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Enhancing Operational Resilience through Gender Diversity in Top Management Teams: A Social System Perspective

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Enhancing Operational Resilience through Gender Diversity in Top Management Teams: A Social System Perspective

Abstract

This study examines whether top management team gender diversity enhances firms' ability to withstand COVID-19 disruptions by sustaining operational continuity. Using a sample of 1,158 Chinese listed firms in 2020, we employ an instrumental variable two-stage least squares regression model to address potential endogeneity concerns and rigorously examine the hypothesised relationships. Grounded in social system theory, our findings suggest that gender diversity as a form of requisite variety is positively related to operational resilience. In addition, the study finds that both process complexity (in the form of absorptive capacity and operational efficiency) and structure complexity (represented by business and sourcing diversification) exert moderating effects on the relationship. The study contributes significantly to the literature by substantiating the causal link between gender diversity and operational resilience and the moderating roles of operations and supply chain management factors in moderating the benefits of gender diversity to firm performance.

Keywords: gender diversity, operational resilience, social system theory

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1. Introduction

Over the past few decades, the issue of gender diversity in leadership has drawn growing attention from both scholars and practitioners (Lucas-Pérez et al., 2015; Yao, 2023). A longstanding concern is the low share of women in senior decision-making roles, especially on top management teams (TMTs), the small group of executives who guide an organisation's strategy and performance (Hambrick et al., 1996; Mustafa and Khatri, 2024). Policymakers, investors and the wider public have therefore urged companies to improve female representation in corporate governance (Yang et al., 2024). Nonetheless, progress has been slow: the 2024 MSCI Women on Boards Progress Report indicates that women occupy just 27.3% of top management seats in large- and mid-cap companies worldwide—only 1.5 percentage points higher than in 2023 and still far from parity (MSCI, 2024).

Numerous researchers have increasingly directed their focus towards the effects of gender diversity on corporate outcomes to justify its legitimacy (Adams and Ferreira, 2009; Martínez-García et al., 2022; Matthews et al., 2024). Overall, the inclusion of females in TMTs offers a multitude of benefits that can positively affect organisations and help them to gain a competitive edge. A wide range of studies demonstrate the impact of gender diversity on various organisational performance metrics, such as innovation capacity (Hemmert et al., 2024; Ruiz-Jiménez et al., 2016) and financial outcomes (e.g. Opstrup and Villadsen, 2015).

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Notably, there is growing preliminary evidence that diversity plays a significant role in fostering operational resilience (OR), which is defined as an organisation's capacity to anticipate, respond to and recover from disruptions or adverse external events while maintaining essential operations (Kwaramba et al., 2024; Tukamuhabwa et al., 2015). Theoretical perspectives suggest that organisational diversity can enhance resilience by improving risk identification, problem solving, and crisis learning (Ali, 2022; Duchek et al., 2020). For example, building on complex adaptability theory, Yan et al. (2024) suggest that resilience depends on how organisations configure and mobilise internal diversity. Upper echelons theory similarly indicates that TMT gender composition shapes how threats are interpreted and prioritised, influencing decisions on resource allocation, continuity, and recovery (Yao, 2023). The categorization-elaboration model further shows that diversity effects are conditional: diversity can enhance information processing, but it may also create subgroup frictions (Havrylyshyn et al., 2023). Taken together, these models imply that TMT gender diversity is likely to strengthen operational resilience.

Beyond academia, real-world cases also illustrate the impact of gender diversity on OR. For example, in 2024, Shandong Bunse Elevator, a listed company and Schneider Electric Thailand's joint venture partner, faced a production disruption because of a supplier's installation error, causing a safety incident. This is a real case study we conducted in December 2024. Although most executives argued that the

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company had no contractual obligation to compensate, the female CEO took a different stance:

> *Legally, we are not responsible. However, the injured worker is his family's sole provider, and his injury affects his children. As a responsible company, we should offer moral and financial support to those in need.*

Her leadership prioritised ethical considerations, leading Bunse to cover the worker's medical expenses. This decision swiftly resolved the crisis, protected the company's reputation and ensured rapid production recovery. The case highlights how the presence of female leaders on TMTs enhances risk mitigation by fostering holistic and socially responsible decision-making.

Moreover, emerging evidence indicates that the resilience advantages of gender-diverse leadership are particularly salient in pandemic-related supply chain disruptions. A recent analysis of Credit Benchmark data shows that S&P 500 and FTSE 350 firms led by female CEOs—or by gender-balanced executive teams—had lower predicted probabilities of default on the eve of COVID-19 and, once the shock hit, experienced smaller credit-risk deteriorations than firms with male-dominated leadership structures (Bain & Company, 2023).

However, a significant amount of the existing literature on diversity's role in fostering resilience either remains largely theoretical or anecdotal (e.g. Ali, 2022; Duchek, 2020) or focuses exclusively on financial aspects of resilience. Empirical evidence on how gender diversity within TMTs contributes to OR is notably scarce.

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This gap highlights a pressing need for further research that clarifies when and under what organisational conditions gender diversity can enhance resilience, thus offering a more comprehensive understanding of its strategic value in today's complex business environments. The unique context of the pandemic provides a critical testbed for examining how TMT gender diversity may contribute to firms' ability to adapt and recover operationally under severe stress.

This study seeks to address this crucial gap by empirically examining the impact of gender diversity in TMTs on OR. Social system theory is particularly well-suited for this research, because it emphasises the importance of complexity and the ways organisations can manage challenges through navigating complexity. By introducing concepts such as the requisite variety and complexity differential, this theory offers a strong theoretical framework for understanding how gender diversity strengthens a firm's capacity to endure and recover from external disruptions.

In addition, the theory emphasises the role of organisational structures and processes in managing complexity. Thus, this study examines two sets of moderators related to organisational process and structural complexity, respectively. Process complexity-related moderators include absorptive capacity and operational efficiency. Structural complexity-related moderators refer to business diversification and sourcing diversification. By integrating both process- and structure-related moderators, this comprehensive approach offers a more holistic understanding of when the positive association between gender diversity and OR becomes stronger.

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Considering these gaps, our study develops the following research questions:

RQ1. What is the impact of TMT gender diversity on a firm's OR during the COVID-19 shock?

RQ2. How do key organisational factors in operations and supply chain management (OSCM)—such as absorptive capacity, process efficiency and structural diversification—influence this relationship?

To answer these questions, we analyse a cross-section dataset of all Chinese A-share firms in 2020—the year in which nationwide lockdowns and supply chain disruptions created a uniform, exogenous test of organisational resilience. Using instrumental variable two-stage least squares (IV-2SLS) approach, we find that greater gender diversity in TMTs is associated with stronger OR during the pandemic. In addition, three internal capability sets—absorptive capacity, operational efficiency and both business and sourcing diversification—each strengthen this relationship.

This research contributes to the literature substantiating the role of gender diversity in enhancing OR, an area previously underexplored in the literature. In addition, it explores how specific OSCM factors moderate the impact of gender diversity on OR, advancing our understanding of how diverse leadership can influence resilience in complex operational environments. Finally, our study extends social systems theory from sociology to OSCM, providing empirical evidence of its applicability to organizational resilience studies.

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2. Literature Review and Hypothesis Development

2.1 Social systems theory

Social systems theory (SST) was originally developed within sociology to explore the structure and functioning of social entities. Over time, this theoretical framework has gained traction in organisational studies, in which it is used to analyse and understand the dynamics within various types of organisations, including business enterprises (Gong et al., 2023; Seidl and Mormann, 2014; Yang et al., 2023). Considering the broad and general nature of SST, to make our analysis more focused, we concentrate on four fundamental concepts: *complexity differential*, *requisite variety*, *process complexity* and *structure complexity*.

Complexity has been central to SST research. It refers to the number of elements that make up a system or its environment, as well as the relationships between these elements (Luhmann, 1995). According to SST, a system is inherently less complex than the environment in which it exists. This means that a system cannot fully comprehend or manage the entirety of environmental complexity simultaneously (Luhmann, 1995; Roth et al., 2020; Schreyögg and Steinmann, 1987).

