Customer Concentration, Level of Research and Development, and Supplier's Profitability Analysis Based on High-Tech Manufactory Industry

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ABSTRACT. *We use multiple regression model to empirically examine how high-tech manufactory supplier's customer concentration and research and development affect the supplier's profitability, and we also address the underlying mechanisms. Along with hypothesis, we justify that higher high-tech manufactory supplier's customer concentration might lead to lower the supplier's profitability. Higher high-tech manufactory supplier's customer concentration might lead to higher customer's relative bargaining power. High-tech manufactory supplier's higher level of R&D might lead to higher the supplier's profitability. Not along with hypothesis, higher high-tech manufactory supplier's customer concentration is likely leading to lower the supplier's risk and lower supplier's operating efficiency. High-tech manufactory supplier's higher research and development might lead to higher the supplier's risk. High-tech manufactory suppliers' higher research and development might lead to lower the supplier's operating efficiency. There might be an inverted-shape association between high-tech manufactory supplier's customer concentration and the supplier's level of research and development.*

KEYWORDS: *Customer concentration, Suppliers' profitability, Research and development, High-tech manufactory*

1. Introduction

1.1 Previous Studies

Regarding customer concentration affecting firms' overall profitability, many literatures have disputed over whether customer has a negative or positive effect on firm's profitability overall, under firms' different life cycle, or under supplier's different market environment. (Patatoukas 2012) introduced that customer concentration has a positive impact overall on firms' profitability through enhancement of asset utilization and reduction of SG&A expenses.[1] (Irvine P J 2016) broadened the discussion of customer concentration impacting firm's financial performances in the firm's life cycle. [2] (Kelly &Gosman2000) drew a result that customer concentration reduces profitability in perfectly competitive market rather than in oligopoly. [3](Chang H, Hall C M, Paz M. 2017)discovered that the effect of competition on the relationship between customer concentration and cost structure is isolated to the COGS and COGM. " [4]

Regarding research and development, and customer concentration affecting supplier's financial performance, (Louis Raymond and Fosee 2004) introduced R&D intensity as a mediator that connects the effect of customer concentration to supplier's gross margin. It's proposed that commercially dependent SMEs allocate their finance for higher R&D, and R&D intensity can allow small firms to mediate the effect of high customer-based concentration by reversing the direction of dependency. [5]

1.2 Results and Implications

We analyze whether customer concentration has a positive or negative impact on the high-tech manufactory suppliers' overall financial performance (profitability) specifically from three aspects including customer bargaining power, supplier's operating efficiencies, and supplier's risk of bankruptcy. Also, we analyze whether suppliers' level of R&D leads to higher level of suppliers' profitability from three aspects including customer bargaining power, supplier's operating efficiencies, and supplier's risk of bankruptcy. Along with hypothesis, we justify that higher high-tech manufactory supplier's customer concentration might lead to lower the supplier's

profitability. Higher high-tech manufactory supplier's customer concentration might lead to higher customer's relative bargaining power. High-tech manufactory supplier's higher level of R&D might lead to higher the supplier's profitability. Not along with hypothesis, higher high-tech manufactory supplier's customer concentration is likely leading to lower the supplier's risk and lower supplier's operating efficiency. High-tech manufactory supplier's higher research and development might lead to higher the supplier's risk. High-tech manufactory suppliers' higher research and development might lead to lower the supplier's operating efficiency. Also, we analyze the possible relationship between customer concentration and supplier's level of research and development based on the two- way scatterplot. There might be an inverted-U shape association between customer concentration and supplier's level of research and development.

Our results give insight for high-tech manufactory suppliers to control customer-based concentration and level of research and development to achieve the higher profitability.

2. Literature Review and Hypothesis Development

2.1 Customer Concentration and Suppliers' Profitability

2.1.1 Customer Concentration and Customers' Bargaining Power

Customer concentration has a positive relationship with bargaining power. In high-tech industry, when the customer concentration of a supplier is high, the bargaining power of their major customer would be strong. To begin with, the bargaining power of major customer may come from their ability to let the supplier company to be more organized. Customer concentration makes production and investment of suppliers' become organized. A shift in this imposes prompt and heavy losses and thus the threat or even the fear of sanctions is enough to provide customers with considerable bargaining power over transaction prices and trade credit terms. The bargaining power of a major customer influences a firm's financial performance in many aspects by letting the supplier to offer them lower prices, extend trade credits and carry extra inventories. (Scherer 1970) [6]

Ha1: Customer Concentration is positively associated with customer's bargaining power

2.1.2 Customer Concentration and Suppliers' Operating Efficiency

Higher customer concentration predicts higher operational efficiencies through reduced SG&A expenses, enhanced asset utilization, which is reflected by enhanced turnover ratios and shorted cash conversion cycle. Also, customer concentration is associated with higher turnover rates in higher competitive market structure. "Higher customer concentration is associated with higher efficiency gains in the form of reduced SG&A expenses and enhanced asset utilization. Suppliers with higher customer concentration spend less on SG&A per dollar of sales, hold less of their assets in inventory, experience higher asset turnover rates and shorter cash conversion cycle." [1]

Ha2: Customer Concentration is positively associated with Suppliers' Operating Efficiency

2.1.3 Customer Concentration and Suppliers' Risks

The difference in bargaining power may lead to the risk of financial performance reduction due to the high customer concentration. Major customers with stronger bargaining power are more likely to shift the risk of relationship-specific investments to suppliers (Kang, Mahoney, and Tang 2009).[7] For example, large customers may use the strong bargaining power they gain from their position as a leading retailer to extend payment terms and transfer some inventory risk to suppliers. (Gosman and Kelly 2003).[8] With the intensification of competition in the market of suppliers' products, the relative bargaining power between suppliers and powerful customers decreases, because customers will have more alternative suppliers to choose from, and the risk of customer loss will also increase. Prior research highlights that suppliers operating under higher competition face greater operating risks when they have higher customer concentration because major customers have more substitute suppliers to buy from (Dhaliwal et al. 2016). [9] There is a different condition in specific relationship, (Banejree et al 2008) thought that major customer relationships are inherently risky and can break down in a few years. [10] Such failures are expensive, especially for suppliers of unique products, which are made to customer specifications rather than to the market. Customer-specific SG&A expenditures are less transferable than general SG&A investments, thus increasing the firm's fixed SG&A costs, resulting in higher operating leverage and greater negative earnings potential. Therefore, Companies with high customer concentration are more likely to suffer initial losses than those with low customer concentration. Because of establishing and maintaining relationships with major customers requires large, fixed investments early in the relationship, firms in the relationship life cycle will face significant operating risks. (Irvine et al 2016) [2]

