The Impact of the Number of Suppliers on Firm Performance

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ABSTRACT

The optimization of supply base has increasingly become a top strategic issue for manufacturers, and the most commonly observed supply base management practice has been directed at how many suppliers manufacturing companies should maintain in their supply bases. Issues surrounding the supply base optimization have been studied during the last two decades. Yet most of the existing literature has been either explorative in nature or based on a simple case study. Little empirical research has been done on these issues with a large sample. This study investigates the relationship between the number of suppliers and firm performance with a large sample of Chinese state-controlled manufactures listed on Shenzhen and Shanghai Exchanges from 2002 to 2006. The results reveal that there is an inverted U-shaped relationship between the number of suppliers and performance at the organizational level. With the reduction of the number of suppliers, transaction cost and supply risk decrease while supplier responsiveness and innovation increase, which result in higher firm performance. However, when the number of suppliers reduces to a critical level, any further reduction leads to an increase in supply risk and a decrease in supplier innovation, which hinder firm performance.

Keywords: Supply Base, Number of Suppliers, Raw Material Inventory, Firms' Operating Performance

INTRODUCTION

Almost all the companies need suppliers to gain materials, products, or services for their growth and success (Dobler and Burt, 1996; Handfield and Nichols, 1999). A group of suppliers constitutes a focal company's supply base. The focal company acts as a central hub that monitors and regulates the operations and performance of the suppliers involved. How to optimize a supply base has increasingly become one of the important strategic questions to companies (Parmar, Wu, Callarman, Fowler, & Wolfe, 2010). During the last two decades, one of the widely-used approaches to optimizing a supply base in practice has been related to control the number of suppliers, including both the increase and decrease in the number of suppliers in the supply base. For example, Trent and Monczka (1998) discuss that companies largely reduced the number of suppliers to optimize their supply base in the late 1980s and early 1990s and predict that this trend will continue. Likewise, Krause (1997) and Ballew and Schnorbus (1994) also report that large manufacturers such as General Motors and General Electric decreased the number of suppliers in their supply bases in the 1990s.

The benefit of a condensed supply base is that the company can save a great deal of expenses during interactions and transactions with only a few suppliers (Dedrick, Xu, & Zhu, 2008). As such, the company can establish long-term strategic relationships with suppliers (e.g., developing and sharing new technology with suppliers in the long run) (Ho & Ganesan, 2013). However, a primary drawback of decreasing the number of suppliers is supplier dependence, which means the company has to rely on the limited suppliers about the quality, price, and supply of materials. If the limited suppliers encounter challenges or crises, the company will have to face the risks of supply disruption and material shortage. As a result, after reducing the number of suppliers, some companies re-increase it to a certain amount to avert the risks (Krause & Handfield, 1999). It indicates that the number of suppliers has a significant impact on firm performance, as such, the optimization of the number of suppliers is to seek the optimal performance at the organizational level. It is thus necessary to investigate the underlying mechanism that the number of suppliers affects firm performance. However, most existing literature in this area has been either explorative in nature or based on a simple case study, few empirically examining the issue with a large sample (c.f., Monczka, Trent, & Callahan, 1993[1]).

The objective of this research is to theorize and examine how the number of suppliers influences firm performance. The paper begins with a review of prior research on supply base management. Then, an inverted U-shaped relationship between the number of suppliers and firm performance is proposed. The following section describes an analysis on longitudinal (2002-2006) data on China listed manufacturing companies to examine the proposed curvilinear relationship. Finally, managerial implications and suggestions for future research are discussed.

[1] While Monczka, Trent, & Callahan (1993) provide evidence of the importance of the supply base to manufacturers, our study examines the influence of the number of suppliers on firm performance.

THEORY AND HYPOTHESES

Based on our review of the literature, prior studies in supply base management has concentrated on four major factors such as transaction cost (Ellram, 1991; Walker & Poppo, 1991), supplier responsiveness (Treleven & Schweikhart, 1988; Zsidisin & Ellram, 2003), supply risk (Carbone, 1999; Goodman et al., 1995), and supplier innovation (Ellram & Choi, 2000; Raia, 1992). We believe that the optimization of the number of suppliers is closely related to these four critical factors in this field. Consequentially, this research is focused to investigate the influence of the number of suppliers on firm performance in terms of above four dimensions.

Impact on Transaction Cost and Firm Performance

Transaction cost in the supply chain management literature refers to the cost or difficulty incurred in making an economic exchange between a purchasing company and a supplier (Walker & Poppo, 1991). The purchasing company has to experience difficulty in selecting and analyzing suppliers, achieving agreements with suppliers, and making and implementing contracts (Dyer, 1996). Ellram (1991) lists some more specific sources of transaction costs, including making an order, transporting merchandise, inspecting goods, and tracking and even changing an order. Such transaction costs increase inventory costs and management expenses of materials.