First, the complexity differential is the perceived gap between a system's complexity and its environment (Luhmann, 1995; Neisig, 2021). Because the external world always exceeds what any system can fully grasp, the key is how much external variety the system internalises (Luhmann, 1995). Richer internal variety "filters in" more information and shrinks the gap; limited variety makes the environment feel

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overwhelming, widening it (Neisig, 2021; Seidl and Mormann, 2014). If this perceived gap grows too large, information processing breaks down, jeopardising timely decisions and organisational viability (Seidl and Mormann, 2014; Wang et al., 2023; Yang et al., 2023).

Accordingly, requisite variety is the key lever for narrowing the perceived complexity gap: a system must match external complexity with sufficient internal complexity to represent it (Gong et al., 2023; Schneider et al., 2017). By broadening perspectives, knowledge, and response options, organisations internalise more external variety, so greater heterogeneity shrinks the perceived gap (Ashby, 1956; Gong et al., 2023).

This overview indicates that to address the challenges posed by increasing environmental complexity, a system must have sufficient requisite variety (Ashby, 1956). Hence, TMT gender diversity becomes a concrete source of requisite variety: by injecting cognitive and experiential breadth, TMT gender diversity provides the system with multiple interpretive lenses and response scripts, softening the impact of external turbulence. Only when a system possesses this breadth can it accurately model environmental contingencies, select effective countermeasures and safeguard organisational viability (Luhmann, 1995; Schneider et al., 2017).

Another important concept is structure complexity. Structure complexity concerns the formal mechanisms firms use to gather and process environmental information, thereby boosting requisite variety and narrowing the complexity gap

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(Gong et al., 2023; Schneider et al., 2017). Effective designs detect early signals and speed assimilation—e.g., environmental-scanning units or cross-functional teams tracking market shifts (Tushman & Nadler, 1978).

Simultaneously, there is another aspect that is crucial for organisations to enhance their internal processes to effectively process and use the information gathered, which is known as process complexity. Process complexity refers to the internal routines that integrate external information into strategy and operations (Daft & Weick, 1984; Tushman & Nadler, 1978). Sophisticated processes ensure seamless flow, analysis, and action on information across units (Gong et al., 2023; Yang et al., 2023). Built alongside structure complexity, these routines raise internal variety, narrow the system–environment gap, and enable more adaptive responses.

Notably, because the complexity differential is hard to observe directly, we compare firms by requisite variety instead. Organisational diversity is a practical proxy; here we use TMT gender diversity, where greater inclusion of women expands interpretive variety and thus lowers the perceived gap. This yields a manageable and visible framework for analysing organisational dynamics within a common context.

2.2 Operational resilience

OR has attracted growing interest from academia in OSCM, because it is seen as a key factor in enabling firms to maintain growth during external disruptions, especially in the context of the COVID-19 pandemic. OR refers to an organisation's ability to prepare for, respond to and recover from disruptions or adverse external

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events while maintaining core operations and functionality (Essuman et al., 2020; Queiroz et al., 2024; Tan et al., 2020). This concept is particularly relevant in situations such as supply chain disruptions, economic shocks, natural disasters or other crises. OR involves the firm's capacity to anticipate potential threats, absorb the impact of these disruptions and adapt or evolve in response, ensuring business continuity (Kortmann et al., 2014; van der Vegt et al., 2015). Some studies reveal the key components of OR, including stability and flexibility (DesJardine et al., 2019). Overall, OR is critical for businesses to remain competitive and sustainable in increasingly complex and uncertain environments (Williams et al., 2017).

Moreover, previous studies identify financial loss as a critical factor for assessing OR. The extent of financial loss represents the degree of disruptions that a firm faces during the crisis (e.g. DesJardine et al., 2019). Over a specific period, a smaller performance loss indicates greater resilience. Our study measures OR by examining the financial performance of organisations, following the methodology adopted in prior studies (e.g. Li et al., 2023).

Compared with other lenses, SST fits this study for two reasons. First, in SST, complexity comprises the many elements and interrelations a firm must manage to survive, while operational resilience (OR) is the capacity to withstand, adapt to, and recover from shocks; OR thus depends on managing complexity. Second, TMT gender diversity increases requisite variety by adding heterogeneous experiences and perspectives, narrowing the system–environment gap. Together, these points make SST

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a strong framework for explaining how diverse leadership improves organisational responses to external challenges.

2.3 Top management team gender diversity and operational resilience: a social systems theory perspective

In SST, an organisation is conceived as a system that survives only to the extent that it perceives its own variety as sufficient to cope with the variety it detects in its environment. When the perceived complexity differential—the gap between external turbulence and internally available variety—grows too wide, the system can no longer make sense of, let alone manage, incoming disturbances (Duncan, 1972). Contemporary business contexts amplify this challenge: economic, technological and geopolitical shocks render the external world highly volatile and, crucially, subjectively more complex than before (Child and Rodrigues, 2011; Emery and Trist, 1965). To keep operating under such turbulence, the firm must continually narrow this perceived gap by expanding its requisite variety—that is, by enriching the range of perspectives and capabilities it can draw on to interpret signals and generate responses (Ashby, 1956).

Consistent with SST, gender diversity in the TMT constitutes a concrete form of requisite variety, an internal resource that curbs the perceived complexity differential. Such variety stems from heterogeneity in both capabilities and knowledge lenses. First, gender-diverse TMTs offer richer expertise, problem-solving abilities and varied competencies (e.g. industry experience, technical skills, interpersonal abilities),

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boosting team effectiveness in complex situations (Afzali et al., 2022; Oh et al., 2024; Terjesen et al., 2016). When an external shock occurs, this broader 'toolkit' raises the odds that at least one leader can tackle each dimension of the crisis—whether technical troubleshooting, crisis communication, resource reallocation or creative improvisation—thus shrinking the organisation's subjective sense of how complex the disruption is.

Second, gender diversity increases the heterogeneity of perspectives and knowledge within TMTs (Ali et al., 2011). Women, as a historically underrepresented group in many TMTs, bring perspectives forged by distinct life experiences and socialisation patterns. Gender diversity introduces a broader range of perspectives and viewpoints within the senior management (Hemmert et al., 2024; Opstrup and Villadsen, 2015). As a result, with a diverse TMT, the organisation is better equipped to perceive and interpret the complexities of its external environment. For example, genders can bring different insights and awareness to social trends, ethical considerations and emerging risks.

Overall, these two sources of requisite variety—a broader skill set and a richer spectrum of knowledge and perspectives—equip a gender-diverse TMT to withstand and recover from operational disruptions more effectively. Consistent with SST, greater gender diversity at the top expands requisite variety, narrows the perceived complexity differential and, thus, strengthens the system's capacity to self-regulate under unpredictable conditions. Accordingly, we expect organisations with gender-diverse

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TMTs to display superior OR. Motivated by this logic, we propose the following hypothesis:

H1: Gender diversity in a firm's top management team is positively related to its operational resilience.

2.4 Moderating roles of process complexity

As discussed, enhancing organisational processes and structures contribute to the evolution of internal complexity, narrowing the complexity differential. In this study, we consider two process-related complexities: absorptive capacity and operational efficiency. We argue that both can act as moderators that enhance the relationship between gender diversity in TMTs and OR.

Absorptive capacity is defined as a firm's ability to recognise, assimilate and apply knowledge gained from external sources for its advantage (Cohen and Levinthal, 1990; Yli-Renko et al., 2001). From the SST perspective, absorptive capacity is crucial in strengthening the positive relationship between TMT gender diversity and OR because it provides an organisational context in which the broader cognitive variety brought by a gender-diverse leadership team can be more effectively utilised. Although TMT gender diversity contributes to organisations' requisite variety by introducing a wider range of perspectives, firms differ in their ability to recognise, assimilate, and apply relevant knowledge.

Absorptive capacity provides favourable organisational conditions under which firms are better able to benefit from the broader perspectives associated with a gender-

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diverse TMT (Martinkenaite and Breunig, 2016). When absorptive capacity is stronger, the broader variety associated with TMT gender diversity is more likely to be matched by the firm's information-processing capabilities. This alignment helps reduce the complexity differential by allowing firms with stronger absorptive capacity to make more effective use of the requisite variety embedded in gender-diverse TMTs. Therefore, we propose the following:

H2a: Absorptive capacity positively moderates the relationship between top management teams' gender diversity and operational resilience.