On the other hand, if major customers get into financial trouble, suppliers will face risk of losing a lot of substantial future sales. Hertzel, Li, Officer, and Rodgers (2008) also found that if a major customer declares bankruptcy, the other remaining major customers will question its viability because of the impact of one of their major customer's bankruptcy declaration, which may make the firm get into a more terrible financial position. [11] At the same time, (Jorion and Zhang 2009) found that suppliers that provide more trade credit to their customers have seen large negative abnormal returns on their shares around the time of the announcement of bankruptcy.[12] So, If the customer goes bankrupt, the supplier will suffer the risk of losing the expected cash flow due to the failure to collect the receivables.

Finally, the supplier/customer investment loses value when the firms go bankruptcy. In addition to the risk of liquidation, there is a high degree of uncertainty about the terms of future transactions, because the results of a particular-relationship investment cannot be fully predicted in advance (Tirole 1999).[13]

Ha3: Customer Concentration is positively associated with Suppliers' Risks

There is a negative relationship between customer's bargaining power and the supplier's financial performance. Major customers would demand lower prices, purchase irregularly and may delay payments. All those behaviors clearly led to a lower gross margin of the suppliers, which later caused lower revenue as well as lower profit. Industry-level measures of downstream bargaining power are associated with lower upstream gross margin. (Lustgarten.1975, LaFrance .1979, Ravenscraft. 1983). [14] Also, as we take the relatively-week supplier into consideration, relatively more powerful customers might use their power within the supply chain to enhance their own performance by extracting the gains to trade from interactions with their relatively weaker suppliers. (Balakrishnan, Linsmeier, and Venkatachalam 1996; Cooper and Slagmulder 2004; Gosman, Kelly, Olsson, and Warfield 2004; Gosman and Kohlbeck 2009).[15] Additionally, bargaining power has caused risk problems. Firms with greater uncertainties are less likely to make payout.

There is positive relationship between operating efficiency and suppliers' profitability. Operating in a efficient way means operating with less costs and gain more.

We do not know whether the customer bargaining power's effect will dominate the supplier operating efficiency effect. We assume that customer bargaining power is dominating.

Ha: Customer Concentration is negatively associated with suppliers' profitability.

2.2 R&D and Supplier's Profitability

In technology-intensive enterprises, there is a two-way correlation between R&D and profitability. The purpose of enterprises' investment in R&D is to obtain higher income, which is consistent with expanding production capacity and reducing production cost. The effect of R&D intensity is not to directly affect the profitability of enterprises, but to affect the profitability of enterprises by affecting productivity. For a company with high productivity, there will be a significant increase in profit margin in the future as the R&D intensity increases. (Irvine et al 2016) says that the long-term nature of the relationship facilitates the information sharing that benefits the firm's R&D productivity.[2]

In the information technology industry which most regard as a technology intensive industry, R&D is the core competitiveness of enterprises. On the one hand, if an enterprise has a high profit level, it will reduce its survival pressure and invest more money in research and development projects. On the other hand, if the profitability of enterprises is low for a long time, the intensity of R&D intensity will be weakened. Once this happens, enterprises in this industry may be replaced, absorbed, or eliminated. (Linghu2020).[16]

The relationship between the R&D and profitability is complex because they affect each other and are reflected in different financial indicators. In some cases, R&D and enterprise profitability are positively correlated, but there is also a negative correlation. (Raymond & St-Pierre 2004) said that customer concentration seems to negatively affect profitability, SMEs whose products R&D activity is more intense reports significantly higher gross margin. R&D intensity is found to counter the negative effect highly-based customers.[5]

(Shi 2019) But in technology-intensive enterprises, there is a law generally, in the short term, the higher R&D intensity of enterprises may negatively impact the profitability of the enterprises, which is mainly due to the time cost of transformation from R&D investment to the actual productivity, so the investment of R&D on profitability has lag, in other words, it cannot be shown on financial statement immediately. But after a certain amount of time, R&D will show a positive effect. [17]

Hb: R&D intensity is positively associated with suppliers' profitability.

2.3 Customer Concentration and Suppliers' R&D

The relationship between customer concentration and R&D intensity is always a debatable question. Marcin Krolikowski and XiaoJing Yuan discuss this uncertain relationship from both sides by considering customer bargaining power and supplier risk. [18]

When they take customer bargaining power as the mediator, they find out that the relationship between customer concentration and R&D intensity is negative. It is clear that customer concertation has a positive relationship with customer bargaining power, and as customer bargaining power has a negative relationship with R&D intensity of the supplier, and customer concentration is positively associated with customer bargaining power, they get to their first conclusion that customer concentration has a negative relationship with R&D intensity of the supplier.

However, after that they then consider the risk arises from high level of customer concentration. There is a positive relationship between risk and level of R&D. As we know that high customer concentration may cause a risk to the supplier, bringing uncertainty to the future management of the supplier company, so when the supplier aware of the high switching costs they need to bear, they would invest more in R&D and innovation to make sure their major customer do not go to somewhere else. Because customer concentration is positively associated with risk, in this way, the relationship between customer concentration and level of R&D becomes positive.

There is no final conclusion in their paper, but Krokowski and Yuan do give us a thinking that the relationship between customer concentration and R&D intensity is variable.