Because transaction cost is incurred in the interaction between a purchaser and its suppliers, the reduction of the number of suppliers can decrease the difficulty experienced by the purchaser (Dedrick, Xu, & Zhu, 2008). In addition, the decrease in the number of suppliers enables the purchasing company to establish long-term collaboration relationships with suppliers. During such long-term relationships, opportunistic behavior that suppliers may engage in will be decreased, in turn, the purchasing company will not have to spend much preventing opportunism (Dyer, 1996). Finally, the purchasing company will be likely to have more trade or cash discounts through large-amount purchase from a few suppliers. Because the decrease in the number of suppliers can bring cost and expense savings addressed above, companies around the world have had a surge interest in reducing the number of suppliers since 1980s and this trend will continue.

Impact on Supplier Responsiveness and Firm Performance

Supplier responsiveness can be defined as the timeliness and accuracy of suppliers' responsiveness to new purchaser inquiries. As just-in-time buying and other time management tactics arise, suppliers' quick response to the buyer inquiries has increasingly become an important issue (Dion et al., 1992; Hendrick, 1994; Schonberger & Gilbert, 1983; Sinkovics, et al., 2011). As Goodman et al. (1995) point out, supplier responsiveness has a significant influence on whether the purchasing company has the ability to satisfy customer needs.

It appears that the greater competitive pressures, the higher will be supplier responsiveness. However, according to Celly, Spekman, and Kamauff (1999) and Goodman et al. (1995), competitive pressure is not an important factor in affecting supplier responsiveness. Close relationship and open communication between the buyer and the supplier are critical to helping the supplier make prompt responses (Liker & Choi,

2004). The buyer can effectively communicate to suppliers about needs and concerns to promote quicker supplier responsiveness through the collaboration with a few adequate suppliers. Treleven and Schweikhart (1988) and Larson and Kulchisky (1998) contrast costs and benefits of single vs. multiple sourcing strategies and find that communication between the buyer and the supplier is closer when the buyer adopts single sourcing strategy and thus supplier responsiveness is quicker and more flexible. So we argue that there is a negative relationship between the number of suppliers and supplier responsiveness. The fewer the suppliers, the higher will be supplier responsiveness. Further, if the supplier can quickly respond to buyer inquiries, the buying company will be more likely to use just-in-time purchasing strategy and maintain a low inventory of raw materials. As such, the company's storage charges will be kept low and the company will be more efficient. Other things being equal, the company will have high performance.

The Impact on Supply Risk and Firm Performance

Supply risk is the potential loss resulting from an incident related to supplier failures or unavailability of necessary raw materials (Zsidisin et al., 2004). Purchasing companies face various sources of supply risk, including product unavailability attributed to a damaging event of a supplier and quality problems due to a factor that supplies do not meet quality specifications (Zsidisin & Ellram, 2003). Supply risk not only leads to material storage problems, but increases expenses and results in detrimental consequences. For example, companies may have to wait for supplies, pay fines to clients, and lose trade credit and potential business opportunities.

In contrast to the linear relationship between the number of suppliers and transaction cost and supplier responsiveness discussed above, there may be a curvilinear relationship between the number of suppliers and supply risk (Choi & Krause, 2006). Suppose the purchasing company has only one supplier. Under such a circumstance, all the raw materials are provided by a single supplier and thus the purchasing company is easier to be influenced by any adverse effects of the supplier (Nishiguchi & Beaudet, 1998). Additionally, the purchasing company is likely to face the risk that cannot access to various innovations. On the other hand, a complex supply base is associated with high supply risk. The increase in the number of suppliers also increases the probability of delayed delivery, inconsistent order and supply, and more defects (Handfield & Nichols, 1999). From the purchasing company's perspective, it is very hard to control a large number of suppliers. Therefore, the above discussion indicates that supply risk is high when the number of suppliers is a few or too many. We propose a U-shaped relationship between the number of suppliers and supply risk.

The Impact on Supplier Innovation and Firm Performance

Supplier innovation is a major contributing factor in reducing product costs and improving product quality (Ellram & Choi, 2000; Liker, 2004). For example, supply innovation can prevent the purchasing company from some product depreciation risks, including the replacement of stocked raw materials with new substitutes and the update of product design. Ahuja (2000) provides evidence that direct and indirect connections between the purchasing company and its suppliers have a significant and positive influence on innovation. Networking among companies channels information and

facilitates the accumulation and exchange of innovative ideas. This finding reveals that each additional supplier of the purchasing company has the ability to seek, process, absorb, and exchange information and knowledge to create a synergy, which is greater than the information-processing capability of the company with a single supplier. Dooley and Van de Ven (1999) also argue that the supply base comprised of suppliers with various cultures and different areas of specialties provides fertile ground for innovation. It indicates that the more suppliers, the higher innovative capability suppliers have.

However, Choi et al. (2001) warns against this simple linear relationship. As supply base complexity reach a point, that is, too many independent suppliers exist in the complex system, supplier activities are likely to become random and unstructured (Dooley & Van de Ven, 1999). So there is a critical point of the positive relationship between the number of suppliers in a supply base and supplier innovation. Once beyond this critical point, supplier innovation decreases as the number of suppliers increases. In sum, there is an inverted U-shaped relationship between the number of suppliers and supplier innovation.