Another internal moderator is operational efficiency, which is defined as a firm's capability to produce output from given inputs in a cost-effective manner (Allen and Rai, 1996; Lam et al., 2016; Tian et al., 2024). Operational efficiency implies optimised learning processes and quick response times; an operationally efficient organisation can better allocate and use its resources (Ambulkar et al., 2023; Lam et al., 2016). Similarly, according to SST, operational efficiency strengthens the positive relationship between TMT gender diversity and OR by creating organisational conditions that allow firms to respond to disruption more effectively.

Operational efficiency reflects the extent to which a firm has well-functioning processes and resource deployment routines, which can make the benefits of gender-diverse leadership more valuable under disruption. Another key aspect is the optimal allocation and use of resources, which is particularly important when dealing with the increased requisite variety brought by a gender-diverse TMT. Firms with higher

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operational efficiency are more likely to possess the organisational discipline and responsiveness needed for the positive effects of TMT gender diversity to be reflected in resilient outcomes. This enhanced process allows the organisation to translate the potential of a gender-diverse TMT into actionable strategies that address real-world challenges, thus reducing the complexity differential and strengthening OR.

Therefore, we propose the following:

H2b: Operational efficiency positively moderates the relationship between top management teams' gender diversity and operational resilience.

2.5 Moderating role of structure complexity

This study considers two moderators related to structure complexity, which are business and sourcing diversification. Business diversification refers to the strategy of engaging in multiple lines of business or industries, whereas sourcing diversification involves procuring materials or services from multiple suppliers or geographic locations (Casalin et al., 2017; Chen et al., 2023; Hendricks et al., 2009; Kim et al., 2017). Diversification allows a firm to expand into new markets that differ from its current ones (Dong et al., 2020; Jacobs and Swink, 2011). We argue that business and sourcing diversification plays a vital moderating role in enhancing the positive effects of TMT gender diversity on OR.

From an SST perspective, business and sourcing diversification inherently increase an organisation's structural complexity by embedding it in a wider constellation of markets, industries and supply chains. It is particularly important in the

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pandemic context. Specifically, during the first wave of COVID-19, this additional structural variety proved valuable: lockdowns, border closures and rolling supplier shutdowns created unprecedented information gaps and supply-side shocks, and only firms that had multiple product lines or geographically dispersed sourcing networks could gather a sufficiently rich stream of real-time signals on demand shifts, raw-material bottlenecks and regulatory disruptions.

By expanding the range of markets and supply relationships they are exposed to, diversified firms create structural conditions under which the broader cognitive variety of gender-diverse TMTs may become more valuable in responding to disruption. In short, under the extreme external complexity of a pandemic, business and sourcing diversification, as forms of structural complexity, provide conditions that may strengthen the resilience benefits associated with TMT gender diversity. This dynamic interaction between structure complexity and TMT gender diversity strengthens OR by reducing the complexity differential and improving the ability to adapt to changes. In line with this, we propose the following:

H3a: Business diversification positively moderates the relationship between top management teams' gender diversity and operational resilience.

H3b: Sourcing diversification positively moderates the relationship between top management teams' gender diversity and operational resilience.

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Finally, we synthesize the preceding arguments into a unified theoretical framework encompassing all constructs and hypotheses (see Figure 1).

[Insert Figure 1]

3. Methodology

3.1 Data collection

To ensure comparability and simultaneous exposure to operational disruptions, we adopt an exogenous shock design by selecting Chinese listed companies operating in 2020. This approach allows us to assess OR to a uniform large-scale disruption, reducing external variation influences. Consistently with prior studies (Chen et al., 2023; Yan et al., 2025), we identify January 2020 as the onset of the COVID-19 pandemic in China. At that time, all 31 provinces and provincial-level jurisdictions in mainland China implemented emergency measures, including strict lockdowns, social distancing and quarantine mandates, causing significant supply chain disruptions and operational challenges across industries. Thus, the pandemic provides a natural experimental setting as a common external shock, enabling a clear analysis of firm resilience. In addition, given that all sampled firms operated within mainland China, they experienced similar pandemic-related regulations and disruptions and had minimal timing variations. This design ensures that observed differences in resilience mainly reflect internal organisational characteristics, such as TMT gender diversity, rather than external condition variability.

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We obtain data from the China Stock Market and Accounting Research database (CSMAR) and Wind database, which are widely used for research on Chinese listed companies because of its comprehensive coverage of financial and governance information (Wang and Qian, 2011). Considering the effects on operational resilience may materialize with a lag, we measure all covariates in 2019 and use OR in 2020 as the outcome.

We construct the sample as follows. We first exclude firms in financial industries and those designated ST or *ST in either 2019 or 2020, yielding 4,181 firms after these universe-level screens. We then merge the required variables: combining the dependent variable, the explanatory variable, two instruments and four moderators leaves 1,706 firms; then adding seven control variables yields 1,158 firm observations. This pattern shows that most attrition arises from variable matching rather than discretionary exclusions, particularly for business and sourcing diversification, which rely on non-mandatory disclosure and are frequently missing. Additionally, during the pandemic, many firm-level data may swing unusually high or low. Such shock-induced extremes generate outliers that can inflate ratio-based measures like ORPPC and exert disproportionate leverage on regression estimates, without necessarily reflecting underlying operational resilience. To limit this undue influence while preserving informative crisis-driven variation, we winsorise continuous variables at the 1st and 99th percentiles.

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3.2 Variable measurements

Dependent variables

In this study, *operational resilience* is defined as the variation in operating revenue per unit of production cost (ORPPC) before and after the outbreak of COVID-19. Prior studies highlight financial loss as a vital indicator for evaluating OR (e.g. Li et al., 2023; Sajko et al., 2021). According to Nikolopoulos et al. (2021), the widespread disruptions caused by the pandemic affected both the demand and supply aspects. Therefore, our approach builds on earlier studies (e.g. Li et al., 2023; Tan et al., 2020) by integrating sales data to represent the demand and operational costs to reflect the supply.

We first calculate ORPPC as follows:

$$\mathrm{ORPPC}_{i,t} = \mathrm{Operating\ Revenu}_{i,t} \ / \ \mathrm{Production\ Cost}_{i,t}$$

Then we use the average ORPPC from 2017 to 2019 as a baseline. Then OR loss was determined by calculating the ratio of 2020 ORPPC to the average 2017–2019 ORPPC:

$$\mathrm{Resilience}_i = \mathrm{ORPPC}_{i,2020} \ / \ \mathrm{ORPPC}_{i,\mathrm{baseline}}$$

A higher ratio indicates smaller financial losses and thus stronger operational resilience. Values above one signify improvement relative to the baseline, whereas values below one indicate deterioration. For example, a resilience value of 1.20 implies a 20% improvement over the pre-pandemic level.

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Independent variable

Following prior studies (e.g. Liu et al., 2024; Qi et al., 2018; Wu et al., 2022), we measure TMT gender diversity as the proportion of women among a firm's senior management. Specifically, we use each company's annual report to identify the senior management team, which includes the general manager, president/CEO, vice-general managers, vice-presidents, the board secretary and any other executives listed in the 'senior management' roster. We calculate gender diversity by dividing the number of female senior managers by the total number. Notably, we exclude managers with non-executive roles, as well as anyone who resigned or retired before the end of the fiscal year. To account for potential lag effects and reduce the risk of reverse causality, all gender diversity measures are based on data from 2019.

Instrumental variables

We employ two instrumental variables: *TMT distributive equity* and a *province-industry female executive supply Bartik IV*. TMT distributive equity is defined as the ratio of the average compensation of female managers to that of male managers within the top management team. The Bartik IV is constructed as the interaction between the baseline female executive share in a given province-industry cell during 2015 to 2017 and the national industry-level female executive share in 2018, excluding the focal province. This instrument is intended to capture both local exposure to female executive supply and broader industry-level shifts in female executive representation. To ensure temporal precedence relative to the endogenous regressor, the Bartik IV is constructed

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using pre-determined baseline shares and a 2018 national industry component, and TMT distributive equity is also measured in 2018.

Moderating variables

Absorptive capacity, defined as the ability to recognise, assimilate and apply external knowledge, is a key factor influencing a firm's innovation output. Prior studies indicate that a firm's absorptive capacity is primarily determined by its investment in R&D and its existing related knowledge (Bellamy et al., 2014). The reasoning is that firms engaged in their own R&D activities are better positioned to use external information effectively. Consequently, we calculate R&D intensity as the percentage of total sales dedicated to R&D expenditures.