A more specific idea from Xu Hong, Linzhong Gao and Rui Chen is that the relationship between customer concentration and R&D intensity is in an inverted-U shape when companies are non-group- affiliated firms and the relationship becomes negative when companies are group-affiliated firms. [19] Similarly, this inverted-U shape still exists in regions with a higher level of financial development, but the relationship takes on negative correlation in regions with a lower level of financial development. Their study also shows that as a kind of specific asset investment, enterprise's R&D investment not only demonstrates its value of signal transfer in terms of customer concentration, but also reflects different intensity in different financing constraints scenarios, highlighting its significant moderating effect. Therefore, considering both the ideas from two papers above, we suggested that the relationship between customer concentration and R&D intensity is in U shape.

We admit that the relationship is variable according to different factors, but we do not think it is in an inverted-U shape. And when customer concentration was high enough, it would be more sensible for the supplier to do more specific investment and increase the R&D intensity for their major customer.

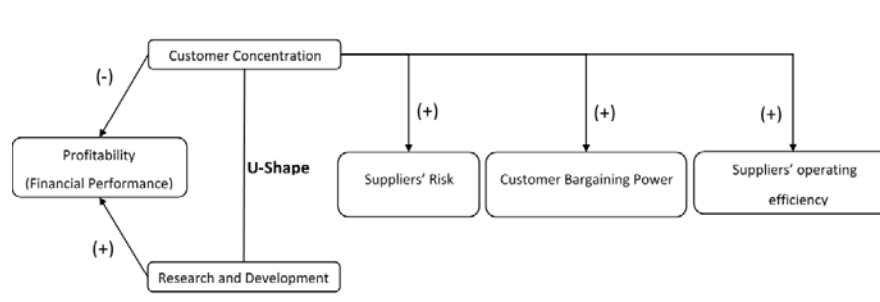Hc: There is a U shape relationship between customer concentration and suppliers' level of R&D.

Fig.1 Hypothesized Relationships between Variables

3. Empirical Analysis

3.1 Summary Statistics

In the study, we adopted data of high-tech manufactory firms of different years. The Standard Industrial Classification (SIC) are four-digit codes that categorize the industries that companies belong to while organizing the industries by their business activities. SIC codes of the chosen high-tech manufactory firms range from 3570 to

3579.

The following are explanations/calculations of all variables.

Explained Variables:

(1) PM: Profit margin. Profit margin is one of the commonly used profitability ratios.

It represents what percentage of sales has turned into profits. Higher supplier's profit margin represents higher supplier's profitability.

PM=gross profit/gross sales

GM: Gross margin. Gross margin is the sales revenue a company retains after incurring the direct costs associated with producing the goods it sells, and the services it provides. Higher supplier's gross margin represents higher supplier's profitability.

GM=operating income after considering depreciation/sales

(2) ROA: Return on asset. Return on Assets (ROA) is an indicator of how well a company utilizes its assets, by determining how profitable a company is relative to its total assets. Higher supplier's ROA indicates more asset efficiency and higher supplier's profitability.

ROA=net income/total assets

(3) ROE: Return on equity. ROE is considered a measure of how effectively management is using a company's assets to create profits. Return on equity (ROE) is a measure of financial performance calculated by dividing net income by shareholders' equity. Higher supplier's ROE indicates more net asset efficiency and higher supplier's profitability.

ROE=(total assets/shareholders' equity)*ROA

=(total assets/shareholders' equity)*(net income/total assets)

=net income/shareholders' equity

(4) %rtopc: percent total revenue from the top customer. Higher supplier's %rtopc indicates higher top customer's relative bargaining power since the supplier has it total revenue highly relied on the top customer.

(5) %rmainc: percent total revenue from major customers. Higher supplier's %rmainc indicates higher major customers' relative bargaining power since the supplier has it total revenue highly relied on the major customers.

(6) Altman Z: The Altman Z-score is the output of a credit-strength test that gauges a publicly-traded manufacturing company's likelihood of bankruptcy.

Z-Score = 1.2A + 1.4B + 3.3C + 0.6D + 1.0E

A = working capital / total assets

B = retained earnings / total assets

C = earnings before interest and tax / total assets

D = market value of equity / total liabilities

E = sales / total assets

(7) FAT: Fix asset turnover. The fixed asset turnover ratio (FAT) is used to measure operating performance. This efficiency ratio compares net sales (income statement) to fixed assets (balance sheet) and measures a company's ability to generate net sales from its fixed- asset investments, namely property, plant, and equipment (PP&E). A higher supplier's FAT indicates that a company has effectively used investments in fixed assets to generate sales, so as supplier's higher operating efficiency.

FAT= annual total sales/ (total Net Property and equipment at the start of a year+ total Net Property and equipment at the end of a year)/2

(8) TAT: Total asset turnover. The asset turnover ratio measures the value of a company's sales or revenues relative to the value of its assets. The asset turnover ratio can be used as an indicator of the efficiency with which a company is using its assets to generate revenue. The higher the asset turnover ratio, the more efficient a company is at generating revenue from its assets, so as supplier's higher operating efficiency.

TAT=Annual Total sales/ (Assets at the start of a year+ Assets at the end of a year)/2 Explanatory Variables:

(1) R&D Intensity: Research and development intensity. It is one of the indicators for science and technology devotion.

R&D intensity= R&D Spending/Revenue

(2) R&D Spend: Research and development spending. It is one of the indicators for science and technology devotion.

(3) CC: Customer concentration. customer concentration is a measure of how total revenue is distributed among your customer base. A company serving a large number of small- volume customers has a lower customer concentration than a firm where a handful of large customers account for the majority of its business.

(4) Rank (CC): Rank customer concentration. I use decile rank transformations. Firms are ranked annually and assigned to deciles based on CC. The raw values of DCC are replaced by the corresponding annual decile ranks, scaled to lie between 0 (lowest rank) and 1 (highest rank). Controlled Variables:

(5) Age: Firm's age.

(6) IHI: Industry Herfindahl Index.

(7) SG: Sales growth.

(8) FL: Financial leverage.

(9) CONGLO: Whether the supplier is a conglomerate. If the firm is a conglomerate, its' CONGLO is "1". If the firm is not a conglomerate, its' CONGLO is "0".