As addressed above, there is not a simple linear relationship between the number of suppliers and firm performance. As the buying company gradually reduces a large number of suppliers, transaction cost and supply risk decrease while supplier responsiveness and innovation increase, which lead to higher organizational performance. However, once the number of suppliers is reduced to a critical point, supply risk increases whereas supplier innovation decreases with continuous decrease of suppliers, which result in dropped firm performance. Therefore, we propose a curvilinear relationship between the number of suppliers and firm performance. Specifically, we believe such a curvilinear relationship is inverted U-shaped.

Hypothesis: There is an inverted U-shaped relationship between the number of suppliers and firm performance.

RESEARCH METHOD

Sample

This study is focused on longitudinal (2002-2006) data of listed manufacturing companies in China stock market. Data sources include Juling stock information system, annual reports on China listed companies, CSMAR database, and cnlist.com. Given the differences between state-controlled and private-owned companies in nature, this study focuses on state-controlled companies. So the sample excludes: a) non-state-controlled shareholding companies and b) the companies with insufficient information about suppliers and firm performance. More specifically, the total number of observed information pieces on listed manufacturing companies involved is 2,416.

Table 1 lists annual observation numbers from 2002 through 2006. The number of observations in 2002 is 480. Under the restrictions of information on certain suppliers, the number of observations drops from 500 in 2005 to 432 in 2006. Industry is a key factor that affects the number of suppliers and firm performance. Table 1 also classifies specific industries of involved observations, according to the industry codes announced by China Securities Regulatory Commission (CSRC). As seen from Table 1, the sampled

companies are mainly coming from the industries like: machinery (26%), petrochemicals (19%), and metals and non-metals (17%).

Measures

The number of suppliers. The exact number of suppliers of listed companies involved is not open to the public. The proportion of supply cost that a purchasing company spends on its largest five suppliers can be used as a proxy for the measure of the number of suppliers because a higher percentage of supply cost that a buying company spends on the largest five suppliers to a large extent can indicate a relatively smaller number of suppliers. As such, this observed proportion is used in this research to measure the number of suppliers.

Table 1: Sample Distribution from 2002 to 2006

Year	2002	2003	2004	2005	2006	Total
Number of Observations	480	498	506	500	432	2416

Industry Distribution

Industry	Number of Observations	%	Industry	Number of Observations	%
Food & Beverage	183	8	Electronics	271	11
Textiles & Apparel	139	6	Metal & Non-metal	399	17
Paper & Printing	79	3	Machinery	621	26
Petrochemicals	468	19	Pharmaceuticals	221	9
Others	35	1	Total	2416	100

Firm Performance. Firm performance is measured by sales margin (Margin), the ratio of operating profit to total assets (OROA), and the ratio of operating profit to total sales of a company (OROS). In addition, from supply management's perspective, raw materials are a main component of a manufacturing company's inventory. An efficient inventory management of raw materials is an important factor to evaluate firm performance. Further, the number of suppliers may directly affect the efficiency of inventory management. So, it is necessary to examine the impact of the number of suppliers on performance of inventory management to show how it affects firm performance. The inventory and the depreciation risk of stocked raw materials are two important indices of the efficiency of inventory management. Low inventory and low depreciation risk of raw materials lead to high efficiency of inventory management. In this study, we use natural logarithm of raw materials inventory (LnRI) and days of turnover of inventory (DayRI) to assess the leverage of raw materials inventory while using the ratio of raw materials depreciation reserve to the price of raw materials (DEratio) and the ratio of raw materials depreciation reserve to the cost of sales (DEcost) to evaluate the depreciation risk of raw materials inventory. In summary, firm performance is evaluated by seven indicators, including Margin, OROA, OROS, LnRI, DayRI, DEratio, and DEcost.

Control Variables. This study also includes control variables that are widely used to examine company performance in prior literature (e.g., Acquaah, 2012; Ju, Zhou, Gao, & Lu, 2013). These control variables are certain company characteristics that affect company performance, such as the share held by the company's largest shareholder (Share), company size (Size), liability level (Lever), percentage of fixed assets (Fix), growth rate (Growth), company age (Age), and local marketing index (REG). The detailed operational definitions are listed in Table 2.

Models

The model used to examine the influence of the number of suppliers on a company's inventory is shown below.

$$RI_{it} = \alpha + \beta_1 SUP_{it-1} + \beta_2 SQSUP_{it-1} + \gamma' X_{i_t} + \kappa' I_{i_t} + \theta' Y_t + \varepsilon_{i_t} \quad (1)$$

where i represents the buying company and t (or t-1) represents a year. RI stands for both natural logarithm of raw materials inventory (LnRI) and days of turnover of inventory (DayRI). SUP represents the proportion of supply cost that a purchasing company spends on its five largest suppliers as the proxy for the independent variable, the number of suppliers. Because we propose a curvilinear relationship between the number of suppliers and firm performance, the square of SUP, SQSUP, is involved in this model. To deal with the endogeneity issue, we examine SUP at t-1 rather than t. X in the model represents a series of control variables, including Share, Size, Level, Fix, Growth, Age, and REG. Because our sample involves seven CSRC industries and five years from 2002 to 2006, Model 1 includes six dummy variables of industries (I) and four dummy variables of years (Y). Finally, *e* represents the residual.

