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Non-financial enterprises' shadow lending and SME survival: the role of spatial spillovers in regional financial stability

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This study examines the impact of non-financial enterprises' shadow lending activities on the survival of small and micro enterprises (SMEs) in China. Utilizing panel data from 243 prefecture-level cities from 2012 to 2021 and applying the Spatial Durbin Model (SDM), we explore both direct and spatial spillover effects of shadow lending on SME mortality. Our empirical findings suggest that non-financial enterprises' shadow lending significantly reduces the local SME mortality rate, while spatial econometric analysis reveals positive spillover effects, whereby shadow lending in one region enhances SME survival in neighboring areas through cross-regional financial linkages. Heterogeneity analyses indicate that these effects are more prominent in the economically developed southeastern regions, while being relatively weaker in less-developed northwestern areas, reflecting disparities in financial accessibility. Robustness checks and lagged effect analyses confirm the consistency and persistence of our findings. While shadow banking improves SME resilience through regional transmission, it may also carry potential financial risks. This study innovatively focuses on the spatial spillover effects of shadow lending by non-financial enterprises on SME survival, an area largely overlooked by previous studies. By integrating spatial econometric analysis and examining systemic vulnerabilities, this paper provides new insights into the regional complexity of informal finance.

KEYWORDS

shadow banking, non-financial enterprises, spatial spillover, regional financial stability
JEL classification: G23, G32, R12, C31, small and micro enterprises

1 Introduction

Small and micro enterprises (SMEs) play an integral role in economic systems worldwide, significantly contributing to employment generation, innovation diffusion, and sustained economic growth. In the context of China, SMEs form the backbone of the private economy and are closely linked to the nation's overall economic resilience and structural vitality [1]. According to the Fourth National Economic Census Series Report released by the National Bureau of Statistics, SMEs represent approximately 99.8% of all corporate legal entities in China¹, underscoring their vital role in the national economic structure. Notably,

¹ See: https://www.stats.gov.cn/sj/zxfb/202302/t20230203_1900574.html for more information.

micro enterprises alone account for 85.3%. These firms are instrumental in employment absorption, accounting for 79.4% of the total workforce employed by enterprises as of the end of 2018, thereby mitigating unemployment pressures and enhancing labor market inclusivity.

Moreover, SMEs are essential for promoting regional economic development and expanding production capacity. Together, they contribute 77.1% of corporate assets and 68.2% of enterprise revenue, underscoring their significance in capital formation and income generation. Despite their limited individual scale, SMEs demonstrate high responsiveness to market conditions, efficient utilization of localized resources, and adaptive organizational structures. These characteristics enable SMEs to act as dynamic agents within regional production systems, stabilizing output and facilitating industrial upgrading. Consequently, SMEs not only inject dynamism into the economy through operational flexibility and innovation but also serve as critical risk transmission nodes in the broader economic and production network.

However, SMEs often face elevated operational risks and long-term survival challenges due to inherent limitations in organizational resources, financing access, technological adoption, and managerial capabilities [2, 3]. Among these constraints, limited access to formal financing channels remains one of the most significant barriers to their sustainable development. In the traditional banking system, strict collateral requirements, credit evaluation standards, and information asymmetry frequently hinder SMEs from securing formal credit, driving them to seek alternative and informal financing channels which may carry higher level of financial risks. Access to finance for SMEs is not uniform across regions. [4] demonstrate that during the financial crisis in the United Kingdom, SMEs in regions distant from bank headquarters experienced more significant credit constraints due to a “flight to headquarters” effect. Similarly, [5] identify a “low SME equity equilibrium” in Wales, characterized by both low demand and supply of equity, with a concentration of deals in urban centers like Cardiff. These studies underscore the spatial disparities in SME financing, justifying our geographical approach to examining shadow banking’s role in SME survival.

In practice, many SMEs struggle to obtain loans from commercial banks, primarily due to inadequate collateral and limited financial transparency [3, 6]. To address short-term liquidity needs, these firms often rely on informal financing sources, including trade credit, private lending, and underground finance. Within this context, shadow banking has emerged as a crucial alternative financing mechanism [7]. Unlike traditional financial institutions, shadow banking entities operate with greater flexibility, more complex intermediation structures, and less stringent regulatory oversight, thus offering SMEs an important, though risky, channel for capital access.

