



Innovative Technologies, Supply Chain Concentration: A Quasi-Experiment from China

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Abstract. This study examines how the innovative technologies affect supply chain concentration. Additionally, we investigate whether this impact will vary under the different regions. China has occupied a position in cutting-edge technology with the support of policies from the Chinese government, which provides us with a quasi-experiment to investigate the problems above. Using the data from China Stock Market & Accounting Research Database (CSMAR), we find that the supply chain concentration increases after the introduction of innovative technologies. However, the introduction of innovative technologies is asymmetric between eastern region and non-eastern region, where the non-eastern region will increase the supply chain concentration led by innovative technologies. Moreover, our research can be generalized to other countries as long as the shock of innovation appears.

Keywords: Chinese Market; Supply Chain Concentration; Innovation; Textual Mining

1 Introduction

This paper systematically examines the impact of innovative technologies on the degree of supply chain concentration. Our research also incorporates the difference of such an effect incurred by the region. Collectively, this paper attests to the enhancement of supply chain concentration induced by the introduction of innovative technologies, and it further testifies to tremendous sunk cost due to the difference in development between eastern regions and non-eastern regions.

An extant strand of literature shed light on the positive effect of the concentrated supply chain on corporates' financial performance due to the mitigation of the bargaining power from downstream corporates (Lanier et al., 2010) ^[1]. Furthermore, scholars also extend this influence from the degree of supply chain concentration to pertinent topics such as the cost of capital, and simultaneously conclude that the higher the supply chain concentration is, the lower the firm risk and cost of equity are (Upson & Wei, 2019) ^[2].

However, previous research only focuses on the impact brought by supply chain concentration but does not elucidate the rationale behind this relationship. In fact, the

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factor that directs this positive impact of supply chain concentration on relevant financial indicators. Upon this belief, we draw on the policy shock to conduct a quasi-experiment design to examine the impact of innovative technologies on supply chain concentration as well as the moderated effect of regional influence. Our research makes main three contributions as follows:

First, our research originally investigates the true factor hidden by supply chain concentration that can induce a positive consequence – the introduction of innovative technologies. We clarify this point by conducting a quasi-experiment for the exact causality instead of naïve correlation. This exploration extends logical thinking from the concentrated supply chain to other rationales, and we expect subsequent insight into this field.

Second, our further investigation of the influence of regional differences. We draw the attention to comparatively large sunk cost that the non-eastern corporates have faced. This contribution points out the risk of innovative technology for those corporates in developed areas and could be generalized to different countries. More importantly, our point supports the implementation of a series of policies that especially aims at helping those corporates in the western area with government subsidy.

Finally, in order to capture the effects of cutting-edge technology utilized by enterprises, we merge textual mining with exogenous policy shock using Python. This helps us comprehend cutting-edge technologies on a variety of levels. The annual report was analyzed using natural language processing (NLP), and the right proxy was provided as the primary dependent variable for our investigations.

The remainder of this paper is structured as follows. Section 2 discusses the relevant previous research and develops our hypothesis. Sections 3 and 4 present the empirical design as well as the empirical results, respectively. The final part contains our conclusion.

2 Literature Review and Hypothesis Development

Outside the limited perspective of product releases, Schumpeter (1934) ^[3] defined innovative activities, which reflect a wide range including new manufacturing techniques, new supply sources, exploitation of new markets, and new organizational structures. Innovative technologies are cutting-edge approaches inducing an upsurge in productivity, where the role of globalization that propels the introduction and application of innovative technologies cannot be left out. Gorodnichenko et al. (2010) ^[4] elucidate the positive association between the foreign competition incurred by globalization and domestic innovation, which leads to an increase in total factor productivity because wide use of technologies appears in various industries. Simultaneously, Schott (2004) ^[5] has already concluded that the evolution of total factor productivity is a credible way to understand the existence of within-product specialization. In China, while a resource allocation capability would boost sales growth in small organizations, a strong R&D capability and related innovation might protect the innovation rate and product competitiveness in big and medium-sized businesses (Yam et al., 2004) ^[6]. Chinese listed firms, upon this analysis, have a strong motivation to introduce innovative technologies to improve their productivity due to the subsidy and support by the