The model used to examine the influence of the number of suppliers on the depreciation risk of a company's inventory is shown below.

Table 2: Definitions of Variables in This Study

Variable	Definition
SUP	Ratio of supply cost spent on the five largest suppliers to the total supply cost
LnRI	Natural logarithm of raw materials inventory
DayRI	Ratio of raw materials inventory to sales times 365 days
DEratio	Ratio of raw materials depreciation reserve to the cost of raw materials
DEcost	Ratio of raw materials depreciation reserve to sales
Margin	Difference between sales and costs divided by sales
OROA	Ratio of operating profit to total assets
OROS	Ratio of operating profit to total sales
Share	The percentage of share held by the largest shareholder
Age	Natural logarithm of firm age
Turn	Ratio of sales to total assets
Fix	Ratio of fixed assets to total assets
Growth	Ratio of investment on fixed and other long-term assets to total assets
Lever	Ratio of total liabilities to total assets
Size	Natural logarithm of sales
DEREC	Ratio of bad debt reserve to sales
DEOREC	Ratio of other receivable bad debt reserve to sales
REG	Equals 1 if marketing índex of a province is higher than that of national average; otherwise equals 0

$$DE_{it} = \alpha + \beta_1 SUP_{it-1} + \beta_2 SQSUP_{it-1} + \beta_3 LnRI_{it} + \gamma' X_{it} + \kappa' I_{it} + \theta' Y_t + \varepsilon_{it} \quad (2)$$

where DE represents two inventory depreciation risk variables, the ratio of raw materials depreciation reserve to raw materials cost (DE ratio) and the ratio of raw materials depreciation reserve to sales cost (DE cost). Given that raw materials inventory plays an important role in affecting the depreciation risk of raw materials, we add the variable lnRI to Model 2. Other variables in Model 2 are the same as those in Model 1.

The model used to examine the influence of the number of suppliers on firm performance is shown below.

$$PER_{it} = \alpha + \beta_1 SUP_{it-1} + \beta_2 SQSUP_{it-1} + \beta_3 DEREC_{it} + \beta_4 DEOREC_{it} + \beta_5 Turn_{it} + \gamma' X_{it} + \kappa' I_{it} + \theta' Y_t + \varepsilon_{it} \quad (3)$$

where PER represents three variables of firm performance, sales margin (Margin), the ratio of operating profit to total assets (OROA), and the ratio of operating profit to total sales of a company (OROS). DEREC and DEOREC in Model 3 are the ratios of receivable and other bad debt reserves to sales, respectively. DEREC has an important effect on firm performance. On one hand, receivable bad debt reserve is a company expense and reduces company profit. On the other hand, high risk that receivable debts will become bad ones to some extent reflects loose credit policy a company uses during sales. With loose credit policy, company sales and product price are likely to be high so that sales margin and profit are also likely to be high. Therefore, the coefficient of DEREC can be either positive or negative. DEOREC is another important factor that can affect firm performance. Similar to DEREC, DEOREC is also an expense and directly decreases company profit. In addition, because other company debts mainly stem from the occupation of company cash flows by large shareholders, the higher risk other debts become uncollectible, the larger damage the occupation behavior of large shareholders bring to company performance. So the coefficient of DEOREC is expected to be negative. Finally, Turn in Model 3 represents the ratio of sales to total assets. The higher Turn, the higher will be assets turnover ratio and profitability. Other variables are the same as those in Model 1.

RESULTS

Table 3 reports descriptive statistics of the number of suppliers on a yearly basis. The range of this variable in the sample is relatively large. The minimum proportion purchased from the five largest suppliers is 1% while the maximum is close to 100%. The Means of the variable across years show that the proportions purchased from the five largest suppliers by the sampled companies are more than one third. In addition, we can see from the listed Means and Medians, the proportions purchased from the five largest suppliers drop gradually along the time. For example, the Mean of this variable in 2002 is 40% and it drops to 36% in 2006.

Table 4 lists descriptive statistics of other variables involved in this study. On average, the turnover days of raw materials inventory are about 43 and standard deviation of this variable is relatively large. Further, take the two variables related to the depreciation of a company's inventory, DE cost and DE ratio as an example. For a few companies, the depreciation of raw materials becomes a serious problem – the maximums of DE cost and DE ratio are .83 and 1.00, respectively. Fortunately, standard deviations of these two variables are not large.

