

Supply Chain Relationship, Earnings Management, and Operational Risks

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Abstract This study discusses the effect of supplier-customer relationships in the supply chain on operational risk and takes into account earnings management to explain the increment and modulation effect on supply chain relationship and operational risk. With listed and over-the-counter (OTC) companies in Taiwan from 2009 to 2018 as subjects, this study finds in its empirical results that in supplier-customer relationships, suppliers may obtain related information in due time and adopt a better cooperation mode in the supply chain to reduce operational risk when they have a higher key customer concentration. However, in such a case, their operational risk may increase with a higher key customer concentration if enterprises take real earnings management to manipulate earnings.

Keywords: *supply chain management, key customer, operational risk, earnings management*

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1. Introduction

This study discusses the effect of supplier-customer relationships in the supply chain on operational risk and takes into account earnings management to explain the effect on supply chain relationships and operational risk. The Institute of Internal Auditors-Chinese Taiwan describes risk as "an event that will happen and affect the possibility of achieving strategic and business objectives". From the perspective of risk, business objectives cover a wide range. When taking internal and external environments faced by an enterprise into account, the scope of the internal environment and business can be considered as individuals in the enterprise who assist the enterprise in achieving its objectives, such as the governance and management personnel. On the other hand, the external environment can be considered individuals who pose indirect effects on business operations, such as regulations and rules formulated by government or regulatory bodies, and business fluency by enterprise decisions or maintenance of supply chain relationships.

Furthermore, from the supply chain perspective, the management must be capable of detecting environmental changes anytime and adjusting operations accordingly. Upstream and downstream business activities in one supply chain are closely connected. In addition to the selection of different types of supply chain partners, which is quite important to business operation, customer risk tolerance also affects supplier decisions [1]. To this end, enterprises should clearly understand their market positioning, recognize their institutional soundness, and

keep abreast of the supply chain and risk profile in due time. Prior literature provided instructions on risk prevention for enterprises in the supply chain [2]. Only when their properties are jeopardized by operational risks can enterprises have certain responses and capabilities of integrating suppliers and customers, interact with each other through business strategies and performance assessment, obtain related information in due time, adopt the best cooperation mode in the supply chain, and improve capabilities and use of funds to mitigate operational risks, take business growth opportunities, increase the overall competitiveness of the industry, and achieve sustainable operation.

Accounting information represents an important source of financial and cost information in the supply chain and reflects the current situation of the supply chain relationship of an enterprise, allowing the enterprise to have timely management [3,4]. For instance, the inventory risk affects the efficiency and profit of enterprises in the supply chain [5,6,7,8,9]. Key customer types of suppliers also indicate their information disclosure quality and are considered by stakeholders in making investment decisions [10]. Enterprises in the supply chain influence each other. Thus, if upstream enterprises conduct improper or illegal behaviors, downstream enterprises in the same supply chain will incur reputational damage [11]. Therefore, customers pay attention to suppliers' violations and review whether they fulfill their social responsibilities [12]. According to prior literature, enterprises in the supply chain try to achieve competitiveness by fulfilling corporate social responsibilities [13], and external stakeholders (e.g., regulatory authority) will formulate acts or inspect enterprises in the supply chain [14,15,16]

to prevent upstream enterprises in the supply chain from transferring risks to downstream enterprises [17].

As discussed above, operational risk is a significant factor that has the most direct effect on business operations. The consequences of various operational risks cannot be ignored when enterprises make operation decisions or external stakeholders make investment decisions. Concerning the risk information assessed in enterprises, people may doubt whether enterprises present actual information or have concealed certain information. Therefore, the signals released by enterprises in the supply chain have information connotations, which can be used by players in the supply (e.g., suppliers and manufacturers) to make decisions [18,19,20]. According to prior studies, long-term partnerships between enterprises, suppliers, and customers may affect executive compensation [21], earnings quality [8,22], and voluntary disclosure [23]; however, no consensus has been reached. Meanwhile, this study argues that enterprises and key customers can easily become acquainted with each other if enterprises are more dependent on key customers. Further, operational risks can be reduced if there is an acceptable relationship model for both parties. Therefore, this study hypothesizes that in a supplier-customer relationship, a partnership between suppliers and key customers is negatively correlated to the operational risks of enterprises. Nevertheless, enterprises will take related policies in the case of excessively close supplier-customer relationships to prevent the expansion of operational risks [24]. Further, earnings management impairs the supply chain relationship of enterprises [25] and increases the subsequent operational risks of enterprises [26]. Therefore, this study argues that if enterprises with high customer concentration take earnings management actions to manipulate earnings, they become more prone to operational risks resulting from supply chain relationship suspension. To this end, this study proposes H2: In the supplier-customer relationship, the adoption of real earnings management has a positive modulation effect on enterprises whose suppliers have key customers.

With listed and OTC companies in Taiwan from 2009 to 2018 as subjects, this study finds in its empirical results that in the supplier-customer relationship, suppliers may obtain related information in due time and adopt a better cooperation mode in the supply chain and reduce operational risks when they have a high key customer concentration. However, in the case of high customer concentration, enterprises are more prone to operational risks and the risk of supply chain relationship suspension if they employ real earnings management to manipulate earnings. In terms of sensibility analysis, it has been found that different types of earnings management have different effects on the operational risks of enterprises when a close supply chain relationship exists. In addition, through other substitution variables of a supply chain relationship, this study also finds that when key customers account for a larger proportion of suppliers' sales, the operational risk is lower; however, different degrees of earnings management still have a modulation effect.