Operational efficiency is proxied by inventory days, as inventory typically represents a substantial share of firms' operating capital. We calculate inventory days as total inventory divided by cost of goods sold, multiplied by 365. This measure captures the average number of days capital remains tied up in inventory. Lower inventory days indicate higher operational efficiency.

Business diversification refers to the extent to which a firm expands across multiple markets or customer segments, which is quantified as 100 minus Business Herfindahl–Hirschman Index. Similarly, *sourcing diversification* captures the extent to which a firm purchases from multiple suppliers, which is measured as 100 minus the Sourcing Herfindahl–Hirschman Index. Higher values correspond to a higher level of diversification. The Herfindahl-Hirschman Index is an economic measure used to

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gauge the level of market concentration, calculated by squaring the market share of each firm in the market and summing those values.

Control variables

Our study incorporates eight control variables: *ESG*, *quick ratio*, *financial leverage*, *operational leverage*, *Return on Assets (ROA)* and *firm size*, *TMT age* and *TMT educational background*.

Specifically, *ESG* is acquired from Huazheng ESG score from Wind database. is *quick ratio* is determined by subtracting inventory and prepaid expenses from current assets, then dividing this result by current liabilities (Yan et al., 2025). *Financial leverage* is measured as long-term debt divided by total assets (DesJardine et al., 2019). *Operational leverage* is measured by the percentage change in earnings before interest and taxes, divided by the percentage change in sales. *ROA* is calculated as net income divided by average total assets (L. Chen et al., 2023). *Firm size* is calculated as the natural logarithm of 1 plus the book value of total assets (Markman and Venzin, 2014).

TMT age is the TMT members' average age in year 2019, and *TMT educational background* is quantified using the average educational level of all TMT members. To compute this average, we assign numerical values to various education levels using dummy variables ranging from 1 to 5, where 1 refers to secondary specialised/ vocational school or below, 2 is associate degree/diploma, 3 stands for bachelor degree, 4 is master degree and 5 is doctoral degree. This coding ensures a standardised approach to measuring educational background across TMTs.

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Fixed effects

To control for unobserved heterogeneity across regions, we include both industry and province fixed effects in all regression models. Industry and province codes are sourced from the CSMAR.

3.3 Estimation methods

Considering potential endogeneity, we adopt IV-2SLS as our main estimation framework. Endogeneity in the gender diversity-OR relationship may arise from at least two sources. First, firms with stronger operational resilience may be more likely to promote gender diversity as part of a broader sustainability or governance strategy, creating a risk of reverse causality. Second, omitted firm-specific factors, such as corporate culture or managerial philosophy, may jointly shape both TMT gender diversity and operational resilience, leading to spurious correlation. To address these concerns, we employ an instrumental variable approach.

Specifically, we use TMT distributive equity and a province-industry female executive supply Bartik IV as two instruments for TMT gender diversity. First, in practice, pay equity is linked to better access to female talent because firms that place greater emphasis on distributive fairness are more likely to establish merit-based promotion and compensation systems rather than systems shaped by entrenched gender bias. Prior research also shows a positive association between distributive equity and the representation of women in senior positions (Amore and Garofalo, 2021; Santero-Sánchez and Núñez, 2025).

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Second, to better capture the supply-side variation in female executive representation, we construct a province-industry female executive supply Bartik IV. The logic is that a firm's access to female executive talent is shaped not only by local conditions but also by broader industry-level shifts in female executive representation. This construction is also consistent with prior research. Flabbi et al. (2019) show that regional trends can provide plausibly exogenous variation in female leadership, while Sieweke et al. (2023) explicitly apply a Bartik-type instrument in the context of TMT gender diversity.

These two instruments are expected to satisfy the exclusion restriction because they affect operational resilience only through their effect on the focal firm's TMT gender diversity. Distributive equity captures internal fairness in executive compensation and is expected to influence resilience only indirectly by improving the firm's ability to attract and retain female executives. The Bartik IV captures province-industry exposure to female executive supply and broader industry-level shifts in female executive representation, rather than the focal firm's short-run operating outcomes. Because this instrument is constructed from pre-determined province-industry exposure and external industry-wide shifts, it should not have a direct mechanical effect on the focal firm's operational resilience. In all models, we additionally include province and industry fixed effects to absorb time-invariant regional and sectoral heterogeneity.

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In the moderation models, TMT gender diversity is treated as endogenous. We therefore estimate a moderated IV-2SLS specification in which the fitted value of gender diversity from the first stage is carried into the second stage, together with the corresponding interaction terms. In this way, both the direct effect and the moderating effects are identified under the same instrumental variable logic. As supplementary robustness checks, we also report Ordinary Least Squares (OLS) and cross-sectional Instrumental Variables-Generalized Method of Moments (IV-GMM) estimates. The IV-GMM specification is non-dynamic and is estimated with heteroskedasticity-robust standard errors.

4. Result Analysis

4.1 General descriptive statistics

Tables 1 and 2 report the descriptive statistics and correlation matrix for the variables. The final sample consists of 1,158 firm observations. The mean value of TMT gender diversity is 0.20, indicating that women account for 20% of top management team members on average and remain underrepresented in Chinese listed firms. The mean value of operational resilience is 1.04, suggesting that, on average, firms' operating revenue per unit of production cost in 2020 was about 4% higher than the 2017–2019 baseline. This indicates that, despite the severe disruption caused by the COVID-19 shock, the sampled firms on average maintained a modest improvement in operational performance relative to the pre-pandemic benchmark. In terms of the instruments, the mean value of TMT distributive equity is 0.81, while the mean value

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of the province-industry Bartik IV is 0.04, providing sufficient variation for the instrumental variable analysis. The descriptive statistics of the remaining variables also suggest substantial cross-firm heterogeneity in firm characteristics, managerial composition, and operational conditions.

The correlation matrix further provides preliminary support for our empirical design. Gender diversity is positively correlated with both instrumental variables, especially TMT distributive equity ($r = 0.43$, $p < 0.01$) and the province-industry Bartik IV ($r = 0.16$, $p < 0.01$), which is consistent with instrument relevance. In addition, most pairwise correlations among the regressors are modest in magnitude, suggesting that multicollinearity is unlikely to be a serious concern in the baseline regressions.

[Insert Tables 1 and 2]

4.2 IV-2SLS regression analysis results

In the first stage of the 2SLS estimation, we regress TMT gender diversity on the two instrumental variables alongside a comprehensive set of control variables (Table 3). The two instruments are positively and significantly associated with gender diversity at the 1% level ($p < 0.01$), confirming their relevance.

[Insert Table 3]

In all second-stage moderation models, we use the instrumented gender diversity term and its IV-consistent interaction with each moderator, rather than the raw observed gender diversity measure. This ensures consistency in addressing endogeneity across all models. Stage two shows that the coefficient on instrumented gender diversity

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is positive and statistically significant ($\beta = 0.188$, $p < 0.01$), providing support for Hypothesis 1 and indicating a robust causal relationship with resilience. All moderation effects are tested using the instrumented gender diversity variable, thus maintaining the integrity of our identification strategy.

Regarding the moderating variables, the results also show several significant interaction effects. First, the interaction between gender diversity and absorptive capacity is positive and significant ($\beta = 1.403$, $p < 0.01$), suggesting that absorptive capacity strengthens the positive effect of gender diversity on resilience, consistent with Hypothesis 2a. Second, operational efficiency significantly moderates the relationship ($\beta = 0.077$, $p < 0.01$), supporting Hypothesis 2b.

For structural moderators, business diversification exhibits a significant and positive interaction effect with gender diversity ($\beta = 0.396$, $p < 0.01$), supporting the idea that a broader product or market scope enhances the resilience benefits of gender-diverse leadership. Similarly, sourcing diversification also shows a significant and positive interaction ($\beta = 0.978$, $p < 0.05$), indicating that a more complex supplier base amplifies the positive effect of gender diversity on resilience. Therefore, Hypotheses 3a and 3b are supported.

For transparency on economic magnitude, we additionally report fully standardized interaction coefficients. The fully standardized interaction coefficients are 0.140 for Gender diversity × Absorptive capacity, 0.192 for Gender diversity × Operational efficiency, 0.143 for Gender diversity × Business diversification, and 0.078

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for Gender diversity × Sourcing diversification. These values indicate that a one-standard-deviation joint increase in instrumented gender diversity and each moderator is associated with an additional 0.08 to 0.19 standard-deviation increase in operational resilience. In relative terms, the moderation strength is highest for Operational efficiency, followed by Business diversification and Absorptive capacity, and then Sourcing diversification.