The involvement of non-financial enterprises in shadow banking activities adds further complexity to the financing ecosystem. In particular, when non-financial listed companies engage in credit intermediation through entrusted loans, entrusted financing, or off-balance-sheet instruments, they contribute to the formation of non-traditional financial linkages within the corporate sector. These practices can partially alleviate the financing constraints faced by SMEs, especially as larger, state-affiliated firms typically have preferential access to formal banking credit [8]. As a

result, non-financial enterprises may function as informal financial intermediaries, redistributing capital across enterprises in ways that are not captured by conventional financial intermediaries. While this type of credit intermediation could improve liquidity for constrained SMEs and enhance their survival prospects, it also introduces new systemic risks. The shadow banking system lacks formal risk assessment frameworks and prudential controls, and the credit it extended is often characterized by higher costs and shorter maturities. These factors can create adverse financial incentives and exacerbate the debt burden of SMEs, potentially increasing the likelihood of firm exit. Furthermore, due to the inter-enterprise nature of shadow credit flows, financial stress in one segment of the production system may be transmitted to other firms through capital linkages, thereby generating contagion effects within the regional economy.

This study addresses two key research questions: (1) How does shadow lending by non-financial enterprises influence the survival rates of SMEs within a region? (2) Are there spatial spillover effects through which shadow lending activities affect SME survival in neighboring regions? Following this, we examine the implications of shadow lending activities by non-financial enterprises on the survival dynamics of SMEs at the regional level. Specifically, we examine how informal credit flows originating from non-financial listed companies influence the mortality rate of SMEs within the same region. In addition, the study explores the presence of spatial spillover effects, assessing whether credit diffusion through shadow banking channels affects SME survival in neighboring regions via interregional financial linkages. To capture these dynamics, the study employs spatial econometric techniques, which are particularly well-suited to identify geographically distributed effects and interdependencies. By analyzing spatial correlation patterns in SME mortality, this paper uncovers how the informal financial system contributes not only to localized economic outcomes but also to broader systemic phenomena such as regional risk transmission, financial contagion, and structural vulnerability. The empirical results suggest that shadow banking provides vital liquidity support to financially constrained SMEs, particularly in regions underserved by formal financial institutions. While this financing channel appears to alleviate immediate funding pressures and enhance firm survival, the potential long-term implications remain ambiguous. Given the higher cost and lower regulatory oversight associated with shadow credit, concerns about financial fragility persist. Furthermore, the spatial spillover effects identified in the analysis imply that localized financial dynamics may propagate through interregional linkages, warranting further investigation into their systemic implications.

By integrating insights from the literature on financial intermediation, financial networks, and spatial spillover, this study contributes to a deeper understanding of the complex interdependencies between informal finance and enterprise dynamics. It emphasizes that shadow banking should be viewed not merely as a supplementary financing channel, but as a structurally embedded component of the production system with both stabilizing and destabilizing potential. Accordingly, the findings carry important policy implications for improving the governance of informal financial activity, managing systemic risk, and fostering the long-term resilience of SMEs in an increasingly networked financial environment.

The remainder of this paper is structured as follows. [Section 2](#) reviews the relevant literature and develops the corresponding research hypotheses. [Section 3](#) describes the dataset, which includes annual data from 2012 to 2022 on shadow lending activities by non-financial enterprises and the SME mortality across 243 prefecture-level cities in China. This section also outlines the data processing procedures, definitions of key variables, and the specification and diagnostic testing of the spatial econometric models employed. [Section 4](#) presents the empirical analyses of the impact of non-financial enterprise shadow banking on regional SME mortality rates, employing the Spatial Durbin Model (SDM) as the primary estimation approach. [Section 5](#) conducts robustness checks to verify the consistency of the findings. [Section 6](#) provides additional analyses, including heterogeneity tests and an exploration of the spatial effects of policy shocks. [Section 7](#) concludes the paper with a summary of key findings and policy implications.