Furthermore, this study makes the following contributions. (1) In recent years, the economic and trade policies implemented by some countries seriously affect the layout of the global supply chain and are more likely

to indirectly cause the restructuring of supply chains in all industries. Current global industries are in urgent need of flexibly meeting customer demands. Moreover, the risk of supply chain suspension may occur in a boom or recession. To this end, this study provides additional evidence for the current supply chain situation by analyzing suppliers with high customer concentration. (2) The operational risk is established with standard deviations of return on equity (ROE) and return on assets (ROA) to connect the supply chain situation and corporate financial indicators—factors that most concern stakeholders. The result shows that the characteristics of enterprises in the supply chain will directly affect stakeholders' views on enterprises. Conversely, it is also proposed that a close connection between supply chain enterprises and key customers will contribute to smooth sale activities. However, careful attention should be paid to supply chain risks. (3) Earnings management is used in the academic circle to determine whether enterprises change earnings for specific purposes. This study analyzes whether enterprises with high customer concentration affect operational risks through earnings management and whether different earnings management methods have different effects on enterprises. Further, it also provides additional evidence on the actions and risk management of supply chain enterprises.

The subsequent structure of this paper is as follows: Section 2 Literature Review and Hypothesis Proposal, Section 3 Research Method, Section 4 Empirical Result Analysis, and Section 5 Conclusion.

2. Literature Review and Hypothesis Proposal

According to the resource dependency theory, enterprises must employ approaches for seeking stable resources from internal and external environments and acquire competitiveness through prudent management if they want to thrive in the market. However, operational risks possibly caused by cost elasticity [27], supplier-customer relationship [9], operation leverage [28], and other factors are inevitable to the operation of enterprises.

From the supply chain perspective, accounting information represents an important source of financial and cost information in the supply chain and reflects the current situation of the supply chain relationship of an enterprise, which allows the enterprise to keep pace with the times in management [4,29]. For instance, inventory in the balance sheet. The risk caused by inventory (inventory risk) is a topic that enterprises in the supply chain must cope with prudently. [7] argued that the inventory risk between suppliers and retailers would affect the supply chain efficiency. When both parties jointly face the inventory risk when entering into a contract, good supply chain management can be formed and reduce such risk. [30] posited that enterprises could reduce supply chain risk by implementing management techniques that can reduce the possibility of adverse events. [31] and [32] also argued that based on the concept of competition, the demands of retailers who attach importance to inventory risk would affect the production strategies of suppliers. [5] and [6] further explained that inventory risk would affect supply chain efficiency and profit allocation through the

two-phase supply chain experiment. In addition, in terms of the effect of the supply chain on performance, [12] argued that the synergy of the supply chain could facilitate closer cooperation between supply chain members, contributing to performance improvement. [33] maintained that a higher degree of supply chain integration would lead to greater overall supply chain network competitiveness, resulting in better supply performance. [34] also argued that resource commitment affects the supply chain performance of enterprises.

In view of the aforementioned correlation between the supply chain and risks, [13] proposed that enterprises in the supply chain would affect each other and could generate competitiveness by fulfilling corporate social responsibilities. In terms of corporate social responsibilities, [17] confirmed that promoting corporate social responsibilities by increasing supply chain transparency and improving conditions for employees at the bottom of the supply chain could prevent suppliers from transferring pressures and risks to employees to transfer the price pressures and supply deadlines provided by buyers. Further, much literature [14,15,16] explains the importance of social audit, supply chain due diligence, and the California Transparency in Supply Chains Act to the maintenance of corporate social responsibilities. Therefore, if upstream enterprises conduct improper or illegal behaviors, downstream enterprises in the same supply chain will incur reputational damage. This outcome further highlights the importance of supply chain management [35].

On the other hand, the operation of and interaction between enterprises in the supply chain are interpreted by different stakeholders in different ways. For instance, public investors will judge enterprises through credit ratings. [36] found that economic risks and credit risks of enterprises and customers in the supply chain are reflected in bond yield. [37] argued that productivity uncertainties in the supply chain have different effects on bond yield (reflecting credit risk) for suppliers and customers. Additionally, [38] found that changes in long-term and short-term credit ratings will affect the changes in suppliers' dividends according to the characteristics of supply chain enterprises. Therefore, it can be concluded that signals in the supply chain have information connotations.

Supply chain information facilitates the interpretation of business operations and risks of enterprises. Therefore, suppliers and manufacturers improve their profitability by sharing information [20]. Further, the degree of reliability of suppliers also contains risk signals. [19] argued that a low degree of reliability of suppliers would hinder the capability of downstream manufacturers to control supplier risks (i.e., information asymmetry in the supply chain would affect the degree of reliability of suppliers). [18] further explained that when there is a high risk of information asymmetry, suppliers with a low degree of reliability may face the risk of supply chain suspension. Nevertheless, such suppliers can release related risk signals by proposing favorable conditions for customers to improve the degree of information visualization in the supply chain.

As discussed above, it is significant to identify the degree of reliability of enterprises in the supply chain. Enterprises in the supply chain identified with good performance may stabilize their supply chain relationship and reduce operational risks through long-term

cooperation. Prior studies interpreted suppliers and customers with a long-term cooperation in different ways. According to [39] and [40], suppliers dependent on key customers will face problematic receivables management when customers face bankruptcy and face suspension of supply chain relationship when customers replace suppliers. All of these circumstances result in a sharp increase in operational risks. In addition, [39] also found that the higher customer concentration was positively correlated to the cost of equity capital, which can explain the increase in the operating cost of suppliers. On the other hand, [23] argued that if a supplier had key customers (i.e., customers accounting for 10% of the sales of the supplier), in view of the excessively high sales concentration of individual customers, the supplier would not disclose information in real-time to prevent the risk of supply chain suspension, thereby increasing information asymmetry between the supplier and its stakeholders.