Table 3: Descriptive Statistics of the Number of Suppliers

	Mean	S.D	Min	10th	25th	Median	75th	90th	Max.
2002	0.40	0.22	0.04	0.14	0.23	0.35	0.52	0.73	1.00
2003	0.38	0.21	0.03	0.15	0.23	0.34	0.50	0.70	0.99
2004	0.38	0.22	0.02	0.14	0.21	0.34	0.52	0.70	1.00
2005	0.37	0.21	0.00	0.14	0.21	0.33	0.49	0.68	0.99
2006	0.36	0.21	0.03	0.14	0.20	0.32	0.48	0.67	0.98
Total	0.39	0.22	0.00	0.14	0.22	0.34	0.51	0.71	1.00

The correlations for the variables used in the models are provided in Table 5. As it reports, the proportion purchased from the five largest suppliers is positively related to Share, Fix, Turn, and Growth and is negatively related to Size, Lever, and REG. Most correlation coefficients are relatively small except the correlations between Level and DEREC and between Size and Turn, .50 and .67 respectively.

Table 6 displays the regression results of Model 1. Results in (1) and (3) reveal that the proportion purchased from the five largest suppliers (SUP) significantly and negatively affects both raw materials inventory (LnRI) and turnover days of inventory (DayRI) (β_{LnRI} = -.722, $p < .01$; β_{DayRI} = -12.612, $p < .01$), which suggest that raw materials inventory decreases as the number of suppliers drops. As a follow-up, then we tested if there is a curvilinear relationship between a company's inventory and the number of suppliers. SQSUP is added to Models (2) and (4), and the result is significant and negative in Model (2) (β_{LnRI} = -2.143, $p < .01$) while insignificant in Model (4). It demonstrates that there is an inverted U-shaped association between the proportion purchased from the five largest suppliers (i.e., the number of suppliers) and raw materials inventory. Generally speaking, the larger raw materials inventory or the longer turnover days of inventory, the lower will be for the efficiency of inventory management and firm performance. That is, the above result of this research suggests a U-shaped relationship between the number of suppliers and firm performance, which is against our hypothesis. We will discuss this difference later.

The regression results of Model 2 are reported in Table 7. Results in (1) and (3) show that the proportion purchased from the five largest suppliers is significantly and positively related to the depreciation risk of raw materials inventory, which is measured by the ratio of raw materials depreciation reserve to raw materials cost (DEratio) and the

Table 4: Descriptive Statistics of Other Study Variables

	Mean	S.D.	Min	25th	Median	75th	Max
LnRI	17.96	1.40	8.06	17.16	17.95	18.81	23.17
DayRI	42.99	53.21	0.14	18.81	31.29	51.11	749.43
DEcost	0.01	0.04	0.00	0.00	0.00	0.00	0.83
DEratio	0.05	0.10	0.00	0.00	0.01	0.05	1.00
Margin	0.21	0.13	-0.37	0.13	0.19	0.27	0.84
OROA	0.02	0.07	-0.32	0.00	0.02	0.05	0.18
OROS	0.00	0.25	-2.05	0.01	0.04	0.08	0.29
Share	0.46	0.16	0.07	0.32	0.47	0.59	0.85
Age	2.20	0.38	1.10	1.90	2.20	2.50	3.09
Turn	0.69	0.42	0.08	0.40	0.58	0.86	2.18
Fix	0.38	0.18	0.00	0.24	0.36	0.52	0.86
Growth	0.06	0.06	-0.38	0.02	0.04	0.08	0.44
Lever	0.51	0.33	0.02	0.37	0.49	0.61	7.98
Size	20.74	1.30	15.21	19.91	20.66	21.50	25.79
DEREC	0.07	0.62	0.00	0.01	0.02	0.03	22.45
DEOREC	0.10	0.95	0.00	0.00	0.00	0.01	24.52

Table 5: Correlations among Study Variables

	SUP	REG	Share	Age	DEREC	DEOREC	Turn	Fix	Growth	Lever
SUP	1.00									
REG	-0.14**	1.00								
Share	0.12**	-0.01	1.00							
Age	-0.10**	0.14**	-0.44**	1.00						
DEREC	-0.03	0.00	-0.09**	0.08**	1.00					
DEOREC	0.02	-0.04†	-0.08**	0.05*	0.44**	1.00				
Turn	0.04*	0.11**	0.07**	0.10**	-0.09**	-0.11**	1.00			
Fix	0.10**	-0.06**	0.10**	-0.04*	0.02	-0.01	-0.07**	1.00		
Growth	0.04*	-0.01	0.10**	-0.20**	-0.08**	-0.09**	0.02	0.50**	1.00	
Lever	-0.05**	0.03	-0.11**	0.20**	0.50**	0.35**	-0.02	0.05**	-0.09**	1.00
Size	-0.07**	0.12**	0.18**	0.05**	-0.15**	-0.22**	0.67**	0.15**	0.19**	-0.05**