Table 1 Summary Statistics of Key Variables for Modeling Customer Concentration, Level of R&D and Suppliers' Financial Performances

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
PM	182	.4747384	.1865316	-.0995946	.9134635
GM	182	-.87391	.2675241	-1.475582	.2376818
ROA	182	-.1280759	.3120161	-2.548673	.3630815
ROE	182	.5628993	11.6929	-10.47619	156.5043
R&D Spend	182	258.2428	954.414	0	5942
R&D Intensity	182	.1795633	.2081931	0	1.574089
CC	182	.1739339	.1774318	.0098526	.9375398
Rank(CC)	182	.507326	.2811288	0	1
AGE	182	17.60989	9.829289	1	40
IHI	182	.0471246	.0035637	.0388658	.051162
SG	182	.1201613	.4221662	-.4724318	2.842147
FL	182	-.4478263	30.6232	-409.1478	16.62603
CONGLO	182	.4065934	.4925528	0	1

Table 2 Summary Statistics of Key Variables for Modeling Customer Concentration, Level of R&D and Customer Bargaining Power

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
CC	152	.1608585	.166322	.0098526	.9025028
Rank(CC)	152	.4912281	.274119	0	1
R&D Intensity	152	.1551419	.1545196	0	.9992547
R&D Spend	152	256.1768	950.5023	0	5942
TAT	152	1.048963	.6099982	.0201611	3.863379
AGE	152	18.67763	9.495626	2	40
SG	152	.0894265	.3189258	-.4724318	1.335308
FL	152	-.9179222	33.47542	-409.1478	16.62603
CONGLO	152	.4276316	.4963706	0	1
IHI	152	.0468914	.0035479	.0388658	.051162

Table 3 Summary Statistics of Key Variables for Modeling Customer Concentration, Level of R&D and Suppliers' Risk of Bankruptcy

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
CC	162	.1760372	.182677	.0098526	.9375398
Rank(CC)	162	.5068587	.2829244	0	1
R&D Intensity	162	.1406544	.1264314	0	.9992547
R&D Spend	162	288.5435	1007.786	0	5942
Altman Z	162	-1.828678	20.86901	-227.6751	14.3272
AGE	162	18.72222	9.396874	1	40
SG	162	.0551476	.2683929	-.4724318	1.147195
FL	162	-.5949228	32.44638	-409.1478	16.62603
CONGLO	162	.4567901	.499674	0	1
IHI	162	.0471454	.0035677	.0388658	.051162

Table 4 Summary Statistics of Key Variables for Modeling Customer Concentration, Level of R&D and Suppliers' Operating Efficiency (Fix Asset Turnover)

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
CC	148	.1580172	.182677	.0098526	.9025028
Rank(CC)	148	.484985	.2829244	0	1
R&D Spend	148	262.5218	.1264314	0	5942
R&D Intensity	148	.1524702	1007.786	0	.9992547
FAT	148	26.94352	20.86901	.1924444	178.5669
AGE	148	9.411357	9.396874	2	40
SG	148	.3196075	.2683929	-.4724318	1.335308
FL	148	33.92425	32.44638	-409.1478	16.62603
CONGLO	148	.496124	.499674	0	1
IHI	148	.0035255	.0035677	.0388658	.051162

Table 5 Summary Statistics of Key Variables for Modeling Customer Concentration, Level of r&d and Suppliers' Operating Efficiency (Total Asset Turnover)

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
CC	152	.1608585	.166322	.0098526	.9025028
Rank(CC)	152	.4912281	.274119	0	1
R&D Intensity	152	.1551419	.1545196	0	.9992547
R&D Spend	152	256.1768	950.5023	0	5942
TAT	152	1.048963	.6099982	.0201611	3.863379
AGE	152	18.67763	9.495626	2	40
SG	152	.0894265	.3189258	-.4724318	1.335308
FL	152	-.9179222	33.47542	-409.1478	16.62603
CONGLO	152	.4276316	.4963706	0	1
IHI	152	.0468914	.0035479	.0388658	.051162

3.2 Empirical Modeling and Robustness Check

We use multiple regression models to examine the relationship between Customer Concentration, Level of R&D and Suppliers' financial performances, the relationship between Customer Concentration, Level of R&D and Customer Bargaining Power, the relationship between Customer Concentration, Level of R&D and Suppliers' Risks, and the relationship between Customer Concentration, Level of R&D and Suppliers' Operating Efficiency.

3.2.1 Customer Concentration, Research and Development, and Suppliers' Profitability

Regarding the relationship between Customer Concentration, Level of R&D and Suppliers' financial performances, we include gross margin(GM), profit margin(PM), return on assets (ROA), return on equity (ROE) as explained variables, customer concentration(CC)and R&D Intensity (R&D Intensity) each as explanatory variable, and age of the firm(AGE),Industry Herfindahl Index(IHI), sales growth(SG), financial leverage(FL), whether or not conglomerate(CONGLO) as controlled variables. To check for the robustness of the relationship between Customer Concentration, Level of R&D and Suppliers' financial performances, we introduce Rank

Customer Concentration (Rank (CC)) and R&D Spending (R&D Spend) each as a new response variable. (ε) is the error term accounting for random disturbances.

Table 6 Customer Concentration, Research and Development, and Suppliers' Profitability

	(1)	(2)	(3)	(4)
VARIABLES	GM	PM	ROA	ROE
CC	0.0164	-0.146**	-0.134	0.439
	(0.0830)	(0.0672)	(0.119)	(0.405)
R&D Intensity	-0.984***	0.498***	-0.675***	-1.836***
	(0.0904)	(0.0732)	(0.129)	(0.440)
AGE	0.00245	-0.000338	8.53e-05	-0.00508
	(0.00170)	(0.00137)	(0.00243)	(0.00827)
IHI	4.810	3.062	3.135	-5.340
	(4.233)	(3.424)	(6.047)	(20.62)
SG	0.266***	-0.0743**	0.263***	0.593***
	(0.0426)	(0.0345)	(0.0609)	(0.208)
FL	0.000104	0.000395	0.000436	-0.381***
	(0.000475)	(0.000384)	(0.000679)	(0.00231)
CONGLO	0.0514	-0.0524*	0.121**	0.655***
	(0.0330)	(0.0267)	(0.0471)	(0.161)
Constant	-0.236	0.303*	-0.213	0.649
	(0.207)	(0.167)	(0.295)	(1.007)
Observations	182	182	182	182
R-squared	0.495	0.320	0.242	0.994

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
GM= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
PM= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROA= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROE= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 7.