However, this study argues that a high customer concentration will reduce suppliers' operational risks. Additionally, key customers can help maintain good business operations, through which stakeholders can benefit from the supervision of key customers over suppliers. [21] argued that executive compensation of enterprises with key suppliers (i.e., suppliers accounting for 10% of the purchase amount of the customer) is principally decided by equity-based compensation as enterprises are confident in their future performance. [41] also argued that major downstream vendors in the supply chain often dominate industry collaboration, and close cooperation between supply chain members is significantly correlated to performance. [22] found that the debtor-creditor relationship allows creditors to obtain private information of key customers of debtors, further allowing the former to effectively supervise debtors. [8] also argued that when the output of suppliers is an important input of customers, customers become more dependent on suppliers, compelling them to comply with the requirements proposed by suppliers on the robustness of their statements.

Therefore, this study discusses the effect of the supply chain on the operational risk of enterprises. The following hypotheses are proposed:

H1: In the supply chain relationship, higher key customer concentration is negatively correlated to the operational risk of enterprises.

Enterprises will take related policies in case of excessively close supplier-customer relationships to prevent the expansion of operational risks. [24] argue that when enterprises have excessively concentrated customers, they must hold a larger amount of cash and have more power to manage earnings. Thus, they become tempted to achieve their purposes by other means (such as tax evasion) when they adopt less real earnings management. [25] argue that the adoption of earnings management will have adverse effects on the duration of the supply-customer relationship. In addition, [26] find that enterprises will execute earnings management in the IPO year to window dress financial statements. However, such enterprises will face an increased risk of bankruptcy in the future. On the other hand, in the supply chain, bargaining power affects the operation of enterprises. Noteworthy, key customers or key suppliers may have higher bargaining

power in the supply chain. [42] argue that customers and suppliers with low bargaining power are easily affected by high conversion costs and will face higher financial risks. If suppliers with low bargaining power in the supply chain may be limited in achieving earnings objectives, they will cope with such a situation through real earnings management [43]. In addition, [44] argued that under the pressure of financial statements, powerful key customers execute earnings management by improving their financial performance. Further, this study argues that enterprises adopt real earnings management by making real business transactions that deviate from normal business activities to affect reported earnings; however, it profoundly impairs enterprise value in the long run. Therefore, this study argues that if enterprises take real earnings management actions to manipulate earnings, they will face increased operational risk and the risk of supply chain relationship suspension especially when they have a high customer concentration. Therefore, H2 is proposed as follows:

H2: In the supply chain relationship, a higher degree of real earnings management and a higher customer concentration increase enterprises' operational risks.

3. Research Design

3.1. Source of Data

Table 1. Sampling Process

	Enterprise-annual observation
Original observation 2009-2018 (suppliers of which customers account for the largest proportion of sales can be identified)	16,640
Minus: samples of finance, insurance, and securities companies	(558)
Minus: samples lacking data to compute dependent variable (Operational Risk)	(549)
Minus: samples lacking data to compute independent variable (Customer HHI)	(2,520)
Minus: samples lacking data to compute earning management variable (DA REM)	(278)
Minus: samples with incomplete control variables	(1,467)
Total	11,268

Key customers whose information must be disclosed by suppliers according to Statement of Financial Accounting Standards (SFAS) No. 131 (formerly No.14) refer to those whose separate income accounts for more than 10% of that of suppliers. To this end, key customers used in this study are measured based on this definition. With the listed and OTC companies in Taiwan from 2009 to 2018 as subjects, this study obtains data from annual reports of shareholders meetings, the Taiwan Economic Journal (TEJ), and the Market Observation Post System (MOPS). Table 1 shows the sampling process illustrating the selection of enterprises by their annual observation values. There are a total of 16,640 sets of enterprise-annual observations of all listed and OTC companies in Taiwan from 2009 to 2018. A total of 11,268 sets of enterprise-annual observation are retained after 558 sets of finance and insurance enterprise data, 549 sets of observation lacking data for computing dependent variable (operational risk), 2,520 sets of observation lacking

data for computing independent variables (customer concentration), 278 sets of observation with incomplete earnings management variables, and 1,467 sets of observation with incomplete control variables are removed.

3.2. Empirical Model

This study discusses the effect of supplier relationships on operational risks and proposes Empirical Model (1) to test H1 as follows:

$$\begin{aligned}
 OpRisk_{i,t} &= \alpha_0 + \alpha_1 CustomerHHI_{i,t} + \alpha_2 SalesGrowth_{i,t} \\
 &+ \alpha_3 Size_{i,t} + \alpha_4 Lev_{i,t} + \alpha_5 Beta_{i,t} + \alpha_6 Age_{i,t} \\
 &+ \alpha_7 Profitability_{i,t} + \alpha_8 Big4_{i,t} + \alpha_9 AC_{i,t} \\
 &+ \alpha_{10} BoardSize_{i,t} + \alpha_{11} DirShakeHold_{i,t} \\
 &+ \alpha_{12} DirFinAccRatio_{i,t} + \alpha_{13} DirFinAccRatio_{i,t} \\
 &+ \alpha_{14} DirMasterRatio_{i,t} + \alpha_{15} DirPledRatio_{i,t} \\
 &+ \alpha_{16} IndDirRatio_{i,t} + \alpha_{17} DirInside_{i,t} \\
 &+ \beta_{18} Dual_{i,t} + YearFE + IndFE + \varepsilon_{i,t}
 \end{aligned} \tag{1}$$