2 Literature and hypotheses

From the perspective of financial intermediation theory, shadow banking functions as a non-traditional financial intermediary and plays a critical role in broadening credit supply and diversifying sources of financing [9]. In contrast to the traditional banking sector, which operates under stringent regulatory oversight and risk management protocols, shadow banking is characterized by greater operational flexibility. This flexibility enables it to provide supplementary liquidity during periods of credit contraction. Consequently, shadow banking has become particularly instrumental in supporting firms that are unable to secure financing through formal banking institutions, especially micro and small enterprises. These enterprises frequently face significant barriers to accessing affordable credit, and shadow banking serves as an alternative financing channel that effectively alleviates their funding constraints [7]. Recent evidence based on the TENET framework suggests that financial risk may spread more rapidly within shadow banking networks during tail events [10].

A substantial gap exists between the financing needs of SMEs and the supply capacity of the traditional financial system. Due to a lack of sufficient collateral and pronounced information asymmetries with banks, SMEs are often excluded from formal credit markets [2, 11]. As a result, many SMEs are compelled to rely on non-traditional financing channels, such as informal lending and trade credit, to sustain their daily operations. Shadow banking, functioning as a financing mechanism similar to trade credit, provides short-term liquidity to these firms, thereby helping them navigate temporary cash flow shortages and reducing the risk of business failure arising from disruptions in the capital chain. As a supplementary source of financing, shadow banking plays an especially important role when traditional financial institutions are unable to meet the funding needs of SMEs. It thus emerges as a critical alternative channel through which financially constrained firms can access much-needed capital [12, 13]. Network-based models show that incorporating inter-firm relationships can improve credit risk prediction for SMEs with limited data [14].

The diversification of financing channels plays a significant and positive role in the survival of SMEs. [15] emphasize that

SMEs require different types of financing at various stages of their development, and that access to a diversified set of financing options is essential for their sustained growth. [3] further demonstrate that SMEs are subject to more severe financial and legal constraints compared to larger firms, and that the diversification of financing channels can help alleviate these constraints and facilitate enterprise growth. The effect of financing diversification on systemic risk depends on the structure of financial networks [16].

Although part of the credit demand of SMEs has been met, a substantial portion of latent demand remains unmet and has not been translated into actual financing. This further underscores the role of shadow banking in filling the gaps left by the traditional financial system by providing flexible financing mechanisms. Shadow banking can offer an alternative source of capital for SMEs, helping them overcome liquidity constraints and reducing the risk of bankruptcy caused by financing difficulties. Shadow banking activities exhibit significant regional disparities. [17] find that in China, the impact of collateral monetary policy on shadow banking by non-financial firms varies across regions, influenced by local financial development levels. [18] further reveal that regional advancements in financial technology are positively associated with increased shadow banking activities among non-financial firms. These findings highlight the necessity of considering regional contexts when analyzing shadow banking phenomena. In addition to regional factors, macro-level economic policies and regulations have significant effects on the growth of shadow banking. [19] argue that fintech innovations and regulatory arbitrage contribute to the rise of shadow banks, highlighting how less regulated financial activities can thrive in the gaps left by formal banking systems. Furthermore, [20] demonstrate that collateral monetary policy and its impact on shadow banking vary significantly across firms and regions, emphasizing the importance of considering broader financial stability measures when examining shadow banking dynamics.

Accordingly, existing literature suggests that when non-financial enterprises provide financing to SMEs through shadow banking channels, it may alleviate their funding constraints, enhance their capacity to survive, and ultimately reduce firm exit rates. Based on this reasoning, the following hypothesis is proposed.

H1a: Non-financial enterprises' shadow lending activities reduce local SMEs' mortality rate.

However, although shadow banking may to some extent alleviate short-term liquidity constraints and expand financing channels for SMEs, its high interest rates and elevated financing costs may also exert adverse effects on the long-term financial health of these firms. [21] points out that while informal financing can facilitate access to capital, it does not exhibit a significant positive correlation with long-term firm growth or productivity.