There is a negative association between customer concentration and suppliers' profit margin at 95% confidence level.

There is a positive association between R&D intensity and profit margin at 99% confidence level, while there are negative associations between R&D intensity and gross margin, return on asset, return on equity at 99% confidence level.

Table 7 Customer Concentration, Research and Development Intensity, and Suppliers' Profitability Robustness Check 1

	(1)	(2)	(3)	(4)
VARIABLES	GM	PM	ROA	ROE
Rank(CC)	0.0286	-0.0237	-0.0611	0.146
	(0.0528)	(0.0433)	(0.0757)	(0.258)
R&D Intensity	-0.988***	0.501***	-0.667***	-1.855***
	(0.0906)	(0.0743)	(0.130)	(0.443)
AGE	0.00230	-0.000478	0.000210	-0.00514
	(0.00172)	(0.00141)	(0.00247)	(0.00842)
IHI	4.772	2.235	2.576	-3.236

	(4.204)	(3.446)	(6.021)	(20.54)
SG	0.268***	-0.0705**	0.263***	0.587***
	(0.0427)	(0.0350)	(0.0612)	(0.209)
FL	0.000105	0.000363	0.000411	-0.381***
	(0.000474)	(0.000389)	(0.000679)	(0.00232)
Conglo	0.0527	-0.0473*	0.123***	0.645***
	(0.0329)	(0.0270)	(0.0472)	(0.161)
Constant	-0.243	0.328*	-0.184	0.561
	(0.206)	(0.169)	(0.296)	(1.009)
Observations	182	182	182	182
R-squared	0.496	0.303	0.239	0.994

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
GM= α0 + α1Rank (CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
PM= α0 + α1Rank (CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROA= α0 + α1Rank (CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROE= α0 + α1Rank (CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 8.

When we use Rank (CC) as the explanatory variable, we do not discover significant correlation between Rank (CC) and all the listed financial performance indicators.

We find positive associations between R&D intensity and all the listed financial performance indicators at 99% confidence level.

Table 8 Customer Concentration, Research and Development Intensity, and Suppliers' Profitability Robustness Check 2

	(1)	(2)	(3)	(4)
VARIABLES	GM	PM	ROA	ROE
CC	0.00597	-0.153**	-0.143	0.418
	(0.104)	(0.0733)	(0.125)	(0.421)
R&D Spend	6.88e-05***	4.51e-05***	6.06e-05***	0.000139*
	(1.91e-05)	(1.35e-05)	(2.30e-05)	(7.73e-05)
AGE	0.00494**	-0.00269*	0.00161	-0.000585
	(0.00210)	(0.00148)	(0.00253)	(0.00851)
IHI	6.924	2.249	4.627	-1.365
	(5.290)	(3.732)	(6.374)	(21.41)
SG	0.0204	0.0507	0.0940*	0.134
	(0.0452)	(0.0319)	(0.0545)	(0.183)
FL	-0.000143	0.000473	0.000259	-0.382***
	(0.000594)	(0.000419)	(0.000716)	(0.00240)
Conglo	0.147***	-0.0879***	0.189***	0.835***
	(0.0402)	(0.0284)	(0.0484)	(0.163)
Constant	-0.582**	0.461**	-0.453	0.00250
	(0.256)	(0.180)	(0.308)	(1.035)
Observations	182	182	182	182
R-squared	0.210	0.191	0.156	0.993

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
GM= α0 + α1CC+ α2R&D Spend + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
PM= α0 + α1CC+ α2R&D Spend + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROA= α0 + α1CC+ α2R&D Spend + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε ROE= α0 + α1CC+ α2R&D Spend + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 9.

When we use R&D Spend as the explanatory variable, we discover negative association between customer concentration and suppliers' profit margin at the significance level of 99%. We find positive associations between suppliers' R&D Spend and all the listed financial performance indicators at 99% confidence level.

We have enough evidence to conclude that customer concentration is negatively associated with suppliers' profitability, and suppliers' level of R&D is positively associated with suppliers' financial performances.

3.2.2 Customer Concentration, Research and Development and Customers' Bargaining Power

Regarding the relationship between Customer Concentration, Level of R&D and Customer Bargaining Power, we include percent total revenue from the top customer (%rtopc) as explained variables, customer concentration(CC)and R&D Intensity (R&D Intensity) each as explanatory variable, and age of the firm(AGE),Industry Herfindahl Index(IHI), sales growth(SG), financial leverage(FL), whether or not conglomerate(CONGLO) as controlled variables. To check for the robustness of the relationship between Customer Concentration, Level of R&D and Customer Bargaining Power, we introduces Rank Customer Concentration (Rank(CC)) ,R&D Spending (R&D Spend) each as a new explanatory variable, and percent total revenue from major customers (%rmainc) as a new response variable. (ε) is the error term accounting for random disturbances.