In terms of dependent variables, operational risk ($OpRisk_{i,t}$), referring to the measurement of risk is defined by [45] as the standard deviation of ROA from year t-2 to year t ($StdROA_{i,t}$) and standard deviation of ROE from year t-2 to year t ($StdROE_{i,t}$). ROA is defined in the earnings model before interest, taxes, and depreciation. On the other hand, ROE is defined in the current profit and loss model. The primary test variable in Empirical Model (1) is customer concentration ($CustomerHHI_{i,t}$) which is measured by referring to [39] and [46]¹

This study further discusses the modulation effect of earnings management on supplier relationships and operational risks and proposes Empirical Model (2) to test H2 as follows:

$$\begin{aligned}
 OpRisk_{i,t} &= \alpha_0 + \alpha_1 HIGHHHI_{i,t} + \alpha_2 REM_{i,t} \\
 &+ \alpha_3 REM_HIGHHHI_{i,t} + \alpha_4 SalesGrowth_{i,t} \\
 &+ \alpha_5 Size_{i,t} + \alpha_6 Lev_{i,t} + \alpha_7 Beta_{i,t} + \alpha_8 Age_{i,t} \\
 &+ \alpha_9 Profitability_{i,t} + \alpha_{10} Big4_{i,t} + \alpha_{11} AC_{i,t} \\
 &+ \alpha_{12} BoardSize_{i,t} + \alpha_{13} DirShakeHold_{i,t} \\
 &+ \alpha_{14} DirFinAccRatio_{i,t} + \alpha_{15} DirMasterRatio_{i,t} \\
 &+ \alpha_{16} DirPledRatio_{i,t} + \alpha_{17} IndDirRatio_{i,t} \\
 &+ \beta_{18} DirInside_{i,t} + \beta_{19} Dual_{i,t} + YearFE + IndFE + \varepsilon_{i,t}
 \end{aligned} \tag{2}$$

In terms of the primary empirical variable in Empirical Model (2), customer concentration ($CustomerHHI_{i,t}$) is

¹ $CustomerHHI_{i,t} = \sum_{j=1}^J \left(\frac{Sales_{i,j,t}}{Sales_{i,t}} \right)^2$; Sales_{i,j,t} is the sales of

supplier i attributed to key customer j in year t; Sales_{i,t} is the net sales of supplier i in year t. A larger value indicates a higher key customer concentration.

divided according to the sample median; if the sample observation is greater than the sample median, the dummy variable ($HIGHHHI_{i,t}$) is set as 1; otherwise, it is zero. Its moderator variable is earnings management ($REM_{i,t}$). By referring to [47,48,49], the moderator variable is defined by three indicators—abnormal cash flows from operation (Abn_CFO), abnormal production cost (Abn_Prod), and abnormal discretionary expense (Abn_Discexp). Moreover, the moderator variable is estimated with the residuals of the year-specific and industry-specific individual regression model in [48]. The total value obtained after the standardization of these three individual indicators ($-\text{Std}(\text{Abn_CFO}) + \text{Std}(\text{Abn_Prod}) - \text{Std}(\text{Abn_Dicexp})$) is used to compute the composite indicator of earnings management. A higher value of composite real earnings management (REM) represents a higher level of overall real earnings management².

In terms of the control variables adopted in all models used to test the hypotheses, enterprise size ($Size_{i,t}$) is measured by the natural logarithm of ending total assets; liability ratio ($Lev_{i,t}$) is interpreted as that in the case of high debt risk of enterprises, where creditors are concerned about the solvency of enterprises. The liability ratio is measured by the ending total liabilities/ending total assets in this study. [50] argued that the fluctuation of sales growth rate can reflect credit risk. Thus, this study also takes the sales growth rate ($SalesGrowth_{i,t}$) into account. The sales growth rate is measured by the net operating revenue in year t minus net operating revenue in year t-1/net operating revenue in year t-1. System risk ($Beta_{i,t}$) is measured by the five-year system risk to control undiversifiable risks caused by macroeconomics or market conditions. Noteworthy, long-established enterprises face lower operational risk than startups [51]. Therefore, enterprise age ($Age_{i,t}$)—the years of establishment—is included as a variable. [52] argued that enterprises with high profitability are sensitive to the voluntary disclosure frequency of peer companies, particularly

²Estimates of abnormal cash flows from operation (Abn_CFO)

$$\frac{CFO_{i,t}}{Asset_{i,t-1}} = \gamma_1 \left(\frac{1}{Asset_{i,t-1}} \right) + \gamma_2 \left(\frac{SR_{i,t}}{Asset_{i,t-1}} \right) + \gamma_3 \left(\frac{\Delta SR_{i,t}}{Asset_{i,t-1}} \right) + \kappa_{i,t}$$

abnormal production cost (Abn_Prod)

$$\frac{Prod_{i,t}}{Asset_{i,t-1}} = \delta_1 \left(\frac{1}{Asset_{i,t-1}} \right) + \delta_2 \left(\frac{SR_{i,t}}{Asset_{i,t-1}} \right) + \delta_3 \left(\frac{\Delta SR_{i,t}}{Asset_{i,t-1}} \right) + \delta_4 \left(\frac{\Delta SR_{i,t-1}}{Asset_{i,t-1}} \right) + \theta_{i,t}$$

abnormal discretionary expense (Abn_Discexp)

$$\frac{Discexp_{i,t}}{Asset_{i,t-1}} = \lambda_1 \left(\frac{1}{Asset_{i,t-1}} \right) + \lambda_2 \left(\frac{SR_{i,t-1}}{Asset_{i,t-1}} \right) + \mu_{i,t}$$