** $p < .01$; * $p < .05$; † $p < .10$.

Table 6: Regression Results Predicting Raw Materials Inventory

	LnRI		DayRI	
	（1）	（2）	（3）	（4）
Constant	2.125**	1.410**	286.478**	280.432**
	（6.76）	(4.28)	(15.67)	（14.52）
SUP	-0.722**	1.331**	-12.612**	4.747
	（-8.55）	（4.22）	(-2.57)	(0.26)
SQSUP		-2.143**		-18.120
		（-6.75）		(-0.97)
REG	-0.142**	-0.155**	-9.474**	-9.586**
	（-3.43）	(-3.78)	(-3.93)	(-3.97)
Share	0.303**	0.295*	15.957*	15.886*
	（2.43）	(2.39)	(2.20)	(2.19)
Age	-0.057	-0.053	-2.864	-2.831
	（-1.02）	(-0.96)	(-0.88)	(-0.87)
Fix	0.640**	0.635**	0.862	0.825
	（-4.87）	（4.88）	(0.11)	(0.11)
Growth	0.389	0.285	8.079	7.203
	（1.18）	（0.87）	(0.42)	(0.38)
Lever	0.315**	0.329**	35.448**	35.566**
	（5.87）	（6.18）	(11.35)	(11.38)
Size	0.770**	0.787**	-11.953**	-11.812**
	（51.95）	（52.83）	(-13.87)	(-13.52)
Adj-R^2	0.637	0.643	0.155	0.155
n	2416	2416	2410	2410

** $p < .01$; * $p < .05$; † $p < .10$. Note. Dummies of Year and Industry are not reported in the table.

Table 7: Regression Results Predicting Depreciation of Raw Materials Inventory

	DEratio		DEcost	
	(1)	(2)	(3)	(4)
Constant	0.203**	0.282**	0.070**	0.093**
	（5.82）	（7.86）	(5.66)	（7.30）
SUP	0.033**	-0.086**	0.010**	-0.062**
	（3.54）	（-2.51）	(3.02)	（-5.08）
SQSUP		0.125**		0.076**
		（3.59）		（6.12）
REG	0.012**	0.013**	0.003†	0.004*
	（2.59）	（2.80）	(1.92)	（2.29）
Share	0.009	0.009	0.002	0.002
	（0.69）	（0.70）	(0.39)	（0.41）
Age	0.017**	0.017**	0.003	0.003
	（2.80）	（2.78）	(1.24)	（1.20）
Fix	0.035**	0.035*	0.013**	0.013**
	（2.46）	（2.43）	(2.57)	（2.54）
Growth	-0.170**	-0.165**	-0.019	-0.015
	（-4.79）	（-4.64）	(-1.47)	（-1.20）
Lever	0.095**	0.093**	0.061**	0.060**
	（16.19）	（16.00）	(29.00)	（28.83）
Size	-0.014**	-0.016**	-0.011**	-0.013**
	（-6.00）	（-6.64）	(-13.69)	（-14.78）
LnRI	0.000	0.001	0.007**	0.008**
	（0.13）	（0.62）	(9.34)	（10.16）
Adj-R^2	0.222	0.226	0.352	0.362
n	2410	2410	2410	2410

** $p < .01$; * $p < .05$; † $p < .10$. Note. Dummies of Year and Industry are not reported in the table.

ratio of raw materials depreciation reserve to sales cost (DEcost) ($\beta_{DEratio}$ = .033, p < .01; β_{DEcost} = .010, p < .01). It suggests that the depreciation risk of raw materials inventory increases as the number of suppliers decreases. Further, in Models (2) and (4), SQSUP significantly and positively affects DE ratio and DE cost ($\beta_{DEratio}$ = .125, p < .01; β_{DEcost} = .076, p < .01), which again reveals a U-shaped relationship between the number of suppliers and the depreciation risk of a company's inventory. As discussed earlier, low depreciation risk of inventory suggests high firm performance. That is, there is an inverted U-shaped relationship between the number of suppliers and firm performance, as we expected.

Table 8 reports the results of regression on firm performance, which is measured by sales margin (Margin), the ratio of operating profit to total assets (OROA), and the ratio of operating profit to total sales of a company (OROS). SUP is significantly related to Margin and OROA and marginally significantly associated with OROS (β_{Margin} = .102, p < .01; β_{OROA} = .068, p < .01; β_{OROS} = .131, p < .10). Moreover, SQSUP significantly and negatively affects Margin, OROA, and OROS (β_{Margin} = -.109, p < .01; β_{OROA} = -.063, p < .01; β_{OROS} = -.162, p < .05), which once again suggest that there is an inverted U-shaped relationship between the number of suppliers and firm performance. Therefore, the proposed hypothesis is supported.

Typically, manufacturing firms spend 55% of their sales income purchasing raw materials (Leenders & Fearon, 1998). So supply base management has an important influence on a company's performance and market value. Manufacturing firms has focused on optimizing the number of suppliers to effectively manage their supply bases during the last two decades. Although there is a growing body of research investigating how to optimize the number of suppliers of a company, most prior work in this area has been either explorative in nature or based on a simple case study. This study theorizes and examines this issue with a large sample. We find that there is an inverted U-shaped relationship between the number of suppliers and firm performance and supply base efficiency.