Table 9 Customer Concentration, Research and Development and Top Customer's Bargaining Power

VARIABLES	(1)%rtopc	(2)%rtopc	(3)%rtopc	(4)%rtopc
CC	0.899*** (0.0493)	-0.228***	0.894*** (0.0490)	
R&D Intensity	-0.156***			
	(0.0537)	(0.0611)		
AGE	0.00127	-0.000324	0.00140	0.000315
	(0.00101)	(0.00116)	(0.000992)	(0.00118)
SG	0.0550**	0.0618**	0.0161	0.00429
	(0.0253)	(0.0288)	(0.0213)	(0.0250)
FL	-0.000237	-8.41e-05	-0.000288	-0.000141
	(0.000282)	(0.000320)	(0.000280)	(0.000329)
CONGLO	0.0159	0.0121	0.0341*	0.0334
	(0.0196)	(0.0222)	(0.0190)	(0.0223)
HHI	0.936	4.093	1.333	4.655
	(2.515)	(2.832)	(2.495)	(2.915)
RANK(CC)		0.528***	3.00e-05***	0.511*** (0.0368)
R&D Spend		(0.0356)		1.85e-05*
	0		(9.01e-06)	(1.07e-05)
Constant	.0704	-0.148	0.0115	-0.225
	(0.123)	(0.139)	(0.121)	(0.142)
Observations	182	182	182	182
R-squared	0.677	0.585	0.681	0.560

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
%rtopc = α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
%rtopc = α0 + α1Rank(CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
%rtopc = α0 + α1CC+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGL
%rtopc = α0 + α1Rank(CC)+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 10.

There is a positive relationship between customer concentration and percent total revenue from top customer at 99% confidence level. There is a negative relationship between R&D Intensity and percent total revenue from top customer at 99% confidence level.

When we use Rank (CC) as the explanatory variable, we discover a positive relationship between Rank(CC) and percent total revenue from top customer at 99% confidence level, and there is a negative relationship between R&D Intensity and percent total revenue from top customer at 99% confidence level.

When we use R&D spend as the explanatory variable, we discover a positive relationship between R&D spend and percent total revenue from top customer at 99% confidence level, and there is a positive relationship between customer concentration and percent total revenue from top customer at 99% confidence level.

When we use Rank(CC) and R&D spend as the explanatory variable, we discover that there is a positive relationship between Rank(CC) and percent total revenue from top customer at 99% confidence level, and there is a positive relationship between R&D spend and percent total revenue from top customer at 90% confidence level.

We have enough evidence to conclude that customer concentration is positively associated with the top customers' bargaining power. However, it seems that the relationship between suppliers' R&D level and the top customer's bargaining power is not robust enough.

Table 10 Customer Concentration, Research and Development and Major Customers' Bargaining Power

VARIABLES	(1)%rmainc	(2)%rmainc	(3)%rmainc	(4)%rmainc
CC	1.148*** (0.0662)	0.0453	1.149*** (0.0669)	
R&D Intensity	0.152**			
	(0.0721)	(0.0615)		
AGE	0.000943	-0.00181	0.000557	-0.00163
	(0.00135)	(0.00117)	(0.00135)	(0.00113)
SG	-0.0458	-0.0281	-0.00790	-0.0166
	(0.0340)	(0.0290)	(0.0291)	(0.0239)
FL	-0.000165	1.76e-05	-0.000127	4.35e-05
	(0.000379)	(0.000322)	(0.000382)	(0.000315)
CONGLO	0.0257	0.0290	0.0109	0.0212
	(0.0263)	(0.0224)	(0.0259)	(0.0213)
HHI	-5.083	-1.622	-5.408	-1.839
	(3.374)	(2.853)	(3.407)	(2.787)
RANK(CC)		0.787*** (0.0359)	-1.05e-05	0.800*** (0.0352)
R&D Spend				-2.98e-05***
			(1.23e-05)	(1.02e-05)
Constant	0.477***	0.178	0.530***	0.196
	(0.165)	(0.140)	(0.165)	(0.136)
Observations	182	182	182	182
R-squared	0.645	0.743	0.638	0.754

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
%rmainc = α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
%rmainc = α0 + α1Ran k(CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
%rmainc = α0 + α1CC+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε
%rmainc = α0 + α1Rank (CC)+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 11.

There is a positive relationship between customer concentration and percent total revenue from major customers at 99% confidence level. There is a positive relationship between R&D Intensity and percent total revenue from major customers at 95% confidence level.

When we use Rank(CC) as the explanatory variable, we discover a positive relationship between Rank(CC) and percent total revenue from major customers at 99% confidence level, and there is not a significant relationship between R&D Intensity and percent total revenue from major customers.

When we use R&D spend as the explanatory variable, we do not discover a significant relationship between R&D spend and percent total revenue from major customers, and there is a positive relationship between customer concentration and percent total revenue from major customers at 99% confidence level. When we use Rank(CC) and R&D spend as the explanatory variable, we discover that there is a positive relationship between Rank(CC) and percent total revenue from top customer at 99% confidence level, and there is a negative relationship between R&D spend and percent total revenue from major customers at 99% confidence level.

We have enough evidence to conclude that customer concentration is positively associated with the major customers' bargaining power. However, it seems that the relationship between suppliers' R&D level and the major

customers' bargaining power is not robust enough.

In conclusion, customer concentration is positively associated with customers' bargaining power. While, the relationship between R&D level and customers' bargaining power is undetermined.

3.2.3 Customer Concentration, Research and Development and Suppliers' Operating Efficiency

Regarding the relationship between Customer Concentration, Level of R&D and Suppliers' Operating Efficiency, we include total assets turnover(TAT) and fix assets turnover (FAT) each as the explained variable, customer concentration(CC)and R&D Intensity (R&D Intensity) each as explanatory variable, and age of the firm(AGE),Industry Herfindahl Index(IHI), sales growth(SG), financial leverage(FL), whether or not conglomerate(CONGLO) as controlled variables. To check for the robustness of the relationship between Customer Concentration, Level of R&D and Suppliers' Operating Efficiency, we introduces Rank Customer Concentration(Rank(CC)) , R&D Spending (R&D Spend) each as a new explanatory variable.(ε) is the error term accounting for random disturbances.