Wherein, $CFO_{i,t}$ refers to the cash flows from business activities of company i in year t; $SR_{i,t}$ is the net operating revenue of company i in year t; $\Delta SR_{i,t}$ is the net operating revenue of company i in year t minus net operating revenue of company i in year t-1. $Prod_{i,t}$ is the sum of sales cost and inventory change of company i in year t; $Discexp_{i,t}$ is the sum of operating expense, advertising expense, and R&D expense of company i in year t; $SR_{i,t-1}$ is the net operating revenue of company i in year t-1.

when they face litigation risks. Therefore, profitability ($Profitability_{i,t}$)—the ratio of net profit after tax in year t to net operating revenue in year t—is included as a variable. If an enterprise is audited by Big Four, the dummy variable ($Big4_{i,t}$) is set as 1; otherwise, it is zero.

In addition, this study includes corporate governance variables for control, considering that the board of directors as the enterprise supervision mechanism also affects operational risk. [53] argued that a lower level of risk is attributed to more sustainable financial policies taken by the board of directors. [54] found that in the case of violations, enterprises can reduce operational risks by appointing new directors or additional independent directors. [55] argued that the property of independent directors affects the degree of risk transfer. [56] found that litigation risks could be reduced if the secretary on the board of directors holds equities. [57] argued that the property of the audit committee can reduce fraud risks. [58] also maintained that the board of directors will promote enterprise risk management for reputation maintenance purposes. Based on the literature review, this study includes nine corporate governance variables described as follows: *audit committee* ($AC_{i,t}$): if an enterprise has set the audit committee in the current year, the dummy variable is set as 1; otherwise, it is zero; *board size* ($BoardSize_{i,t}$) is measured by the number of all directors of an enterprise in the current year; *director shareholding ratio* ($DirShareHold_{i,t}$) is measured by the ratio of shares held by directors to outstanding shares of an enterprise in the current year; *internalization of directors* ($DirInside_{i,t}$): if directors of an enterprise are served by family members with final control in the current year, the dummy variable is set as 1; otherwise, it is zero; *directors with finance and accounting background ratio* ($DirFinAccRatio_{i,t}$) is measured by the ratio of directors with finance and accounting backgrounds to all directors in an enterprise in the current year; *chairman of the board of directors concurrently serving as general manager* ($Dual_{i,t}$): if the chairman of the board of directors concurrently serves as general manager of an enterprise in the current year, the dummy variable is set as 1; otherwise, it is zero; the *ratio of directors holding a master's or doctoral degree* ($DirMasterRatio_{i,t}$) is measured by the ratio of directors with a master's degree and above to all directors in an enterprise in the current year; *equity pledge ratio of directors* ($DirPledRatio_{i,t}$) is measured by the number of shares pledged by directors and supervisors/the number of shares held by directors and supervisors; the *ratio of independent directors* ($IndDirRatio_{i,t}$) is measured by the ratio of independent director seats to the seats on the board of directors.

4. Empirical Result Analysis

4.1. Descriptive Statistics

Table 2 lists descriptive statistics of related variables used in the empirical models. This study winsorizes the extreme values of all continuous variables in the models (i.e., replacing data preceding the 1st percentile and data following the 99th percentile with the former and the latter).

In terms of dependent variables, operational risk ($OpRisk_{i,t}$) is classified into standard deviation of ROA ($StdROA_{i,t}$) and standard deviation of ROE ($StdROE_{i,t}$). The variable information shows that mean values (medians) are 0.041 (0.026) and 0.083 (0.045), respectively. Both indicate the right-skewed distribution of samples and that some sample enterprises face high operational risks. Further, the mean value (median) of the primary empirical variable, customer concentration ($CustomerHHI_{i,t}$) is 0.271 (0.065). The mean value (median) of real earnings management ($REM_{i,t}$) is 0.010 (0.016), indicating that some enterprises take less real earnings management.

Table 2. Descriptive Statistics (N=11,268)

Variables	Mean	sd	Q1	Median	Q3
$StdROA_{i,t}$	0.041	0.064	0.013	0.026	0.049
$StdROE_{i,t}$	0.083	0.246	0.023	0.045	0.087
$CustomerHHI_{i,t}$	0.271	0.345	0.015	0.065	0.495
$REM_{i,t}$	-0.010	0.262	-0.101	-0.016	0.069
$SalesGrowth_{i,t}$	0.060	0.387	-0.109	0.013	0.142
$Size_{i,t}$	22.130	1.370	21.190	21.950	22.890
$Lev_{i,t}$	0.400	0.179	0.260	0.398	0.530
$Beta_{i,t}$	0.857	0.314	0.639	0.859	1.082
$Age_{i,t}$	11.790	8.308	6.079	10.830	15.630
$Profitability_{i,t}$	0.013	0.253	0.002	0.044	0.101
$Big4_{i,t}$	0.866	0.340	1.000	1.000	1.000
$AC_{i,t}$	0.209	0.406	0.000	0.000	0.000
$BoardSize_{i,t}$	7.045	1.837	5.000	7.000	8.000
$DirShareHold_{i,t}$	0.230	0.147	0.120	0.190	0.302
$DirFinAccRatio_{i,t}$	0.219	0.188	0.083	0.200	0.333
$DirMasterRatio_{i,t}$	0.403	0.256	0.200	0.400	0.600
$DirPledRatio_{i,t}$	0.070	0.151	0.000	0.000	0.054
$IndDirRatio_{i,t}$	0.251	0.166	0.000	0.286	0.400
$DirInside_{i,t}$	0.779	0.415	1.000	1.000	1.000