Furthermore, although the financing terms offered by shadow banking institutions are generally more flexible than those of traditional banks, they are often associated with higher interest rates and less transparent contractual conditions. [22] argue that while borrowing from multiple lenders may increase short-term liquidity, such dispersed lending relationships often result in higher overall financing costs. For SMEs that rely on shadow banking, the

inherent risks and opaque lending terms further exacerbate financial pressures and may undermine their long-term viability.

Moreover, the study by [23] indicates that although increased competition in the credit market may lead to lower lending rates, such rate reductions do not significantly expand the credit available to SMEs, particularly in the presence of persistent financing constraints. This suggests that even when shadow banking provides an alternative source of financing, firms may still face considerable financial burdens arising from high costs and elevated risks, which could ultimately increase their probability of default. Based on the above theoretical and empirical insights, it can be inferred that while shadow banking offers short-term liquidity support, its high-risk and high-cost nature may intensify financial stress for firms. This effect is likely to be more pronounced in unstable financial environments, potentially exacerbating the failure rates of SMEs. Therefore, the following hypothesis is proposed.

H1b: Non-financial enterprises' shadow lending activities improve local SMEs' mortality rate.

When examining the mortality of SMEs, it is essential to consider both region-specific factors and spatial interdependence, which refers to the mutual influences across geographic areas. The mortality of SMEs in one region may be shaped by economic activity in neighboring regions. The interregional flow of financial resources, spillover effects along industrial and supply chains, and the spatial diffusion of economic activity can all influence the business environment and the survival prospects of firms in adjacent areas [24]. Studies in spatial econometrics have shown that regional economic activities exhibit significant spatial spillover effects [25]. The survival or failure of firms is often affected by surrounding economic conditions. For example, [26] find that the emergence of new firms within a region can indirectly affect regional employment and economic development by enhancing competition and improving supply conditions.

Second, the flow of funds within the shadow banking system may also generate spatial spillover effects. Financing activities conducted by non-financial enterprises through shadow banking channels may not only affect SMEs within the local region but may also influence the financing environment and survival conditions of SMEs in neighboring areas through interregional financial linkages. Existing studies have shown that entrusted loans, as a component of shadow banking activities, can facilitate the cross-regional allocation of capital and thereby influence the distribution of financial resources and financing conditions across regions [27]. This effect is particularly pronounced in regions with a high degree of economic integration, where the flow and allocation of shadow banking capital may exert either positive or negative spillover effects on nearby SMEs. [21] find that the extent of dependence on shadow banking varies across regions, with firms in coastal areas being more reliant on shadow banking compared to those in central regions. Such disparities in capital flows may result in uneven financing capacities among SMEs across different regions, thereby influencing their mortality.

These findings suggest that the flow of shadow banking capital may produce spatial spillover effects through interregional financial interactions, ultimately shaping the survival prospects of SMEs. Therefore, it is necessary to account for the spatial correlation of SME mortality and the spatial spillover effects arising from non-financial

TABLE 1 Summary statistics.

Variables	N	Mean	SD	Min	P50	Max
<i>MSEMR</i>	2,673	11.779	9.249	0.869	9.252	46.458
<i>SL</i>	2,673	15.845	9.806	0	20.596	29.387
<i>SL_sum</i>	2,673	16.583	9.408	0	20.808	29.395
<i>PopDen</i>	2,673	5.835	0.994	0.964	6.005	8.212
<i>PerGDP</i>	2,673	10.88	0.553	9.084	10.869	13.056
<i>Edu</i>	2,673	22.539	0.788	19.054	22.531	25.486
<i>FD</i>	2,673	26.031	1.171	23.379	25.819	29.898
<i>Gov</i>	2,673	0.475	0.218	0.058	0.447	1.541
<i>Service</i>	2,673	44.012	10.055	11.4	43.84	83.9

This table reports the summary statistics of the variables included in the empirical analyses over the period of 2012–2022. Within the table, variables are listed with their corresponding number of observations (N), mean, standard deviation (SD), and the values at the minimum (Min), median (P50), and maximum (Max). Regression t-statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. See Table 1 for detailed definitions of these variable.

enterprises' shadow lending activities. Based on the above analysis, the following hypothesis is proposed.