Although the results in Table 6 support the curvilinear relationship between the number of suppliers and firm performance, the relationship is in the opposite direction of our prediction. Other things being equal, the higher a company's inventory, the lower will be the efficiency of its supply base management. As a matter of fact, this argument is based on two assumptions. First, costs spent on the storage of raw materials increase corporate expenses. Second, large raw materials inventory increases the depreciation risk of raw materials. If a company purchases raw materials on credit and the depreciation risk of raw materials inventory is low, its large inventory will not hurt firm performance but reduce the loss accredited to being out of stock and thus have a positive effect on firm performance. We hence examine the relationship between the number of suppliers and credit buying. In this study, credit buying is measured by the ratio of cash spent on raw materials to sales (Cash RI). The lower Cash RI, the lower proportion of cash spent on inventory, accordingly, the higher credit buying. Table 9 reports the results of regression on Cash RI. In Model (2), SQSUP is significant and positive (β = .534, p < .01), which shows a U-shaped relationship between the proportion purchased from the five largest suppliers and Cash RI. Further, the higher Cash RI and corporate expenses, the lower will be firm performance. So the results in Table 9 also suggest an inverted U-shaped

relationship between the number of suppliers and firm performance, the proposed hypothesis is supported again by the empirical data used in this research.

Table 8: Regression Results Predicting Firm Performance

	Margin	OROA	OROS
	（1）	（2）	（3）
Constant	0.393** (7.77)	-0.236** (-8.64)	-0.696** (-7.41)
SUP	0.102** (2.62)	0.068** (3.21)	0.131† (1.81)
SQSUP	-0.109** (-2.78)	-0.063** (-2.97)	-0.162* (-2.22)
REG	-0.020** (-4.00)	-0.005† (-1.83)	-0.008 (-0.81)
Share	-0.016 (-1.08)	-0.003 (-0.41)	-0.017 (-0.61)
Age	-0.002 (-0.30)	-0.013** (-3.62)	-0.037** (-2.87)
Turn	-0.083** (-11.63)	0.024** (6.29)	0.008 (0.63)
Fix	-0.074** (-4.51)	-0.026** (-2.95)	-0.013 (-0.44)
Growth	0.328** (8.15)	0.270** (12.38)	0.534** (7.13)
Lever	-0.072** (-9.36)	-0.077** (-18.38)	-0.232** (-16.18)
Size	0.001 (0.50)	0.014** (10.51)	0.040** (8.70)
DEREC	0.017** (3.91)	0.016** (7.05)	0.047** (6.03)
DEOREC	-0.020** (-7.73)	-0.004** (-2.83)	-0.094** (-19.77)
Adj-R^2	0.343	0.373	0.388
n	2416	2416	2416

** $p < .01$; * $p < .05$; † $p < .10$. Note. Dummies of Year and Industry are not reported in the table.

Table 9: Regression Results Predicting CashRI

	(1)	(2)
Constant	0.826**	0.994**
	(8.35)	(9.62)
SUP	0.027	-0.481**
	(1.00)	(-4.86)
SQSUP		0.534**
		(5.33)
REG	0.051**	0.055**
	(3.90)	(4.23)
Share	0.012	0.013
	(0.32)	(0.34)
Age	0.007	0.006
	(0.40)	(0.36)
Fix	-0.443**	-0.445**
	(-10.77)	(-10.88)
Growth	0.353**	0.377**
	(3.44)	(3.69)
Lever	0.014	0.009
	(0.82)	(0.53)
Size	-0.003	-0.011†
	(-0.52)	(-1.64)
LnRI	0.014*	0.019**
	(2.24)	(2.96)
Adj-R^2	0.068	0.079
n	2410	2410

** $p < .01$; * $p < .05$; † $p < .10$. Note. Dummies of Year and Industry are not reported in the table.

CONCLUSION

The results of this study suggest that manufacturing companies must consider the potential positive and negative effects of the number of their suppliers on company performance when they increase or decrease the number of suppliers to reach an optimal number. As companies decrease from a large number of suppliers, their transaction costs and supply risks decrease while supplier responsiveness and innovation increase, which lead to better firms' performance. However, as the number of suppliers is decreased to a critical point, any further reduction of the number of suppliers may result in the increase in supply risks and the decrease in supplier innovation and thus lowering firms' performance. Therefore, companies have to analyze the combined effects of the above factors to make a strategic sourcing decision. Adding transaction cost, supplier responsiveness, supply risk, and supplier innovation to the analysis provides a foundation from which researchers embark upon future explorations of the influence of the number of suppliers on company performance. We encourage more research to contribute to a fuller picture of the impact of the number of suppliers.

REFERENCES

Acquaah, M. (2012). Social networking relationships, firm-specific managerial experience and firm performance in a transition economy: A comparative analysis of family owned and nonfamily firms. *Strategic Management Journal,* 33(10):1215-1228.

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: a longitudinal study. *Administrative Science Quarterly* 45, 425–455.

Ballew, B., & Schnorbus, R. (1994). Realigning in auto supplier industry. *Economic Perspectives* 1 (1), 2–9.

Carbone, J. (1999). Supplier service is critical to contract manufacturers. *Purchasing* 127 (8), 35–40.

Celly, K., Spekman, R., & Kamauff, J. (1999). Technological uncertainty, buyer preferences and supplier assurances: an examination of Pacific Rim purchasing arrangements. *Journal of International Business Studies* 30 (2), 297–316.