In terms of control variables, the mean value of sales growth rate ($SalesGrowth_{i,t}$) is 0.060; the mean value of enterprise size ($Size_{i,t}$) is 22.130, equivalent to NTD 3,895 million; the mean value (median) of liability ratio ($Lev_{i,t}$) is 0.400, indicating that 40% of the capital structure of sample enterprises is from trading on equity; the mean value of enterprise age ($Age_{i,t}$) is 11.790, indicating that sample enterprises have existed for 11 years since the collecting year (1983). In addition, the mean value of profitability ($Profitability_{i,t}$) is 0.013, and the mean value of system risk ($Beta_{i,t}$) is 0.857. In terms of corporate governance control variables, about 86% of sample enterprises are audited by Big Four ($Big4_{i,t}$); about 20% of sample enterprises have set the audit committee ($AC_{i,t}$); the number of directors is about 7 ($BoardSize_{i,t}$); the shareholding ratio of directors ($DirShareHold_{i,t}$) is about 23%; about 21% of directors have a finance and accounting background ($DirFinAccRatio_{i,t}$) and more than 40% of directors have a master's or doctoral degree ($DirMasterRatio_{i,t}$). The equity pledge ratio of directors ($DirPledRatio_{i,t}$) is 7%; independent director ratio ($IndDirRatio_{i,t}$) is 25%; about 80% of directors are served by family members with final control ($DirInside_{i,t}$); nearly 35% of chairmen of the board

of directors concurrently serve as general managers ($Dual_{i,t}$).

4.2. Correlation Coefficient Analysis

Table 3 lists the Pearson correlation coefficients of operational risk and other variables. Notably, this study only lists the correlation between primary and dependent variables. According to the results, customer concentration ($CustomerHHI_{i,t}$) is significantly and negatively correlated to the standard deviation of ROE and standard deviation of ROA ($StdROA_{i,t}$) ($p < 0.01$), which is within the expectation of this study. Earnings management ($REM_{i,t}$) is significantly and positively correlated to the standard deviation of ROE ($StdROE_{i,t}$) and standard deviation of ROA ($StdROA_{i,t}$) ($p < 0.01$), indicating that adopting earnings management can increase operational risk, which is in line with the inference of this study. However, the correlation coefficient table presents a univariate analysis. The succeeding sections will describe through more rigorous multivariable analysis and use the Variance Inflation Factor (VIF) to test multicollinearity.

Table 3. Correlation coefficient matrix (only primary variables are listed)

Panel A: $StdROA_{i,t}$			
	$StdROA_{i,t}$	$CustomerHHI_{i,t}$	$REM_{i,t}$
$StdROA_{i,t}$	1.000		
$CustomerHHI_{i,t}$	-0.044***	1.000	
$REM_{i,t}$	0.068***	-0.009	1.000
Panel B: $StdROE_{i,t}$			
	$StdROE_{i,t}$	$CustomerHHI_{i,t}$	$REM_{i,t}$
$StdROE_{i,t}$	1.000		
$CustomerHHI_{i,t}$	-0.022***	1.000	
$REM_{i,t}$	0.061***	-0.009	1.000

4.3. Multiple Regression Analysis

Table 4 lists the regression results of supply chain relationship and operational risk (Empirical Model [26]). First, this study finds that when the dependent variable is the standard deviation of ROA ($StdROA_{i,t}$), the coefficient of customer concentration ($CustomerHHI_{i,t}$) is 0.003, and the t-statistic is 1.970, achieving the level of significance of 5%. Hence, H1 is supported. This result shows that, in the supplier-customer relationship, enterprises are exposed to lower operational risk when suppliers have excessively high key customer concentration (i.e., suppliers having key customers is negatively correlated to operational risks of enterprises). On the other hand, when the dependent variable is the standard deviation of ROE ($StdROE_{i,t}$), the correlation does not reach the level of significance, but the coefficient is within our expectation. However, over-interpretation is inappropriate. In terms of control variables, larger enterprise age (Age) will lead to higher operational risks, higher profitability ($Profitability_{i,t}$) will lead to lower operational risks, and a higher independent director ratio ($IndDirRatio_{i,t}$) will lead to lower operational risks, indicating that the appointing more independent directors is favorable for improving supervision efficiency and stabilizing business operations.

Table 4. Multiple regression analysis—supply chain key customers and operational risks

Var	StdROA _{i,t}		StdROE _{i,t}	
	Coefficient	t-stat	Coefficient	t-stat
CustomerHHI _{i,t}	-0.003**	-1.970	-0.010	-1.490
SalesGrowth _{i,t}	0.018***	11.430	0.048***	7.970
Size _{i,t}	-0.009***	-15.500	-0.026***	-11.210
Lev _{i,t}	0.002	0.600	0.204***	14.030
Beta _{i,t}	0.002	0.790	-0.023**	-2.470
Age _{i,t}	0.000***	3.600	0.001***	3.370
Profitability _{i,t}	-0.038***	-15.340	-0.077***	-8.020
Big4 _{i,t}	-0.002	-1.260	-0.007	-1.050
AC _{i,t}	0.006***	3.590	0.018***	2.580
BoardSize _{i,t}	-0.001*	-2.030	-0.002	-1.480
DirShareHold _{i,t}	-0.011***	-2.650	-0.014	-0.870
DirFinAccRatio _{i,t}	0.009***	2.750	0.019	1.430
DirMasterRatio _{i,t}	0.009***	3.370	0.025**	2.420
DirPledRatio _{i,t}	-0.001	-0.320	-0.017	-1.110
IndDirRatio _{i,t}	-0.009*	-1.840	-0.057***	-3.120
DirInside _{i,t}	-0.010***	-6.520	-0.031***	-5.450
Dual _{i,t}	0.000	0.150	-0.004	-0.820
Intercept	0.251***	21.610	0.628***	13.900
N	11,268		11,268	
F-stat	54.74***		35.35***	
Year-Effect	Yes		Yes	
Industry-Effect	Yes		Yes	
Adjusted R ²	0.103		0.069	

a. Variables are defined and listed in Table 2.
 b. *, **, and *** represent statistical significance of 0.1, 0.05, and 0.001 (two-tailed test).