central and municipal governments. Such an improvement commenced the necessary product specialization because of the extremely tremendous ex-ante cost input. Accordingly, this response that is reflected on the product enters the requirement for supplier and customer. On the one hand, the specialization of products requires seasoned suppliers to provide corresponding materials for the unique important product; on the other hand, owing to this specialization, usually, the customers they served will be concentrated in a niche market. Therefore, the scope of both suppliers and customers will shrink to a limited scale, and namely, the whole supply chain finally concentrates. We thus summarize the first hypothesis below:

H1: The introduction of innovative technologies increases the supply chain concentration, *ceteris paribus*.

Gao & Kling (2008)^[7] find the discrepancy in corporate governance between Chinese eastern coastal firms and others. Proverbially, there is a serious imbalance between the Chinese eastern coastal area and another area. The thriving economy offers a positive business environment even if the growth rate is slower than in Western China (Qi et al., 2013)^[8]. However, prosperous and convenient finance approaches to decrease the risk of the introduction of innovative technologies. In contrast, the firms from the non-eastern area have to burden the huge risk of severe consequences, which is regarded as the extra sunk cost relative to those firms from the eastern area. Therefore, firms from the non-eastern area are struggling to increase their profitability and are more likely to focus on unique start products to dominate a niche market, which enhances the intensity of supply chain concentration after introducing innovative technologies. Upon our analysis, we propose the second hypothesis as follows:

H2: Non-eastern firms enhance the increase in supply chain concentration incurred by the introduction of innovative technologies, *ceteris paribus*.

3 Research Design

In this section, we employ the event shock to examine the hypothesis. Next, we will offer an introduction to event identification as well as a brief discussion of the benefit of textual mining. And finally, we will elaborate on our empirical design.

3.1 Event Identification

The Chinese government long emphasized the development of technological development, which is shown in the official documents Outline of the National Program for Medium and Long-term Scientific and Technological Development (2006-2020). But for the innovative technology especially related to the Blockchain, Cloud computing, and other innovative technologies, the Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System (thereafter OPINIONS) published in 2012 empowers corporates with motivation for innovation, in which government provides series of services such as the pre-tax deduction for R&D expenses. Furthermore, the wide implementation of this

policy makes this shock strongly valid to examine the impact of innovative technologies on supply chain concentration.

3.2 Adoption of Textual Mining and Viability

Dinh Thi & Schultze (2011) ^[9] mention that the naïve capitalization of R&D may bring idiosyncratic noise in comparability between different firms’ financial reports, which damages the precision of financial analysis. Thus, we harness the textual mining tool to circumvent this circumstance and enhance the credibility of our further analysis.

In our research, we use Python software to harness the Jieba package and parse the relevant keywords from annual reports of listed firms from 2012 to 2020 to measure the application of innovative technology. For the detailed keyword statistics, we count the frequency of each word related to innovative technology (Blockchain, Big Data, Cloud Computing, Internet plus, Internet of Things, Artificial Intelligence, Biometrics, and Cloud Service). Logically, the annual report is an important tie bonding the external investors and firms for which firms are more likely to disclose the relevant information after they use innovative technology.

3.3 Sample Selection and Descriptive Statistics

We collect relevant financial data from China Stock Market & Accounting Research Database (CSMAR). And the final dataset is the merge of pertinent data from CSMAR and word statistics by year and firm individual. Each variable is defined in Table 2. As per the descriptive statistics (Statistica in Table 1), we find that a large variance of supply chain concentration exists (customer concentration, supplier concentration, or supply chain concentration), which means the difference in supply chain concentration may be greater than we expected. Also, it is important to note that the correlation coefficients show there is no multicollinearity between any variable, which ensures the accuracy of our regression model's estimation (refer to Table 3).