Table 11 Customer Concentration, Research and Development and Suppliers' Operating Efficiency

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	TAT	TAT	TAT	TAT	FAT	FAT	FAT	FAT
CC	0.00969		0.117		-19.52		-16.87	
	(0.284)		(0.284)		(13.80)		(13.59)	
R&D Intensity	-1.074***	-1.071***			-18.52	-15.75		
	(0.333)	(0.331)			(16.72)	(16.44)		
AGE	0.0198***	0.0212***	0.0246***	0.0257***	0.453*	0.551**	0.580**	0.654**
	(0.00537)	(0.00544)	(0.00532)	(0.00539)	(0.262)	(0.263)	(0.254)	(0.254)
SG	0.140	0.118	0.0135	-0.00826	2.383	1.096	0.823	-0.134
	(0.154)	(0.154)	(0.148)	(0.148)	(7.395)	(7.301)	(7.071)	(6.983)
FL	-0.00193	-0.00190	-0.00212	-0.00208	-0.140**	-0.142**	-0.143**	-0.144**
	(0.00137)	(0.00137)	(0.00137)	(0.00137)	(0.0658)	(0.0647)	(0.0647)	(0.0638)
CONGLO	-0.349***	-0.366***	-0.283***	-0.299***	-20.38***	-21.17***	-19.75***	-20.59***
	(0.103)	(0.103)	(0.100)	(0.0999)	(4.970)	(4.882)	(4.766)	(4.707)
HHI	-6.746	-6.585	-6.067	-5.323	-368.7	-458.5	-447.4	-519.1
	(13.35)	(13.23)	(13.36)	(13.26)	(646.2)	(633.4)	(637.6)	(626.2)
RANK(CC)		-0.183		-0.120		-21.24**		-19.09**
		(0.173)		(0.176)		(8.354)		(8.324)
R&D Spend			-0.000153***	-0.000147***			-0.00538**	-0.00482**
			(4.84e-05)	(4.87e-05)			(0.00229)	(0.00227)
Constant	1.295**	1.363**	1.013	1.042	50.14	59.79*	49.53	58.41*
	(0.655)	(0.655)	(0.644)	(0.646)	(31.56)	(31.26)	(30.73)	(30.50)
Observations	152	152	152	152	148	148	148	148
R-squared	0.202	0.208	0.200	0.201	0.155	0.181	0.180	0.201

Standard errors in parentheses

***p<0.01, **p<0.05, *p<0.1

TAT= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

TAT= α0 + α1Rank(CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

TAT= α0 + α1CC+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε   TAT= α0 + α1Rank(CC)+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε FAT= α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+

α7CONGLO+ε

FAT= α0 + α1Rank(CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

FAT= α0 + α1CC+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

FAT= α0 + α1Rank(CC)+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

The following are the descriptions of the regressions results displayed in table 12

There is no significant relationship between customer concentration and total asset turnover. R&D intensity is negatively associated with TAT at a confidence level of 99%. There is no significant relationship between CC and TAT.

When we use Rank (CC) as the explanatory variable, we discover no significant relationship between Rank (CC) and TAT, and R&D intensity is negatively associated with TAT at a confidence level of 99%. When we use R&D Spend as the explanatory variable, we discover no significant relationship between CC and TAT, and R&D spend is negatively associated with TAT at a confidence level of 99%.

When we use Rank (CC) and R&D spend as explanatory variables, we discover no significant relationship between Rank(CC) and TAT, and R&D spend is negatively associated with TAT at a confidence level of 99%.

We have enough evidence to conclude that there is a negative association between suppliers' R&D intensity and suppliers' total assets turnover. While, the relationship between customer concentration and total assets turnover is not significant.

There is no significant relationship between customer concentration and fix asset turnover. There is no significant relationship between R&D intensity and FAT.

When we use Rank (CC) as the explanatory variable, we discover negative relationship between Rank (CC) and total asset turnover at a confidence level of 95%, and there is no significant relationship between R&D intensity and FAT.

When we use R&D Spend as the explanatory variable, we discover negative relationship between R&D spend and FAT at a confidence level of 95%, and there is no significant relationship between CC and FAT.

When we use Rank (CC) and R&D spend as explanatory variables, we discover a negative relationship between Rank (CC) and FAT at a confidence level of 95%, and R&D spend is negatively associated with FAT at a confidence level of 95%.

We have enough evidence to conclude that there is a negative association between suppliers' level of R&D and suppliers' fix asset turnover. While, there is a negative association between customer concentration and suppliers' fix asset turnover.

In conclusion, there is a negative association between suppliers' R&D level and suppliers' operating efficiencies, and there is a negative association between customer concentration and suppliers' operating efficiencies.

3.2.4 Customer Concentration, Research and Development and Suppliers' Risks

Regarding the relationship between Customer Concentration, Level of R&D and Suppliers' Risks, we include Altman Z score (Altman Z) as the explained variable, customer concentration(CC)and R&D Intensity (R&D Intensity) each as explanatory variable, and age of the firm(AGE),Industry Herfindahl Index(IHI), sales growth(SG), financial leverage(FL), whether or not conglomerate(CONGLO) as controlled variables. To check for the robustness of the relationship between Customer Concentration, Level of R&D and Suppliers' Risks, we introduce Rank Customer Concentration (Rank (CC)), R&D Spending (R&D Spend) each as a new explanatory variable. (ε) is the error term accounting for random disturbances.

Table 12 Customer Concentration, Research and Development and Suppliers' Risks

VARIABLES	(1) Altman Z	(2) Altman Z	(3) Altman Z	(4) Altman Z
CC	-28.15*** (9.136)	-28.25*** (8.890)		
R&D Intensity	-2.577		-1.862	
	(13.33)		(13.39)	
AGE	0.0291	0.0286	0.0909	0.0920
	(0.195) 13.14**	(0.186) 11.64*	(0.200) 12.82**	(0.191) 11.24*

SG	(6.296)	(6.150)	(6.332)	(6.178)
FL	-0.00163	0.00228	-0.00605	-0.00196
	(0.0505)	(0.0492)	(0.0506)	(0.0492)
CONGLO	0.178	1.421	0.203	1.420
	(3.602)	(3.501)	(3.617)	(3.511)
HHI	212.4	347.1	112.0	250.9
R&D Spend Rank(CC)	(484.4)	(473.2) -0.00459*** (0.00159)	(482.9) -17.48***	(471.3) -0.00471*** (0.00160) -17.96***
			(6.046)	(5.874)
Constant	-8.072	-13.86	-0.684	-6.315
	(23.55)	(22.70)	(23.57)	(22.70)
Observations	157	157	157	157
R-squared	0.098	0.145	0.091	0.141

Standard errors in parentheses
*** *p<0.01, ** p<0.05, * p<0.1*

Altman Z = α0 + α1CC+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε Altman Z = α0 + α1Rank(CC)+ α2R&D Intensity + α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε Altman Z = α0 + α1CC+ α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

Altman Z = α0 + α1Rank (CC)+α2R&D Spend+ α3AGE+ α4IHI+ α5SG+ α6FL+ α7CONGLO+ε

There is a negative association between CC and Altman Z at a confidence level of 99%. There is no significant association between R&D Intensity and Altman Z.