Table 5. Multiple regression analysis—supply chain key customers, real earnings management, and operational risks

Var	StdROA _{i,t}		StdROE _{i,t}	
	Coefficient	t-stat	Coefficient	t-stat
HIGHHHI _{i,t}	-0.001	-0.930	-0.003	-0.730
REM _{i,t}	0.005	1.410	0.007	0.540
REM_HIGHHHI _{i,t}	0.015***	3.380	0.030*	1.750
SalesGrowth _{i,t}	0.018***	11.590	0.049***	8.020
Size _{i,t}	-0.009***	-15.500	-0.026***	-11.230
Lev _{i,t}	-0.001	-0.290	0.198***	13.430
Beta _{i,t}	0.002	0.970	-0.022**	-2.370
Age _{i,t}	0.000***	3.470	0.001***	3.290
Profitability _{i,t}	-0.037***	-15.000	-0.075***	-7.860
Big4 _{i,t}	-0.002	-1.150	-0.007	-1.000
AC _{i,t}	0.006***	3.620	0.018***	2.580
BoardSize _{i,t}	-0.001**	-2.010	-0.002	-1.460
DirShareHold _{i,t}	-0.012***	-2.830	-0.016	-0.960
DirFinAccRatio _{i,t}	0.009**	2.670	0.018	1.400
DirMasterRatio _{i,t}	0.010***	3.590	0.026**	2.510
DirPledRatio _{i,t}	-0.001	-0.300	-0.017	-1.100
IndDirRatio _{i,t}	-0.009**	-1.970	-0.058***	-3.180
DirInside _{i,t}	-0.009***	-6.490	-0.031***	-5.440
Dual _{i,t}	0.000	0.090	-0.004	-0.850
Intercept	0.251***	21.690	0.630***	13.940
N	11,268		11,268	
F-stat	51.50***		32.14***	
Year-Effect	Yes		Yes	
Industry-Effect	Yes		Yes	
Adjusted R ²	0.106		0.069	

a. Variables are defined and listed in Table 2.
 b. *, **, and *** represent statistical significance of 0.1, 0.05, and 0.001 (two-tailed test).

Table 5 lists the regression results of supply chain relationship, real earnings management, and operational risk (Empirical Model [53]). This study finds that when the dependent variables are the standard deviation of ROA (StdROA_{i,t}) and standard deviation of ROE (StdROE_{i,t}), all cross-product terms of the model (REM_HIGHHHI_{i,t}) reach the level of significance, and the coefficients show a positive correlation. This finding indicates that when enterprises take real earnings management actions to manipulate earnings in case of high customer concentration, they will face increased operational risk and the risk of supply chain relationship (i.e., negative modulation effect). Hence, this result supports H2.

4.4. Additional Analyses

This study adopts two types of additional analysis. First, accrual earnings management is also a common earnings management method, apart from the method adopted in the primary empirical model. Based on the model of [59], this includes enterprise performance in the Jones Model and substitutes the cross-section data of the same year and same industry into the model to estimate discretionary accruals. A greater value of discretionary accruals indicates that enterprises execute more accrual earnings management. This study considers that the model should be established as follows:

$$\begin{aligned}
 OpRisk_{i,t} &= \beta_0 + \beta_1 HIGHHHI_{i,t} + \beta_2 DA_{i,t} \\
 &+ \beta_3 DA_HIGHHHI_{i,t} + \alpha_4 SalesGrowth_{i,t} \\
 &+ \alpha_5 Size_{i,t} + \alpha_6 Lev_{i,t} + \alpha_7 Beta_{i,t} + \alpha_8 Age_{i,t} \\
 &+ \alpha_9 Profitability_{i,t} + \alpha_{10} Big4_{i,t} + \alpha_{11} AC_{i,t} \\
 &+ \alpha_{12} BoardSize_{i,t} + \alpha_{13} DirShakeHold_{i,t} \\
 &+ \alpha_{14} DirFinAccRatio_{i,t} + \alpha_{15} DirMasterRatio_{i,t} \\
 &+ \alpha_{16} DirPledRatio_{i,t} + \alpha_{17} IndDirRatio_{i,t} \\
 &+ \beta_{18} DirInside_{i,t} + \beta_{19} Dual_{i,t} \\
 &+ YearFE + IndFE + \varepsilon_{i,t}
 \end{aligned} \tag{3}$$

wherein, in terms of variables in the model, real earnings management is replaced with accrual earnings management, and the other variables are the same as those in Empirical Model (2).

As presented in Table 6, two proxy variables of operational risk are also used as dependent variables. In terms of the cross-product term (DA_HIGHHHI_{i,t}), both modes show a significant negative correlation, which indicates that in the case of a close supply chain relationship, the adoption of accrual earnings management has different effects on the operational risk of enterprises. In the empirical results not listed in the table, the moderator variables are replaced by the extent of accrual earnings management and multiplied the latter by the primary variables. The coefficient shows a significant positive correlation. This finding indicates that the adoption of accrual earnings management by enterprises with high customer concentration can reduce operational risks. However, a greater extent of accrual earnings management will lead to higher operational risk.