H2: The mortality of SMEs exhibits spatial dependence, and non-financial enterprises' shadow lending activities generate spatial spillover effects on SME mortality across regions.

3 Empirical design

3.1 Sample data

To examine the impact of shadow lending of non-financial enterprises on the regional survival environment of SMEs, our study focuses on a sample of 243 prefecture-level cities in China over the period from 2012 to 2022. The empirical analysis relies on three main types of data. First, data on non-financial enterprises' shadow lending activities are obtained from the CNRDS database. Second, data used to measure SME mortality are derived from the industrial and commercial enterprise registration records available through AiQicha. Following the classification criteria proposed in the *Opinions of the State Administration for Industry and Commerce on Further Improving the Development of the Micro and Small Enterprise Directory* (Gongshangezi [2015] No. 172), enterprises with registered capital of 5 million RMB or less are classified as micro and small enterprises. Third, data used to construct the spatial weight matrices and regional-level control variables are drawn from the *China Statistical Yearbook* and the CNRDS database. To minimize the influence of outliers, all continuous variables are winsorized at the 1% level. After data cleaning and processing, the final balanced panel includes 2,673 city-year observations. Descriptive statistics of all variables are presented in Table 1.

TABLE 2 Lagrange Multiplier Tests.

Models	LM tests		Robust LM tests	
	Test Statistic	P-value	Test Statistic	P-value
Spatial Error Model	2818.977	0.000	2129.215	0.000
Spatial Lag Model	793.643	0.000	103.882	0.000

This table reports the results of Lagrange Multiplier (LM) tests and Robust Lagrange Multiplier tests for spatial econometric models.

3.2 Testing the applicability of the spatial econometric model

Before selecting an appropriate spatial econometric model, it is standard practice to conduct a series of specification tests to assess model suitability. Commonly used spatial econometric models include the Spatial Lag Model (SLM), the Spatial Error Model (SEM), and the Spatial Durbin Model (SDM). To determine the most appropriate model for this study, this section first applies the Lagrange Multiplier (LM) test and the Robust LM test to the data. If the results indicate the presence of only spatial error dependence, the SEM is considered more appropriate. If only spatial lag dependence is significant, the SLM is preferred. However, if both effects are found to be statistically significant, the SDM is deemed the most suitable specification [28, 29]. The SDM allows for more complex spatial interactions, making it more suitable for analyzing spatially dependent data in our study.

According to the LM and Robust LM test results presented in Table 2, both spatial error dependence and spatial lag dependence are statistically significant ($P < 0.01$), indicating that the SDM is more appropriate for the analysis in this study. Subsequently, a Hausman test is conducted to determine whether to adopt a random effect or fixed effect specification. The test yields a statistic of 29.1858 with a p-value of 0.0001, leading to the rejection of the null hypothesis. Therefore, the fixed effects SDM is selected. Finally, post-estimation diagnostic tests including the Wald test and the Likelihood Ratio (LR) test are employed to examine whether the SDM can be simplified to either the SLM or SEM specification.

As shown in Table 3, the results of the LR tests reject the null hypothesis, indicating that the two-way fixed effects model is more appropriate. The Wald test further confirms the significance of spatial lag effects and suggests that there is no simple linear relationship between the spatial lag term and the spatial error term. Therefore, the SDM is better suited to capture spatial dependence and spatial spillover effects, making it a more appropriate choice for the empirical analysis in this study.

3.3 Specification of the spatial durbin model and variable definitions

Given the complexity of capital flows involved in the non-financial enterprises' shadow lending activities, and the difficulty in tracing the destination of such funds at the individual level within the sample of listed firms, it is plausible that these activities generate spatial spillover effects on SMEs in neighboring regions.