Table 1. Descriptive Statistics

Variable	N	p25	p50	Mean	SD	p75	p95
CUSCEN	39000	14.59	26	32.37	23.38	44.87	82.34
SUPCEN	30000	19.97	31.05	35.74	20.97	47.46	78.71
SCCEN	40000	15.84	26.89	29.66	18.05	40.50	63.62
Inv	40000	0.0600	0.116	0.151	0.140	0.192	0.439
Rec	40000	0.0370	0.0970	0.121	0.107	0.176	0.327
Roa	40000	0.0130	0.0360	0.0480	3.815	0.0660	0.129
Lever	40000	0.275	0.440	0.474	1.199	0.604	0.814
Size	40000	20.96	21.73	21.88	1.328	22.62	24.32
Tech	40000	0	0	0.440	0.496	1	1
East	40000	0	1	0.586	0.493	1	1

Source: own work by STATA 17

Table 2. Variable Definition

Variables	Explanation
Control Variables	
$Inv_{i,t}$	The ending inventory for firm i in year t scaled by total assets for firms i in year t .
$Rec_{i,t}$	The ending net accounts receivable for firm i in year t scaled by ending total assets for firms i in year t .
$Roa_{i,t}$	The ending return of assets for firm i in year t .
$Lever_{i,t}$	The ending total liabilities for firm i in year t scaled by ending total assets for firm i in year t .
$Size_{i,t}$	The natural log of the ending total assets for firm i in year t .
Dependent Variable	
$CUSCEN_{i,t}$	Customer concentration, proportion of top five customer sales that total annual sales for firm i in year t .
$SUPCEN_{i,t}$	Supplier concentration, proportion of top five customer sales that total annual sales for firm i in year t .
$SCCEN_{i,t}$	The average of the sum of purchasing and sales ratios from the top 5 suppliers and customers for firm i in year t .
Other Independent Variables	
$Post_{i,t}$	Dummy variable equals 1 for firm i if the year t is after 2011, otherwise 0 in section.
$Tech_{i,t}$	Dummy variable for firm i in year t equals 1 if there is any keyword relating to the Blockchain in its annual report, otherwise 0.
$East_{i,t}$	Dummy variable for firm i in year t equals 1 if the longitude of firm's registration location is bigger than a critical value according to the standard in China Statistical Yearbook.

Table 3. Correlation Matrix

	CUSCEN	SUPCEN	SCCEN	Inv	Rec	Roa	Lever	Size	Tech	East
CUSCEN	1									
SUPCEN	0.299***	1								
SCCEN	0.762***	0.785***	1							
Inv	-0.149***	-0.042***	-0.143***	1						
Rec	0.099***	-0.099***	0.073***	-0.095***	1					
Roa	0.00200	-0.033***	-0.00400	-0.00600	-0.00800	1				
Lever	0.023***	0.018***	0.013**	0.039***	0.00500	0.475***	1			
Size	-0.166***	-0.225***	-0.170***	0.098***	-0.181***	-0.026***	-0.00800	1		
Tech	0.009*	0.034***	0.00200	0.047***	-0.00800	0.00200	0.040***	-0.018***	1	
East	-0.036***	-0.031***	0.00700	0.009*	0.074***	-0.00400	-0.028***	0.039***	-0.107***	1

3.4 Empirical Design

Given that 2012 is recognized as the beginning of the widespread deployment of innovative technology, as we indicated above, we apply the fixed effect model to evaluate the impact of the implementation of OPINIONS on supply chain concentration for Chinese listed companies. In this section, we analyze this impact by using the Difference-in-Differences framework (DID) approach as our identification strategy. The final model is designed based on works of Lai (2009) ^[10] and Dechow et al. (2010) ^[11]:

$$Dependent\ Variable_{i,t} = \beta_0 + \beta_1 Tech_{i,t} * Post_{i,t} + \beta_2 Control_{i,t} + \sum_k \pi_k Year + \sum_l \delta_l Firm + \epsilon_{i,t} \tag{1}$$

$$Dependent\ Variable_{i,t} = \alpha_0 + \alpha_1 Tech_{i,t} * Post_{i,t} + \alpha_2 Tech_{i,t} * Post_{i,t} * East_{i,t} + \alpha_3 Control_{i,t} + \sum_k \pi_k Year + \sum_l \delta_l Firm + \nu_{i,t} \tag{2}$$

4 Empirical Results

According to the regression design, we first test the impact of innovative technologies on supply chain concentration without the moderation of regional factors.

