, which is proprietary. Therefore, we use investments on both custom and own account software to measure the use of proprietary IT of firms.

As to industry dynamism, we measure it by using industry gross output from the BEA's Use Tables. As Keats and Hitt (1988) mentioned^[19], we regress the natural logarithms of annual figures of industry gross output on time. Then the antilog of the standard error of the regression slope coefficient can be a measure of industry dynamism. This variable describes the instability of industry environment. Moreover, we take industry dynamism as a moderating variable, which is used to study the moderating effects of industry environment on the relationship between IT and the vertical scope of firms.

In addition, we include non-IT capital (firm's total capital excluding IT), computer hardware capital, and labor as control variables. Using data from the BEA's Fixed Assets Tables, we can compute the value of non-IT capital and computer hardware capital. To measure the labor, we follow the way of prior research^[20]. First, we get the data of the number of full-time equivalent employees from the BEA's Full-Time Equivalent Employees Table. Then we can calculate the value of labor by multiply the number by 2080 hours (average work hours). All independent variables (except for industry dynamism) are divided by the value-added of the corresponding industry to control the size effect.

4.2 Econometric model

To test the effects of open and proprietary IT on vertical scope of firms and the moderating effects of industry dynamism, we implement econometric model as follows:

$$VS_{it} = \beta_0 + \beta_1 Cst_{it} + \beta_2 Pkg_{it} + \beta_3 K_IT_{it} + \beta_4 L_{it} + \beta_5 Hd_{it} + \beta_6 Ind_dyn_{it} + \beta_7 (Ind_dyn * Cst)_{it} + \beta_8 (Ind_dyn * Pkg)_{it} + \varepsilon_{it} \quad (2)$$

VS_{it} represents the vertical scope of firms in an industry i at year t . Cst_{it} and Pkg_{it} are independent variables, representing proprietary and open IT investments of firms for an industry i at year t . Control variables includes non-IT capital, labor, and computer hardware capital of firms of an industry i at year t . The ε_{it} in the model represents the error term of observation. In addition, we add 61 industry dummies (62 industries totally) to control for industry fixed effects and 17 year dummies (1998-2015) to control for time effects in the analysis.

4.3 Results

Following Han et al. (2011)^[20], we analyze the data using OLS with panel-corrected standard errors (OLS-PCSE). The summary of the analysis results is provided by Table 1.

As shown in the table, Model 1 only includes direct effects. There is a significant negative relationship between open IT and vertical scope of firms ($\beta = -0.225$, $p < 0.001$ for the PCSE-PSAR1 model; $\beta = -0.227$, $p < 0.001$ for the PCSE-AR1 model). Hypothesis 1 is supported. As for proprietary IT, we found a significant positive relationship between proprietary IT and vertical scope of firms ($\beta = 0.149$, $p < 0.01$ for the PCSE-PSAR1 model; $\beta = 0.119$, $p < 0.01$ for the PCSE-AR1 model), which is consistent with Hypothesis 2.

Model 2 of Table 1 adds the hypothesized interaction terms between different type of IT investment and the moderator variable. As Table 1 shows, Hypothesis 3 is also supported. The interaction term involving industry dynamism and open IT has a negative coefficient ($\beta = -0.170$, $p < 0.001$ for the PCSE-PSAR1 model; $\beta = -0.237$, $p < 0.001$ for the PCSE-AR1 model), showing an increasingly negative effect of open IT on vertical scope in highly dynamic industries. On the other hand, the interaction term of industry dynamism and proprietary IT has a positive effect on vertical scope ($\beta = 0.285$, $p < 0.01$ for the PCSE-PSAR1 model; $\beta = 0.328$, $p < 0.001$ for the PCSE-AR1 model). The results suggest a stronger positive relationship between proprietary IT and vertical scope in dynamic industries than in stable industries, which supports Hypothesis 4.

Table 1. Main results of OLS-PCSE analysis

Variables	Model 1		Model 2	
	PCSE(PSAR1)	PCSE(AR1)	PCSE(PSAR1)	PCSE(AR1)
Control variables				
Non-IT capital(K_IT)	-0.546***	-0.524***	-0.541***	-0.514***
Labor(L)	-0.602***	-0.603***	-0.614***	-0.610***
Computer hardware capital(Hd)	-0.404***	-0.377***	-0.398***	-0.378***
Direct effects				
Open IT (Pkg)	-0.225***	-0.227***	-0.216***	-0.191***
Proprietary IT (Cst)	0.149**	0.119**	0.111*	0.068
Moderating effects				
Industry dynamism x open IT			-0.170***	-0.237***
Industry dynamism x proprietary IT			0.285**	0.328***

†p<0.1, *p<0.05, **p<0.01, ***p<0.001

5. CONCLUSIONS

In this paper, we classify IT into two categories, namely open IT and proprietary IT, and conduct an

empirical analysis on the relationships between them and vertical scope of firms as well as the moderating effects of industry dynamism. The results show that the effects of open IT and proprietary IT on vertical scope are opposite to each other. The increasing use of open IT will reduce a firm's vertical scope while increase in proprietary IT can expand the vertical scope. In addition, the results also show that the effects of open and proprietary IT become even stronger with the increase of industry dynamism.

Open IT lowers external transaction costs^[6] and provide flexibility to firms when they procure outside. For firms using open IT, external procurement offers more benefits than internal production. As a result, it is a rational decision for those firms to choose external procurement and reduce their vertical scope. However, proprietary IT has exactly the opposite effect. Once firms use proprietary IT, there will be a high cost for procuring from external suppliers^[10]. But internal production is at a low cost. Thus firms will choose to produce internally and expand their vertical scope if they rely on proprietary IT. In addition, industry dynamism intensifies above relationships. Both effects are stronger for high levels of industry dynamism as compared to low levels. External procurement can provide agility to firms when they use open IT, which is of vital importance for them to survive in dynamic environment. So firms which use open IT are even more inclined to procure from outside in dynamic environment. But for those using proprietary IT, high industry dynamism will increase their external transaction costs and make it hard for them to find a willing and suitable external supplier. Therefore in dynamic environment, these firms prefer even more internal production.

Previous researches have examined the impacts of IT on vertical firm boundaries. To our knowledge, however, there is no study that has investigated the roles of open and proprietary IT on this issue. Our study contributes to the research by distinguishing between the effects of open IT and proprietary IT on vertical firm boundaries. In addition, this research also offers implications to enterprise managers when they making business decisions on IT. Finally, our study shows that industry dynamism has significant moderating effects on the relationships between open/proprietary IT and vertical firm boundaries. Future research may augment our understandings by examining the roles of other important industrial environment factors, such as industry munificence and industry concentration, in above relationships.

ACKNOWLEDGEMENT

This research was supported by the National Natural Science Foundation of China under Grant 71572180.

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