Choi, T.Y., Dooley, K., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. *Journal of Operations Management* 19, 351–366.

Choi, Thomas Y., Krause, & Daniel R, (2006). The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. *Journal of Operations Management* 24, 637–652.

Dedrick, J., Xu, S. X., & Zhu, K. X. (2008). How does information technology shape supply-chain structure? Evidence on the number of suppliers. *Journal of Management Information Systems,* 25(2): 41-72.

Dion, P., Blenkhorn, D., & Banting, P. (1992). Buyer experience with JIT: some new roles for buyers. *Mid-Atlantic Journal of Business* 28 (2), 113–123.

Dobler, D., & Burt, D. (1996). *Purchasing and Supply Management*. McGraw-Hill, New York.

Dooley, K., & Van de Ven, A. (1999). Explaining complex organizational dynamics. *Organization Science* 10 (3), 358–372.

Dyer, J. H. (1996). Does governance matter? Keiretsu alliances and asset specificity as sources of Japanese competitive advantage. *Organization Science* 7 (6), 649–666.

Ellram, L. (1993). Total cost of ownership: elements and implementation. *International Journal of Purchasing and Materials Management* 29 (4), 3–11.

Ellram, L., & Choi, T. (2000). *Supply Management for Value Enhancement*. National Association of Purchasing Management, Tempe, AZ.

Goodman, P., Fichman, M., Lerch, F., & Snyder, P. (1995). Customer–firm relationships, involvement, and customer satisfaction. *Academy of Management Journal* 38, 1310–1324.

Handfield, R. B., & Nichols, E. L. (1999). *Introduction to Supply Chain Management*. Prentice Hall, Englewood Cliffs, NJ.

Hendrick, T.E. (1994). *Purchasing's Contributions to Time-Based Strategies*. Center for Advanced Purchasing Studies, Tempe, AZ.

Ho, H., & Ganesan, S. (2013). Does knowledge base compatibility help or hurt knowledge sharing between suppliers in competition? The role of customer participation. Journal of Marketing, 77(6): 91-107.

Ju, M., Zhou, Z., Gao, Y., & Lu, J. (2013). Technological Capability Growth and Performance Outcome: Foreign Versus Local Firms in China. *Journal of International Marketing,* 21(2):1-16.

Krause, D.R. (1997). Supplier development: current practices and outcomes. *International Journal of Purchasing and Materials Management* 33 (2), 12–19.

Krause, D.R., & Handfield, R. B. (1999). *Developing a World-Class Supply Base*. Center for Advanced Purchasing Studies, Tempe, AZ.

Larson, P.D., & Kulchitsky, J. D. (1998). Single-sourcing and supplier certification: performance and relationship implication. *Industrial Marketing Management* 27, 73–81.

Leenders, M.R., & Fearon, H. E. (1998). *Purchasing and Supply Management*, 11th ed. Irwin, Chicago.

Liker, J. K. (2004). *The Toyota Way*. McGraw-Hill, New York.

Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard Business Review* 82 (12), 104–113.

Monczka, R. M., Trent, R. J., & Callahan, T. J. (1993). Supply base strategies to maximize supplier performance. *International Journal of Physical Distribution & Logistics Management,* 4: 23-42.

Nishiguchi, T., & Beaudet, A. (1998). The Toyota group and the Aisin fire. *Sloan Management Review* 40 (1), 49–59.

Parmar, D., Wu, T., Callarman, T., Fowler, J., & Wolfe, P. (2010). A clustering algorithm for supplier base management. *International Journal of Production Research,* 48(13): 3803-3821.

Schonberger, R., & Gilbert, J. (1983). Just-in-time purchasing: a challenge for U.S. industry. *California Management Review* 26 (1), 54–68.

Sinkovics, R.R., Jean, R.J., Roath, A.S., & Cavusgil, S. T. (2011). Does IT integration really enhance supplier responsiveness in global supply chains. *Management International Review,* 51(2): 193-212.

Raia, E. (1992). Advantage Chrysler: supplier ideas save automaker millions. *Purchasing* 112 (10), 43.

Treleven, M., & Schweikhart, S. B. (1988). A risk/benefit analysis of sourcing strategies: single vs. multiple sourcing. *Journal of Operations Management* 7 (4), 93–114.

Trent, R. J., & Monczka, R. M. (1998). Purchasing and supply management: trends and changes throughout the 1990s. *International Journal of Purchasing and Materials Management* 34 (3), 2–11.

Walker, G., & Poppo, L. (1991). Profit centers, single-source suppliers, and transaction costs. *Administrative Science Quarterly* 36, 66– 87.

Zsidisin, G. A. & Ellram, L. M. (2003). An agency theory investigation of supply risk management. *Journal of Supply Chain Management,* 39, 15-27.

Zsidisin, G. A., Ellram, L. M. Carter, J.R., & Cavinato, J. L. (2004). An analysis of supply risk assessment techniques. *International Journal of Physical Distribution & Logistics Management,* 34, 397-413.

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