When we use R&D spend as the explanatory variable, we discover negative association between R&D intensity and Altman Z at a significance level of 99%, and there is a negative association between CC and Altman Z at a significance level of 99%.

When we use Rank (CC) as the explanatory variable, we discover negative association between Rank (CC) and Altman Z at a significance level of 99%, and there not a significant association between R&D Intensity and Altman Z.

When use Rank (CC) and R&D Spend as explanatory variables, we discover negative association between Rank (CC) and Altman Z at a significance level of 99%, and there is a negative association between R&D Spend and Altman Z at a significance level of 99%.

We have enough evidence to conclude that there is a negative association between customer concentration and suppliers' risk. There is a negative association between suppliers' level of R&D and suppliers' risk.

3.2.5 Customer Concentration and Research and Development

We use the two-way scatter plot to display the potential relationships between customer concentration and level of R&D.
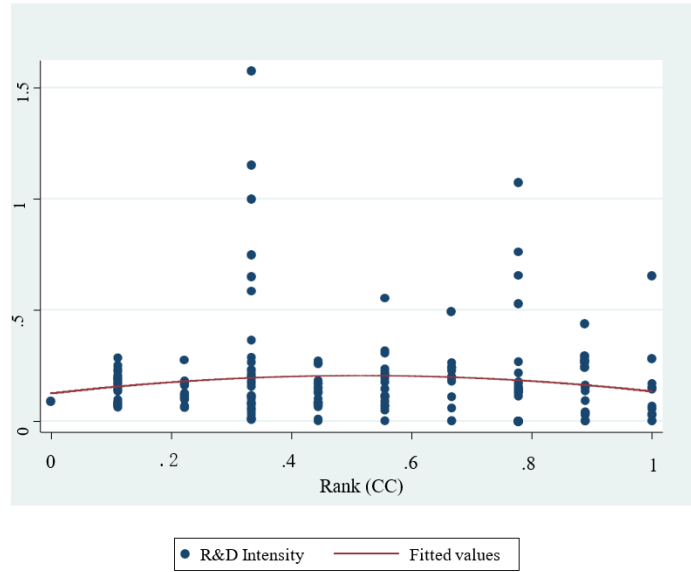
Fig.2 Customer Concentration and Research and Development

There seems an inverted U shape relationship between Rank (CC) and R&D Intensity.

4. Conclusion

4.1 Results and Implications

Based on empirical analysis, we find that higher customer concentration might lead to lower overall high-tech manufactory suppliers' profitability. Higher customer concentration might lead to higher customer bargaining power. Higher level of R&D might lead to higher high-tech manufactory suppliers' profitability. What is interesting is that higher customer concentration is likely leading to lower high-tech manufactory suppliers' risk and operating efficiencies. High-tech manufactory suppliers' higher research and development might lead to higher risk. Higher research and development level might lead to lower suppliers' operating efficiency.

There might be an inverted-shape association between customer concentration and suppliers' level of research and development. However, we do not know whether higher customer concentration cause suppliers' level of research and development to change because we cannot conclude that it's higher suppliers' risk causing suppliers' lower level of R&D, that it's higher operating efficiency causing suppliers' lower level of R&D.
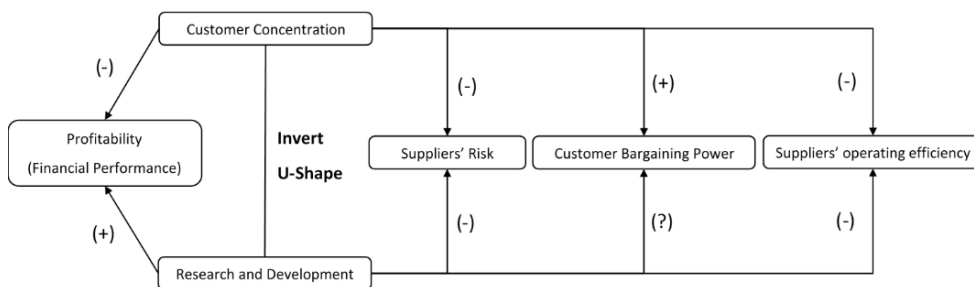

Fig.3 Relationships between Variables Based on Empirical Analysis

4.2 Limitations and Further Studies

From the sampling standpoint, we chose high-tech manufactory firms which SIC codes range from 3570 to

3579. Further studies might enlarge the sample.

For the indicator of suppliers' risk, we only use Altman Z score which measures the suppliers' like-hood of bankruptcy. There might be other indicators to measure suppliers' risks. Further studies might include more variables indicating for suppliers' risks. For the indicator of suppliers' operating efficiencies, we only include total asset turnover and fix asset turnover. There are other indicators to measure suppliers' operating efficiency. Further studies might include more variables indicating for suppliers' operating efficiency.

We only study the potential association between customer concentration and level of research and development, association doesn't imply causation. Further studies might identify possible controlled variables influencing suppliers' decision to change level of R&D, so that causation relationship might be discovered. Also, regarding the customer concentration and level of research and development, further studies can include moderating variables.

Further studies might explain why higher level of high-tech manufactory suppliers' research and development might lead to lower like-hood of the suppliers' bankruptcy and why higher high-tech manufactory suppliers' level of research and development might lead to lower suppliers' operating efficiency.

Regarding the suppliers' level of R&D and suppliers' profitability, further studies might consider time lag.

Acknowledgement

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