To further verify the validity of our instrumental variable approach, we conduct four diagnostic tests. First, we perform the underidentification test using the Anderson canonical correlation LM statistic. The result—an F statistic of 199.404 with a p value less than 0.01—rejects the null hypothesis of underidentification, confirming that the model is properly identified.

Second, we conduct the weak identification test. The Cragg-Donald Wald F statistic is 188.808, which far exceeds the conventional threshold of 10 (Staiger and Stock, 1997). This provides strong evidence that the instruments are not weak and possess substantial explanatory power for the endogenous regressor, TMT gender diversity.

Third, we assess the validity of the overidentifying restrictions using the Hansen J test. The test yields $p = 0.496$, so we do not reject the joint exogeneity of the instruments. While this does not prove the exclusion restriction, it is consistent with our identification assumptions and supports the use of IV–2SLS in our setting.

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Finally, we assess whether endogeneity is present and IV estimation is warranted using the Durbin–Wu–Hausman test. The statistic of 4.527 with $p = 0.033$ rejects equality of the OLS and IV estimates at the 5% level, indicating that TMT gender diversity is endogenous and that IV–2SLS is preferred to OLS for consistent inference.

Collectively, these diagnostics confirm that our instruments satisfy the relevance and exclusion conditions necessary for consistent estimation, reinforcing the credibility of our identification strategy.

4.3 Robustness checks

To further validate the robustness of our empirical findings, we conduct a series of additional analyses. First, we re-estimate the IV model using efficient GMM with the same instrument set. Under IV-GMM, both the main effect of TMT gender diversity and the moderated effects remain statistically significant and close in magnitude to the IV-2SLS estimates. Specifically, the coefficient on instrumented gender diversity remains positive and significant ($\beta = 0.188$, $p < 0.01$). The interaction terms between gender diversity and absorptive capacity ($\beta = 1.280$, $p < 0.01$), operational efficiency ($\beta = 0.074$, $p < 0.01$), business diversification ($\beta = 0.388$, $p < 0.01$), and sourcing diversification ($\beta = 0.882$, $p < 0.05$) are all positive and statistically significant. The Hansen J test fails to reject the overidentifying restrictions ($p = 0.598$), and the Durbin-Wu-Hausman test indicates that endogeneity is present and IV estimation remains warranted ($p = 0.033$). Together, these results suggest that the estimated effects are not sensitive to the specific IV estimator used (Table 4).

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[Insert Tables 4]

Second, we also estimate the models using OLS to evaluate whether the results are consistent under a standard linear framework. The OLS regression results, presented in Table 5, reveal that the coefficient on TMT gender diversity remains significant and positive ($\beta = 0.099$, $p < 0.01$) when only control variables are included, indicating a robust association with operational resilience. Models 2 through 5 incorporate each of the four moderators, absorptive capacity, operational efficiency, business diversification, and sourcing diversification, individually. In each case, the interaction term remains positive and statistically significant, consistent with the IV results. In Model 6, which includes all moderators and interaction terms simultaneously, the coefficient on gender diversity remains positive and significant ($\beta = 0.122$, $p < 0.01$), while all four interaction terms also remain positive and significant. These findings suggest that the relationship between gender diversity and resilience is not driven by the estimation technique (Table 5).

[Insert Tables 5]

Third, we redefine the outcome using an EBITDA-based measure of operational resilience. As reported in Table 6, the coefficient on instrumented gender diversity remains positive and statistically significant ($\beta = 0.191$, $p < 0.01$). The four interaction terms also remain positive and significant: gender diversity × absorptive capacity ($\beta = 1.328$, $p < 0.01$), gender diversity × operational efficiency ($\beta = 0.078$, $p < 0.01$), gender diversity × business diversification ($\beta = 0.353$, $p < 0.01$), and gender diversity ×

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sourcing diversification ($\beta = 1.366$, $p < 0.01$). The diagnostic tests continue to support the validity of the specification (Table 6).

[Insert Table 6]

Fourth, we probe sensitivity to alternative measurement windows on both the right- and left-hand sides using OLS (see Table 7). Model 1 lengthens the window for TMT gender diversity by replacing the single-year 2019 value with the 2017-2019 average. The coefficient on gender diversity remains positive and significant ($\beta = 0.091$, $p < 0.01$), and all four interaction terms remain positive and statistically significant. Model 2 extends the pre-pandemic baseline used to construct resilience from a three-year average (2017-2019) to a five-year average (2015-2019). The coefficient on gender diversity remains positive and significant ($\beta = 0.104$, $p < 0.01$), and the interaction remain positive and significant, while the interaction with sourcing diversification becomes statistically insignificant. Model 3 redefines the outcome by measuring resilience using the lowest ORPPC observed between 2020 and 2024 rather than 2020 alone. Again, the coefficient on gender diversity remains positive and significant ($\beta = 0.100$, $p < 0.01$), and the interaction terms remain positive and significant, whereas the interaction with sourcing diversification is no longer statistically significant. Overall, across these alternative specifications, the main effect remains stable and most moderating effects remain directionally consistent with the baseline estimates, reinforcing the robustness of our findings (Table 7).

[Insert Table 7]

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Finally, we re-estimate all models on the unwinsorised sample; the main and moderating effects remain statistically significant and directionally consistent with the baseline, indicating that our conclusions are not driven by tail treatment. Overall, the robustness of our findings across multiple alternative specifications reinforces the validity of our findings.

4.4 Further analyses

According to SST, increasing TMT gender diversity can enhance cognitive variety and adaptive decision quality, but very high diversity may also raise coordination and communication costs. These countervailing mechanisms imply a possible non-monotonic main effect. To address the potential concern that the main effect and the moderating effects of structural complexity may follow a non-linear pattern, we conduct additional tests to examine the possibility of U-shaped relationships.

In the first test, we introduce a squared term of gender diversity into the model to test for a curvilinear main effect. The coefficient on the squared term is statistically insignificant in both specifications (see Appendix 2), suggesting no evidence of a U-shaped relationship between gender diversity and operational resilience.

In the second test, we add squared terms for the two structural complexity variables, business diversification and sourcing diversification, together with their interaction terms with gender diversity. The results show that the squared term of business and sourcing diversification and their interactions with gender diversity

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remain statistically insignificant, indicating no evidence of a non-linear moderating effect.

5. Discussion and Conclusion

This study investigates the relationship between gender diversity in TMTs and OR through the lens of SST. Using a sample of Chinese listed firms from 2020, the study applies IV-2SLS approach analyses to assess the hypotheses. Findings suggest that TMT gender diversity is associated with enhanced OR. The study further finds that this relationship is contingent on process and structure complexity. It posits that both process complexity and structure complexity have positive moderating effects.

Notably, although these findings advance the diversity–resilience debate, they should be interpreted considering China's sociocultural context. First, the country's collectivist, consensus-oriented norms value relational and collaborative leadership, which often associated with female executives' attributes, facilitate rapid information sharing and coordinated action during shocks. Second, traditional gender expectations (e.g. 'men lead outside, women lead inside') set a higher bar for women's promotion; those who do reach the TMT are therefore a positively selected group with strong problem-solving and risk-assessment skills, further enhancing organisational resilience (Li and Tong, 2023).

5.1 Theoretical contributions

This study contributes to OSCM research in the following ways. First, this may be the first to offer the large-sample empirical evidence that gender diversity as a form

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of requisite variety in SST terms within TMTs enhances OR. Although prior studies such as the conceptual work by Ali (2022) and Duchek et al. (2020)—broadly link diversity to resilience, direct, operations-oriented analyses remain scarce. For instance, Kim et al. (2021) focus primarily on financial resilience, overlooking the operational dimensions of firm adaptability. Our study addresses this critical gap by empirically examining the relationship between TMT gender diversity and firms' OR. Our findings show that gender-diverse TMTs help organisations maintain and restore operations more effectively under extreme conditions (e.g., large scale supply chain disruptions). Overall, this adds a new dimension to OSCM literature and resilience theory and deepens understanding of how diverse executive teams contribute to organisational stability and effectiveness when supply chains are most fragile and uncertainty is highest.