Table 6. Supply chain key customers, accrual earnings management, and operational risks

Var	<i>StdROA_{i,t}</i>		<i>StdROE_{i,t}</i>	
	Coefficient	t-stat	Coefficient	t-stat
<i>HIGHHHI_{i,t}</i>	-0.001	-1.150	-0.004	-0.930
<i>DA_{i,t}</i>	0.044***	6.950	0.118***	4.760
<i>DA_HIGHHHI_{i,t}</i>	-0.056***	-6.420	-0.260***	-7.680
<i>SalesGrowth_{i,t}</i>	0.018***	11.400	0.049***	8.150
<i>Size_{i,t}</i>	-0.009***	-15.650	-0.026***	-11.330
<i>Lev_{i,t}</i>	0.002	0.550	0.206***	14.220
<i>Beta_{i,t}</i>	0.002	0.890	-0.023**	-2.500
<i>Age_{i,t}</i>	0.000***	3.480	0.001***	3.310
<i>Profitability_{i,t}</i>	-0.039***	-15.760	-0.076***	-7.890
<i>Big4_{i,t}</i>	-0.002	-1.210	-0.008	-1.090
<i>AC_{i,t}</i>	0.006***	3.570	0.017**	2.530
<i>BoardSize_{i,t}</i>	-0.001**	-1.970	-0.002	-1.400
<i>DirShareHold_{i,t}</i>	-0.012***	-2.820	-0.016	-0.940
<i>DirFinAccRatio_{i,t}</i>	0.009***	2.660	0.018	1.360
<i>DirMasterRatio_{i,t}</i>	0.009**	3.350	0.024**	2.320
<i>DirPledRatio_{i,t}</i>	-0.002	-0.420	-0.019	-1.230
<i>IndDirRatio_{i,t}</i>	-0.008*	-1.770	-0.055***	-3.010
<i>DirInside_{i,t}</i>	-0.010***	-6.580	-0.031***	-5.500
<i>Dual_{i,t}</i>	0.000	0.110	-0.004	-0.820
<i>Intercept</i>	0.252***	21.770	0.632***	14.010
N	11,268		11,268	
F-stat	51.79		34.68	
Year-Effect	Yes		Yes	
Industry-Effect	Yes		Yes	
Adjusted R ²	0.106		0.072	

a. Variables are defined and listed in Table 2.

b. *, **, and *** represent statistical significance of 0.1, 0.05, and 0.001 (two-tailed test).

4.5. Sensitivity Analysis

Furthermore, based on the practice of [60] and [39], this study replaces the measurement index (*CustomerHHI_{i,t}*) in primary empirical test with total key customer sales (*TotalMajorCustomerSales_{i,t}*) as a substitution variable of supply chain relationship³. Then, it tests the aforementioned models again. Unlisted results support the conclusion of the primary empirical test, which indicates that when key customers account for larger proportions of sales of suppliers, the operational risk decreases. This supports H1. On the other hand, the effect of the adoption of real earnings management (*REM_{i,t}*) as a moderator variable meets the expectation of H2 (i.e., adoption of real earnings management will positively increase operational risk).

5. Conclusion, Suggestions, and Limitations

With the listed and OTC companies in Taiwan from 2009 to 2018 as subjects, this study discusses the effects

$${}^3\text{Total Major Customer Sales}_{i,t} = \sum_{j=1}^J \left(\frac{\text{Sales}_{i,j,t}}{\text{Revenue}_{i,t}} \right)$$

Wherein, *Sales_{i,j,t}* is sales of supplier *i* in year *t* attributable to key customer *j* (10% and above); *Revenue_{i,t}* is total revenue of supplier *i* in year *t*.

of supplier-customer relationships in the supply chain on operational risk and includes earnings management to explain the effects on supply chain relationships and operational risks. According to empirical results, in supplier-customer relationships, suppliers may obtain related information in due time and adopt a better cooperation mode in the supply chain to reduce operational risks when they have higher key customer concentration. In addition, if enterprises take real earnings management to manipulate earnings in the case of high customer concentration, they will face increased operational risks and the risk of supply chain relationship suspension. In terms of sensitivity analysis, different types of earnings management have different effects on the operational risk of enterprises in the case of a close supply chain relationship.

The policy and management implications of this study discuss supply chain relationships (i.e., whether the business interactions between suppliers and customers who have a real transaction or contractual relationship will affect operational risks). This means the management must be capable of detecting changes in the environment anytime and adjusting operations accordingly. In addition, this study discusses whether the management will take earnings management actions to maintain supply chain relationships in response to changing risks and whether different earnings management instruments will have different effects. Therefore, this study provides phenomena that can be tested for the state of supply chain relationship to verify the correlation between supply chain relationship and operational risk and the possibility of suppliers taking actions (earnings management) to meet the earnings threshold under the influence of bargaining. In terms of subsequent studies, this study suggests that the supply chain be measured to different extents for different industries and in different environments. Furthermore, differentiated measurement methods (e.g., the supply chain patterns of the electronics industry and the manufacturing industry are quite different and should not be measured with the same indicators) should be used to analyze the roles of suppliers and customers. On the other hand, operational risk in the supply chain affects the views of banks or other financing sources on enterprises. In this way, the economic results of supply chain risks can be extended in subsequent studies.

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