To capture these cross-regional financial interactions and economic fluctuations, we constructs a spatial weight matrix to reflect the spatial interdependence across regions. Based on the applicability tests conducted in the previous section, the SDM is selected as the appropriate framework for analyzing both the direct impact of shadow banking by non-financial enterprises on regional SME mortality and its potential spillover effects on adjacent areas. The model is specified in Equation 1:

$$MSEMR_{it} = \alpha + \rho \sum_{j=1}^n W_{ij}MSEMR_{jt} + \beta_1 SL_{it} + \beta_2 Controls_{it} + \theta_1 \sum_{j=1}^n W_{ij}SL_{jt} + \theta_2 \sum_{j=1}^n W_{ij}Controls_{jt} + City_i + Year_t + \varepsilon_{it} \tag{1}$$

where i denotes the prefecture-level city, and t denotes the year. W_{ij} represents the element of the spatial weight matrix, which captures the spatial relationship between city i and city j . We constructs three types of spatial weight matrices: a distance matrix ($W1$), an adjacency matrix ($W2$), and an economic matrix ($W3$). The dependent variable, $MSEMR_{it}$, refers to the mortality of micro and small enterprises in city i during year t . The key explanatory variable, SL_{it} , measures the amount of shadow lending by non-financial listed companies in city i at time t , following the calculation approach described in the previous sections. The spatially lagged dependent variable, $W_{ij}MSEMR_{jt}$, captures the impact of SME mortality in neighboring cities on that of city i . The term $W_{ij}SL_{jt}$ represents the spatial lag of shadow banking activities, indicating the influence of shadow banking intensity in adjacent regions on SME mortality in city i . The vector $Controls_{it}$ includes a set of control variables for city i at time t , while $W_{ij}Controls_{jt}$ denotes the spatially lagged controls. $City_i$ and $Year_t$ represent city and year fixed effects, respectively. α is the intercept term, and ε_{it} is the error term.

To mitigate the influence of spurious correlations on the empirical results, we select a set of regional-level control variables. Specifically, the following variables that may affect the volume of credit disputes are included: population density ($PopDen$), economic development level ($PerGDP$), education level (Edu), financial development (FD), government support (Gov), and industrial structure ($Service$). The definitions and calculation methods of these variables are provided in Table 4. All variables are measured at year t .

In conventional non-spatial regression models, the magnitude of the regression coefficients can be directly interpreted as the marginal effects of explanatory variables on the dependent variable. However, as discussed earlier, due to the presence of spatial dependence in spatial econometric models, explanatory variables in a given region may not only influence the local dependent variable but also exert indirect effects on neighboring regions through spatial interaction mechanisms. Therefore, once spatial lag terms are included in the model, the estimated coefficients cannot be directly interpreted as the total effects of the explanatory variables on the dependent variable [28, 29]. To address this issue, spatial effects are decomposed following the methodology proposed by [28]. A significantly positive direct effect indicates that non-financial enterprises' shadow lending activities increase the mortality of SMEs within a region, thereby supporting Hypothesis H1b. Conversely, a significantly negative direct effect implies that such activities reduce SME mortality, supporting Hypothesis H1a.

TABLE 3 Likelihood Ratio and Wald Tests.

Tests	Null hypothesis H_0	Test statistic	P-value
LR Tests	Spatial fixed effects model is nested within the two-way fixed effects model	121.32	0.000
	Time fixed effects model is nested within the two-way fixed effects model	1900.64	0.000
Wald Tests	All coefficients of spatially lagged explanatory variables are equal to zero (no spatial lag effects)	138.28	0.000
	Existing a specific linear relationship between the spatial lag and spatial error terms	159.56	0.000

This table reports the results of Likelihood Ratio (LR) and Wald Tests for the Spatial Durbin Model (SDM).

TABLE 4 Definitions of Variables.

Variables	Definitions	Calculations
<i>MSEMR</i>	Micro and Small Enterprise Mortality Rate	The number of exited firms divided by the sum of firms existing at the end of the previous year and newly established firms in the current year, multiplied by 100%
<i>SL</i>	Shadow Lending	Natural logarithm of the sum of entrusted loans, entrusted wealth management products, and private loans (i.e., other receivables) financed by the listed companies registered within the city
<i>SL_sum</i>	Sum of <i>SL</i> and chain-based shadow lending activities	The natural logarithm of the scale of non-financial listed firms involves in intermediary (i.e., <i>SL</i>) and chain-based shadow banking activities as lenders, where chain-based shadow banking activities refers to the amount of listed companies indirectly involving in shadow banking activities through purchasing trust products, bank wealth management products, and internet financial products
<i>PopDen</i>	Population Density	the natural logarithm of the number of persons per square kilometer in each region
<i>PerGDP</i>	Per capita GDP	The natural logarithm of the GDP <i>per capita</i>
<i>Edu</i>	Education	The natural logarithm of education expenditure in each region (in yuan)
<i>FD</i>	Financial Development	Degree of financial development, measured as the ratio of bank loan balances to local GDP.
<i>Gov</i>	Government Support	The ratio of public fiscal revenue (in yuan) to public fiscal expenditure (in yuan)
<i>Service</i>	Proportion of Tertiary Industry	Share of tertiary industry in GDP (%)