The second notable contribution of our study is its exploration of how the relationship between TMT gender diversity and OR is contingent on certain OSCM factors underpinned by SST. This is a significant advancement in the literature, because prior gender diversity studies predominantly focus on governance or financial variables (e.g. Jabari and Muhamad, 2021), neglecting the OSCM context. By introducing and analysing four OSCM moderators, we address the gap and offer a richer understanding of how diversity influences organisational outcomes.

Drawing on SST, we argue that these moderators capture the organisational conditions under which the positive relationship between TMT gender diversity and

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OR becomes stronger. Absorptive capacity and operational efficiency reflect internal process conditions, while business and sourcing diversification reflect structural conditions that shape how valuable the broader cognitive variety of gender-diverse TMTs becomes under disruption. The study therefore highlights that the effect of gender diversity on OR is not uniform but depends on the firm's internal processes and external structures, revealing that the interplay between gender diversity and OSCM factors can significantly affect OR.

A notable aspect of our findings concerns the role of business and sourcing diversification, which have been widely debated in the literature. Although diversification is often viewed as a risk-mitigating strategy, it also introduces additional layers of complexity that may challenge operational efficiency and decision-making. Our research contributes to this debate by demonstrating that both business and sourcing diversification can amplify the benefits of gender diversity on OR. Our findings suggest that rather than being inherently beneficial or detrimental, the impact of business and sourcing diversification on resilience depends on how effectively organisations manage the accompanying complexity. These findings significantly enrich the OSCM literature.

Third, our study extends social system theory by empirically validating its suitability for OSCM studies. We draw on four fundamental constructs from this theoretical lens—complexity differential, requisite variety, process complexity and structural complexity—incorporating them into our empirical study in the OSCM

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realm. Although SST has been used to explain organisational adaptability from theoretical perspectives (e.g. Schneider et al., 2017), few studies have empirically applied SST to the OSCM literature. This study makes contributions to SST by providing empirical evidence that links SST's concept of requisite variety directly to gender diversity, demonstrating that diversity-related factors can serve as a suitable proxy for requisite variety.

5.2 Practical implications

Gender-diverse TMTs enhance operational resilience where two features of China's sociocultural context prevail: collectivist, consensus-oriented norms and higher promotion thresholds for women. In such settings, diverse leadership supplies cognitive variety that improves anticipation, response, and recovery. In China's collectivist firms, this diversity strengthens resilience by reinforcing collaborative decision-making and adaptability.

As women's roles expand—supported by regulation and shifting attitudes—gender diversity becomes a strategic asset, not mere compliance. The payoff, however, is context-dependent: in rigid hierarchies or where gender-inclusion policies are weak, organisations need targets, accountability, and bias-free promotion to realise similar gains; in already inclusive environments, the priority is to embed diverse perspectives into strategy and crisis-response routines.

In addition, realising the benefits of gender-diverse TMTs requires strong operational efficiency and absorptive capacity. Our results show that the payoff to

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gender diversity is larger in more efficient operations. Moving operational efficiency from the 25th to the 75th percentile increases the marginal resilience gain from diversity by about 20%. For executives, combining basic efficiency programs, such as reducing inventory days and improving throughput, with effective R&D investment and targeted diversity initiatives yields higher resilience returns than pursuing each in isolation.

In the post-COVID context, policies that incentivise gender diversity in corporate leadership through executive training funds, tax credits, or public recognition can help maintain critical operations during future shocks. Complementary rules that encourage product and sourcing diversification expand response options when supply chains stall. Together, these measures strengthen resilience, support innovation, and enhance long-term competitiveness amid recurring disruptions.

5.3 Limitations and future research directions

A main limitation of this study is its focus on Chinese listed firms in a single COVID year. While this setting captures responses under a severe shock, it is unclear whether the same relationships and boundary conditions hold when uncertainty declines, coordination costs rise, or institutional settings differ. Because the data are cross-sectional, we also cannot model resilience trajectories or fully establish dynamic causal effects. Future research should use multi-year and cross-country panel data with firm and year fixed effects, dynamic and non-linear tests, and, when suitable shocks or policy changes occur, event-study or difference-in-differences designs to strengthen external validity and causal inference.

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Second, our quantitative design cannot fully capture the firm-specific context. For example, informal power dynamics, decision-making processes, and the actual inclusion of female executives in crisis responses are difficult to observe in archival data. Future research could adopt mixed method designs that combine econometric analyses with case studies, interviews, or survey evidence to uncover the underlying mechanisms and channels.

Third, data constraints limit the breadth of our complexity measures. Our current operationalization captures only part of internal variety and does not fully reflect structural and cognitive diversity within the TMT or the complexity of coordination inside the firm. Future work could pair indicators of external turbulence with richer internal variety measures beyond gender alone, to better examine how different types of complexity jointly shape resilience outcomes.

Finally, the endogeneity of four moderators may remain. Moderator-specific instruments, quasi-experiments, and richer multi-shock panels would improve causal identification and reduce dependence on a single-year setting.

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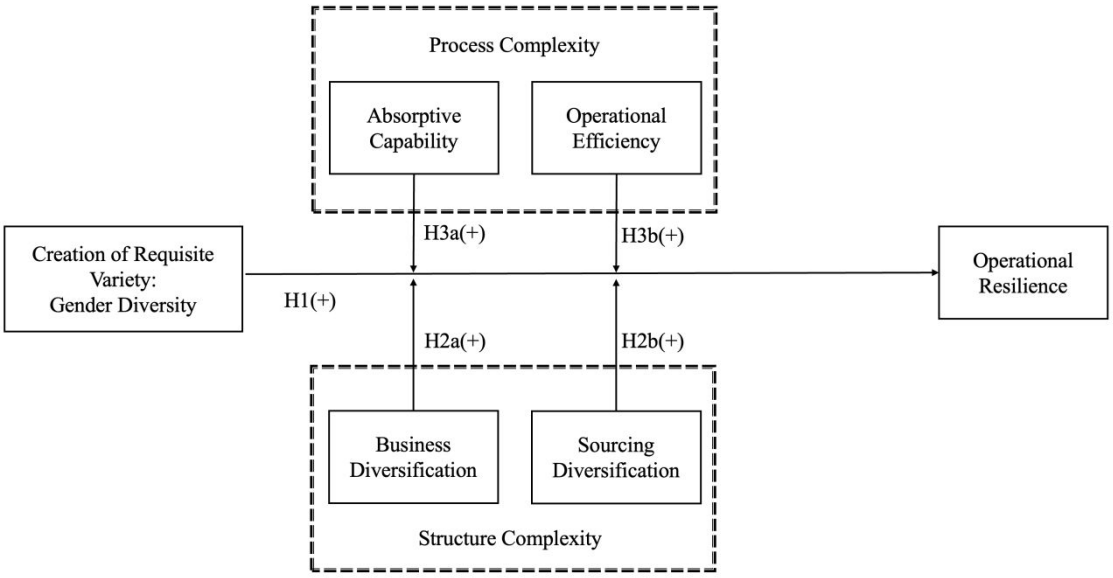


Figure 1. Theoretical Framework

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Table 1. Descriptive Statistics

	Observations	Mean	SD	Min	Max
Operational resilience	1158	1.04	0.17	0.20	3.60
Gender diversity	1158	0.20	0.17	0.00	1.00
Absorptive capacity	1158	0.05	0.10	0.00	3.08
Operational efficiency	1158	1.08	2.49	0.00	19.44
Business diversification	1158	0.05	0.36	0.01	10.00
Sourcing diversification	1158	0.02	0.08	0.01	0.90
TMT distributive equity	1158	0.81	0.50	0.02	7.25
Province-industry Bartik IV	1158	0.04	0.02	0.00	0.28
ESG	1158	71.92	6.37	47.94	86.53
Quick ratio	1158	2.06	1.98	0.04	20.26
Financial leverage	1158	1.74	3.92	0.28	60.08
Operational leverage	1158	1.52	0.84	1.00	16.30
ROA	1158	0.07	0.22	-0.01	7.45
TMT Education	1158	3.23	0.66	1.00	5.00
TMT age	1158	46.34	5.91	28.50	70.00
Firm size	1158	22.05	1.16	17.86	26.67