Table 4 shows that all interactions are significantly positive, which indicates that the introduction of innovative technologies does increase the degree of concentration. Especially, the increase in customer concentration (1.661) is bigger than that in supplier concentration (1.496). In totality, the introduction of innovative technologies can increase the whole supply chain concentration under any proxy, which attests to the robustness of our hypothesis 1.

Table 4. The Impact of Innovative Technologies on Supply Chain Concentration

Dependent Variables	(1) CUSCEN	(2) SUPCEN	(3) SCCEN
Tech*Post	1.661** (2.05)	1.496* (1.87)	1.578** (2.40)
Inv	-14.843*** (-5.77)	-0.806 (-0.30)	-7.824*** (-3.61)
Rec	14.168*** (4.75)	-11.620*** (-3.87)	1.274 (0.50)
Roa	0.475 (0.59)	0.359 (0.59)	0.417 (0.66)
Lever	0.193 (1.63)	0.265** (2.28)	0.229** (2.52)
Size	-4.171*** (-9.78)	-4.923*** (-12.72)	-4.547*** (-13.24)

Constant	118.628*** (13.41)	142.480*** (17.51)	130.557*** (18.22)
Observations	29,910	29,910	29,910
R-squared	0.049	0.054	0.070
Number of firms	4,182	4,182	4,182
Firm FE	YES	YES	YES
Year FE	YES	YES	YES

Source: own work by STATA 17

Table 5 is a further analysis of the moderating effect of regional factors. As aforementioned, the non-eastern region will inherently enhance the impact of innovative technologies on supply chain concentration. As per the interaction (Tech*Post*East) in regression results, we find that firms from the eastern region will mitigate concentrated supply chain (2.657-1.835, 2.365-1.451) respectively even if the result is not significant under the proxy of supplier concentration. Namely, in other words, firms from the non-eastern region will enhance the impact of innovative technologies on supply chain concentration, which is consistent with our hypothesis 2.

Table 5. Moderating Effect of Region on the Impact of Innovative Technologies

Dependent Variables	(1)	(2)	(3)
	CUSCEN	SUPCEN	SCCEN
Tech*Post	2.657*** (2.68)	2.074** (2.12)	2.365*** (2.91)
Tech*Post*East	-1.835* (-1.95)	-1.067 (-1.14)	-1.451* (-1.88)
Inv	-14.868*** (-5.80)	-0.820 (-0.31)	-7.844*** (-3.64)
Rec	14.162*** (4.75)	-11.624*** (-3.86)	1.269 (0.50)
Roa	0.481 (0.61)	0.362 (0.60)	0.422 (0.68)
Lever	0.192 (1.65)	0.264** (2.27)	0.228** (2.51)
Size	-4.151*** (-9.74)	-4.912*** (-12.68)	-4.531*** (-13.19)

Constant	118.302*** (13.37)	142.290*** (17.47)	130.299*** (18.18)
Observations	29,910	29,910	29,910
R-squared	0.050	0.055	0.071
Number of firms	4,182	4,182	4,182
Firm FE	YES	YES	YES
Year FE	YES	YES	YES

Source: own work by STATA 17

5 Conclusion

Our paper investigates the impact brought by innovative technologies on supply chain concentration. Furthermore, we explore how a discrepancy in registration area moderates the aforementioned positive relationship in view of the different sunk cost. Our research makes contributions to a viable methodology related to textual mining and the theoretical foundation behind the association between the concentrated supply chain and another financial phenomenon. Simultaneously, based on the Chinese context, our paper also can help foreign investors to learn the current status of the supply chain. Furthermore, our research can be generalized to other countries as long as the shock of innovation appears.

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