This table reports the definition, calculation (if applicable) of main variables used in our empirical analyses.

If the spatial autoregressive coefficient ρ is significantly different from zero, it indicates the presence of spatial dependence in SME mortality, meaning that the survival environment of SMEs in one region is significantly influenced by that of neighboring regions. Furthermore, if the spatially lagged explanatory variable θ is significantly different from zero, it suggests that shadow banking activities have cross-regional spillover effects. In other words, SL_{it} affects not only the SME mortality in its own region but also that of surrounding or economically linked regions through spatial interaction, thereby validating Hypothesis H2.

4 Empirical results

4.1 Test for spatial correlation

Before implementing Spatial Durbin Model (SDM), we conduct spatial correlation tests using the Global Moran's I Index [30] and the Local Moran's I Index [31] as part of a spatial exploratory analysis. These tests assess whether regional credit risks exhibit spatial dependence, justifying the use of spatial econometric models in subsequent analyses. The Global Moran's I Index is used to test

global spatial correlation, measuring the overall spatial distribution of regional credit risks. The formula for the Global Moran's I Index is as follows:

$$I = \frac{N \sum_{i=1}^N \sum_{j=1}^N w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{W \sum_{i=1}^N (x_i - \bar{x})^2} \quad (2)$$

where in Equation 2, $N = 243$, representing the number of prefecture-level cities in the sample. x_i and x_j denote credit risk values for cities i and j respectively. $\bar{x}$ is the mean value of x_i and x_j , and w_{ij} is the spatial weight matrix defining the relationship between city i and j . W is the sum of w_{ij} . The Global Moran's I Index typically ranges between -1 and 1 ($I \in [-1, 1]$). A positive value of I indicates positive spatial correlation, meaning that neighboring cities exhibit similar credit risk characteristics. The larger the absolute value of I , the stronger the spatial correlation. Conversely, a negative value of I indicates negative spatial correlation, meaning that neighboring cities exhibit dissimilar credit risk characteristics. If I equals 0, it suggests that the credit risks of cities are independently distributed in space, with no spatial correlation.

The significance of the spatial correlation is tested using the standardized Z-statistic, calculated as:

$$Z = \frac{I - E(I)}{\sqrt{\text{Var}(I)}} \quad (3)$$

where in Equation 3, I is the Global Moran's I value calculated from the formula above. $E(I)$ is the expected value of I , typically equal to $-1/(N-1)$, $\text{Var}(I)$ is the variance of the Global Moran's I. Table 5 presents the Global Moran's I indices for SMEs mortality under three different spatial weight matrix specifications. The results indicate that the Global Moran's I values are positive across all three spatial weight matrices and that the null hypothesis of no spatial correlation is rejected at the 1% significance level. This suggests that SME mortality rate exhibits significant spatial autocorrelation and spatial dependence among prefecture-level cities in China during the sample period.

In other words, if the business environment for SMEs is favorable in a given city, neighboring regions also tend to exhibit similarly favorable conditions for SME survival, and *vice versa*. This spatial clustering effect implies that the analysis of SME mortality should not be confined to individual cities but should instead account for cross-regional transmission mechanisms and interdependencies. Therefore, based on the results of the spatial correlation tests, it is both reasonable and necessary to adopt a spatial econometric approach to examine the impact of shadow lending of non-financial enterprises on SME mortality.