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Table 2. Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operational resilience	1.00															
Gender diversity	0.09***	1.00														
Absorptive capacity	0.40***	0.07**	1.00													
Operational efficiency	0.31***	-0.05*	-0.08***	1.00												
Business diversification	0.02	0.01	-0.04	0.11***	1.00											
Sourcing diversification	0.08***	-0.03	0.27***	0.00	0.06**	1.00										
TMT distributive equity	0.10***	0.43***	0.05	-0.04	-0.02	-0.01	1.00									
Province-industry Bartik IV	0.13***	0.16***	-0.01	-0.06**	-0.03	-0.01	0.09***	1.00								
ESG	0.16***	0.10***	-0.03	0.09***	0.11***	0.02	0.07**	-0.03	1.00							
Quick ratio	-0.03	0.08***	0.11***	-0.19***	-0.04	-0.04	0.03	0.01	0.10***	1.00						
Financial leverage	-0.19***	0.05*	-0.05*	0.10***	-0.02	0.02	-0.05*	-0.13***	-0.11***	-0.13***	1.00					
Operational leverage	-0.11***	0.00	-0.01	-0.12***	-0.03	-0.02	0.01	0.01	-0.06**	-0.05	0.07***	1.00				
ROA	-0.09***	0.00	-0.00	-0.05	-0.01	-0.01	0.01	-0.00	-0.07**	0.04	-0.05*	-0.10***	1.00			
TMT Education	0.08***	0.00	0.02	0.13***	0.07**	-0.02	-0.04	-0.04	-0.02	-0.06**	0.10***	-0.06**	0.00	1.00		
TMT age	-0.10***	-0.07**	-0.03	-0.01	0.00	0.02	-0.05*	-0.07**	0.08***	0.03	0.16***	-0.08***	-0.01	0.05*	1.00	
Firm size	-0.04	-0.14***	-0.15***	0.13***	0.21***	0.01	-0.03	-0.06**	0.19***	-0.27***	-0.04	-0.07**	-0.04	0.17***	0.05*	1.00

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table 3. IV-2SLS Analysis Results

	Stage 1	**Stage 2**
	Gender diversity	Operational resilience
Distributive equity	0.115***	
	(0.011)	
Province-industry Bartik IV	10.048***	
	(1.182)	
Gender diversity (predicted value from stage 1)		0.188***
		(0.065)
ESG	0.000	0.004***
	(0.001)	(0.001)
Quick ratio	0.001	-0.003
	(0.002)	(0.003)
Financial leverage	0.001	-0.006**
	(0.002)	(0.003)
Operational leverage	-0.005	-0.022***
	(0.005)	(0.006)
ROA	-0.010*	-0.085***
	(0.006)	(0.027)
TMT Education	0.010*	0.020***
	(0.006)	(0.007)
TMT age	-0.001**	-0.001
	(0.001)	(0.001)
Firm size	-0.011***	-0.001
	(0.004)	(0.005)
Absorptive capacity		0.272***
		(0.091)
Gender diversity * Absorptive capacity		1.403***
		(0.331)
Operational efficiency		0.025***
		(0.002)
Gender diversity * Operational efficiency		0.077***
		(0.015)
Business diversification		-0.034**
		(0.014)
Gender diversity * Business diversification		0.396***
		(0.089)
Sourcing diversification		-0.009
		(0.059)
Gender diversity * Sourcing diversification		0.978**
		(0.462)
Fixed effect: Industry	Yes	Yes
Fixed effect: Province	Yes	Yes
_cons	0.440***	1.180***
	(0.096)	(0.106)
Observations	1158	1158
R-squared	0.558	0.524
F-statistic		122.576

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Underidentification test (Anderson canon. corr. LM statistic)	199.404 (p = 0.000)
Weak identification test (Cragg-Donald Wald F statistic)	188.808
Hansen J Statistic	0.464 (p = 0.496)
Durbin-Wu-Hausman test	4.527 (p = 0.033)

Standard errors in parentheses

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

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Table 4. Robustness Check 1: IV-GMM as Alternative Estimation Method

	Stage 1	**Stage 2**
	Gender diversity	Operational resilience
Distributive equity	0.115***	
	(0.011)	
Province-industry Bartik IV	10.048***	
	(1.182)	
Gender diversity (predicted value from stage 1)		0.188***
		(0.067)
ESG	0.000	0.004***
	(0.001)	(0.001)
Quick ratio	0.001	-0.003
	(0.002)	(0.003)
Financial leverage	0.001	-0.006**
	(0.002)	(0.003)
Operational leverage	-0.005	-0.022***
	(0.005)	(0.006)
ROA	-0.010*	-0.084***
	(0.006)	(0.027)
TMT Education	0.010*	0.020***
	(0.006)	(0.007)
TMT age	-0.001**	-0.001
	(0.001)	(0.001)
Firm size	-0.011***	-0.000
	(0.004)	(0.005)
Absorptive capacity		0.325***
		(0.111)
Gender diversity * Absorptive capacity		1.280***
		(0.367)
Operational efficiency		0.025***
		(0.002)
Gender diversity * Operational efficiency		0.074***
		(0.013)
Business diversification		-0.033***
		(0.012)
Gender diversity * Business diversification		0.388***
		(0.105)
Sourcing diversification		-0.017
		(0.037)
Gender diversity * Sourcing diversification		0.882**
		(0.372)
Fixed effect: Industry	Yes	Yes
Fixed effect: Province	Yes	Yes
_cons	0.440***	1.177***
	(0.096)	(0.137)
Observations	1158	1158
R-squared	0.558	0.398
F-statistic		26.54

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Hansen J Statistic	0.277 (p = 0.598)
Durbin-Wu-Hausman test	4.527 (p = 0.033)

Standard errors in parentheses

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

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Table 5. Robustness Check 2: OLS as Alternative Estimation Method

Operational resilience	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gender diversity	0.099***	0.095***	0.086**	0.089***	0.100***	0.122***
	(0.034)	(0.036)	(0.036)	(0.034)	(0.042)	(0.041)
ESG	0.004***	0.004***	0.004***	0.004***	0.004***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Quick ratio	-0.003	-0.002	-0.001	-0.002	-0.001	-0.001
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
Financial leverage	-0.007**	-0.006**	-0.008***	-0.007**	-0.007**	-0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Operational leverage	-0.022***	-0.020***	-0.019***	-0.022***	-0.021***	-0.018***
	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)
ROA	-0.087***	-0.085***	-0.079***	-0.087***	-0.083***	-0.077***
	(0.028)	(0.029)	(0.029)	(0.027)	(0.028)	(0.030)
TMT Education	0.022***	0.018***	0.017**	0.022***	0.018**	0.014**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
TMT age	-0.001*	-0.001	-0.001	-0.001*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm size	-0.002	0.001	0.005	-0.002	-0.002	0.007
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Absorptive capacity		0.167				0.034
		(0.197)				(0.197)
Gender diversity * Absorptive capacity		1.266***				1.459***
		(0.392)				(0.388)
Operational efficiency			0.022***			0.023***
			(0.007)			(0.007)
Gender diversity * Operational efficiency			0.023***			0.015***
			(0.007)			(0.006)
Business diversification				-0.058**		-0.079***
				(0.028)		(0.025)
Gender diversity * Business diversification				0.225***		0.286***
				(0.086)		(0.080)
Sourcing diversification					-0.507**	-0.121*
					(0.234)	(0.065)
Gender diversity * Sourcing diversification					0.717**	0.727**
					(0.341)	(0.391)
Fixed effect: Industry	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effect: Province	Yes	Yes	Yes	Yes	Yes	Yes
_cons	1.264***	1.131***	1.081***	1.257***	1.239***	0.958***
	(0.171)	(0.158)	(0.159)	(0.173)	(0.162)	(0.153)
Observations	1158	1158	1158	1158	1158	1158
R-squared	0.316	0.477	0.355	0.318	0.406	0.515

Standard errors in parentheses

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

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Table 6. Robustness Check 3: EBITDA as Alternative Measurement of Operational Resilience

	Stage 1 Gender diversity	**Stage 2** Operational resilience (Measured by EBITDA)
Distributive equity	0.114***	
	(0.011)	
Province-industry Bartik IV	10.093***	
	(1.181)	
Gender diversity (predicted value from stage 1)		0.191***
		(0.066)
ESG	0.000	0.004***
	(0.001)	(0.001)
Quick ratio	0.001	-0.003
	(0.002)	(0.003)
Financial leverage	0.001	-0.007**
	(0.002)	(0.003)
Operational leverage	-0.006	-0.020***
	(0.005)	(0.006)
ROA	-0.011*	-0.080***
	(0.006)	(0.029)
TMT Education	0.010*	0.023***
	(0.006)	(0.007)
TMT age	-0.001**	-0.001
	(0.001)	(0.001)
Firm size	-0.012***	-0.001
	(0.004)	(0.005)
Absorptive capacity		0.255***
		(0.095)
Gender diversity * Absorptive capacity		1.328***
		(0.346)
Operational efficiency		0.025***
		(0.002)
Gender diversity * Operational efficiency		0.078***
		(0.016)
Business diversification		-0.035**
		(0.014)
Gender diversity * Business diversification		0.353***
		(0.093)
Sourcing diversification		0.025
		(0.062)
Gender diversity * Sourcing diversification		1.366***
		(0.485)
Fixed effect: Industry	Yes	Yes
Fixed effect: Province	Yes	Yes
_cons	0.292***	1.080***
	(0.117)	(0.112)
Observations	1158	1158
R-squared	0.558	0.368

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F-statistic	28.60
Underidentification test	288.891 (p = 0.000)
(Anderson canon. corr. LM statistic)	
Weak identification test	188.690
(Cragg-Donald Wald F statistic)	
Hansen J Statistic	0.026 (p = 0.872)
Durbin-Wu-Hausman test	5.581 (p = 0.018)

Standard errors in parentheses

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

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Table 7. Robustness Check 4: Sensitivity to Measurement Windows

Operational resilience	Model 1	Model 2	Model 3
Gender diversity	0.091***	0.104***	0.100***
	(0.027)	(0.027)	(0.020)
ESG	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
Quick ratio	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
Financial leverage	-0.012***	-0.009***	-0.009***
	(0.003)	(0.003)	(0.003)
Operational leverage	-0.015***	-0.021***	-0.021***
	(0.006)	(0.006)	(0.006)
ROA	-0.079**	-0.087***	-0.086***
	(0.032)	(0.030)	(0.030)
TMT Education	0.018***	0.014**	0.014**
	(0.006)	(0.006)	(0.006)
TMT age	-0.001**	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)
Firm size	-0.003	-0.003	-0.004
	(0.005)	(0.005)	(0.005)
Absorptive capacity	0.289**	0.306***	0.312***
	(0.112)	(0.108)	(0.108)
Gender diversity * Absorptive capacity	1.386***	1.513***	1.497***
	(0.367)	(0.359)	(0.358)
Operational efficiency	0.025***	0.024***	0.023***
	(0.002)	(0.002)	(0.002)
Gender diversity * Operational efficiency	0.062***	0.067***	0.066***
	(0.011)	(0.012)	(0.012)
Business diversification	-0.030***	-0.029**	-0.028**
	(0.011)	(0.012)	(0.012)
Gender diversity * Business diversification	0.336***	0.424***	0.419***
	(0.078)	(0.105)	(0.102)
Sourcing diversification	-0.006	-0.059	-0.061
	(0.037)	(0.043)	(0.043)
Gender diversity * Sourcing diversification	1.028***	0.420	0.400
	(0.322)	(0.401)	(0.399)
Fixed effect: Industry	Yes	Yes	Yes
Fixed effect: Province	Yes	Yes	Yes
_cons	1.158***	1.357***	1.366***
	(0.094)	(0.128)	(0.127)
Observations	1,125	1,115	1,101
R-squared	0.390	0.393	0.391

Standard errors in parentheses

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

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Appendix 1. Industry Distribution of Samples

Industry	Number	Percentage (%)
Manufacturing	781	67.44
Information Transmission, Software, and Information Technology Services	135	11.66
Construction	29	2.50
Wholesale and Retail Trade	28	2.42
Transportation, Storage, and Postal Services	27	2.33
Leasing and Business Services	25	2.16
Water Conservancy, Environment, and Public Facilities Management	23	1.99
Real Estate	21	1.81
Scientific Research and Technical Services	18	1.55
Electricity, Heat, Gas, and Water Production and Supply	15	1.30
Culture, Sports, and Entertainment	14	1.21
Agriculture, Forestry, Animal Husbandry, and Fishery	14	1.21
Mining	12	1.04
Comprehensive	9	0.78
Health and Social Work	5	0.43
Accommodation and Food Services	2	0.17
Total	1158	100

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Appendix 2. Non-linear Test of Main Effects

Operational resilience	Model 1	Model 2
Gender diversity	0.025	-0.083
	(0.057)	(0.060)
Gender diversity²	0.141	0.114
	(0.116)	(0.096)
ESG	0.004***	-0.003***
	(0.001)	(0.001)
Quick ratio	-0.003	-0.001
	(0.003)	(0.002)
Financial leverage	-0.007**	-0.008***
	(0.003)	(0.003)
Operational leverage	-0.022***	-0.018***
	(0.006)	(0.005)
ROA	-0.087***	-0.077***
	(0.027)	(0.030)
TMT Education	0.021***	0.013**
	(0.007)	(0.007)
TMT age	-0.001*	-0.001
	(0.001)	(0.001)
Firm size	-0.002	0.007
	(0.005)	(0.006)
Absorptive capacity		0.040
		(0.197)
Gender diversity * Absorptive capacity		1.436***
		(0.389)
Operational efficiency		0.022***
		(0.007)
Gender diversity * Operational efficiency		0.018
		(0.017)
Business diversification		-0.077***
		(0.025)
Gender diversity * Business diversification		0.279***
		(0.082)
Sourcing diversification		-0.126*
		(0.066)
Gender diversity * Sourcing diversification		0.470
		(0.390)
Fixed effect: Industry	Yes	Yes
Fixed effect: Province	Yes	Yes
_cons	1.272***	0.964***
	(0.173)	(0.153)
Observations	1,158	1,158
R-squared	0.316	0.516

Standard errors in parentheses

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

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Appendix 3. Non-linear Test of Business and Sourcing Diversification

Operational resilience	Model 1	Model 2	Model 3
Gender diversity	0.086**	0.093**	0.089**
	(0.035)	(0.036)	(0.037)
ESG	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)
Quick ratio	-0.003	-0.002	-0.002
	(0.003)	(0.002)	(0.002)
Financial leverage	-0.007**	-0.006**	-0.006**
	(0.003)	(0.003)	(0.003)
Operational leverage	-0.022***	-0.022***	-0.022***
	(0.006)	(0.005)	(0.005)
ROA	-0.087***	-0.085***	-0.085***
	(0.027)	(0.028)	(0.028)
TMT Education	0.023***	0.018**	0.018**
	(0.007)	(0.007)	(0.007)
TMT age	-0.001*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
Firm size	-0.001	0.000	0.001
	(0.005)	(0.005)	(0.006)
Business diversification	-0.250		-0.245
	(0.193)		(0.195)
Business diversification²	0.098		0.093
	(0.103)		(0.103)
Gender diversity * Business diversification	0.615		0.680
	(0.593)		(0.604)
Gender diversity * Business diversification²	-0.271		-0.264
	(0.310)		(0.311)
Sourcing diversification		-0.232	-0.013
		(0.273)	(0.276)
Sourcing diversification²		-0.327	-0.575
		(0.482)	(0.499)
Gender diversity * Sourcing diversification		-1.305	-2.031
		(1.151)	(1.261)
Gender diversity * Sourcing diversification²		1.520	1.336
		(1.548)	(1.690)
Fixed effect: Industry	Yes	Yes	Yes
Fixed effect: Province	Yes	Yes	Yes
_cons	1.250***	1.183***	1.174***
	(0.175)	(0.161)	(0.163)
Observations	1,158	1,158	1,158
R-squared	0.321	0.423	0.428

Standard errors in parentheses

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

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Appendix 4. Measures of Moderators

Construct	Measurement	Formula
Absorptive capacity	R&D intensity	$\frac{\text{R\&D Investment}_{i,t}}{\text{Total Sales}_{i,t}}$
Operational efficiency	Inventory days	$\frac{\text{Total Inventory}_{i,t}}{\text{Cost of Goods Sold}_{i,t}} \times 365$
Business diversification	100 minus Business Herfindahl Index	$100 - \sum_{i=1}^{N} B_i^2$
Sourcing diversification	100 minus Sourcing Herfindahl Index	$100 - \sum_{i=1}^{N} S_i^2$

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