To further examine the spatial spillover effects of regional credit risks, we compute the Local Moran's I Index for each city, assessing the statistical significance of spatial clustering patterns [31]. The Local Moran's I Index is given by (see Equation 4):

$$I_i = \frac{(x_i - \bar{x}) \sum_{j=1}^N w_{ij} (x_j - \bar{x})}{\sum_{j=1}^N (x_i - \bar{x})^2} \quad (4)$$

Using a distance-based spatial weight matrix (w_1), we compute the Local Moran's I index for all 243 prefecture-level cities

over time. Figure 1 presents the Moran's I scatter plots for selected years (2012, 2015, 2017, and 2022). The x-axis represents the standardized Z-statistic for credit risk in each city, while the y-axis represents the spatially lagged credit risk in neighboring cities (Wz). The scatter plots illustrate that most cities fall within the first and third quadrants, indicating a strong spatial clustering effect where high-credit-risk cities are located near other high-risk cities, and low-risk cities are clustered together. These findings confirm that regional credit disputes do not occur in isolation but propagate through spatial financial linkages, supporting the need for spatial econometric modelling in our study.

4.2 Analysis of total effects

Based on Equation 1, this section analyzes the total effects of shadow lending of non-financial enterprises on the survival of SMEs, covering both local and neighboring regions. The estimation results of the SDM under three spatial weight matrices are presented in Table 6. The distance matrix ($W1$) serves as the benchmark, while the adjacency matrix ($W2$) and the economic matrix ($W3$) are used for robustness checks. The table reports the estimation results for both random effects and fixed effects specifications of the SDM.

As shown in Table 6, the estimation results from the SDM under all three spatial weight matrices indicate that the null hypothesis is rejected at the 1% significance level in the Hausman test. This finding is consistent with the results reported in Section 3.1, suggesting that the fixed effects SDM provides a better fit for the data and is therefore adopted for interpretation. Furthermore, the coefficient of the spatially lagged dependent variable (ρ) is significantly positive at the 1% level across all specifications, indicating strong spatial dependence among the variables. This result is in line with the Global Moran's I test presented in Section 4.1, confirming that the survival environments of SMEs in prefecture-level cities are spatially interrelated. In other words, the business environment for SMEs in one city significantly influences that of neighboring or proximate cities under spatial weighting structures.

With respect to the core explanatory variable, the coefficient of shadow banking by non-financial enterprises (SL) is significantly negative at the 1% level across all six regressions using the three spatial weight matrices. Its spatially lagged counterpart (WSL) is also significantly negative in all specifications, with the exception of the fixed effects model under the adjacency matrix ($W2$), where it is significant at the 5% level ($t = -2.21$); in the remaining cases, the coefficient remains significantly negative at the 1% level. These results provide preliminary evidence that shadow lending of non-financial enterprises reduce SME mortality, thereby having a positive impact on SME survival, which is consistent with some prior research [12, 13]. Moreover, the negative and significant coefficient on the spatial lag of shadow banking suggests the presence of a spillover effect, whereby shadow banking activity in neighboring regions further contributes to a reduction in local SME mortality. These findings offer initial empirical support for Hypotheses H1a and H2, indicating that non-financial enterprise shadow banking mitigates regional SME mortality and exerts significant spatial spillover effects on the SME survival environment.

TABLE 5 Moran's I Index.

Year	Moran's I (W1)	Z-value	Moran's I (W2)	Z-value	Moran's I (W3)	Z-value
2012	0.067	10.112	0.304	6.962	0.269	8.665
2013	0.058	8.936	0.249	5.855	0.218	7.201
2014	0.038	7.126	0.160	4.476	0.140	5.497
2015	0.069	10.129	0.310	6.916	0.261	8.205
2016	0.073	10.252	0.365	7.817	0.300	9.067
2017	0.076	10.573	0.343	7.328	0.281	8.439
2018	0.064	9.013	0.335	7.174	0.255	7.720
2019	0.063	8.900	0.342	7.303	0.236	7.129
2020	0.050	7.174	0.262	5.634	0.159	4.838
2021	0.064	9.226	0.352	7.658	0.151	4.681
2022	0.063	9.205	0.277	6.171	0.187	5.889

This table reports the Global Moran's I Index for mortality micro and small enterprises mortality amounts across prefecture-level.

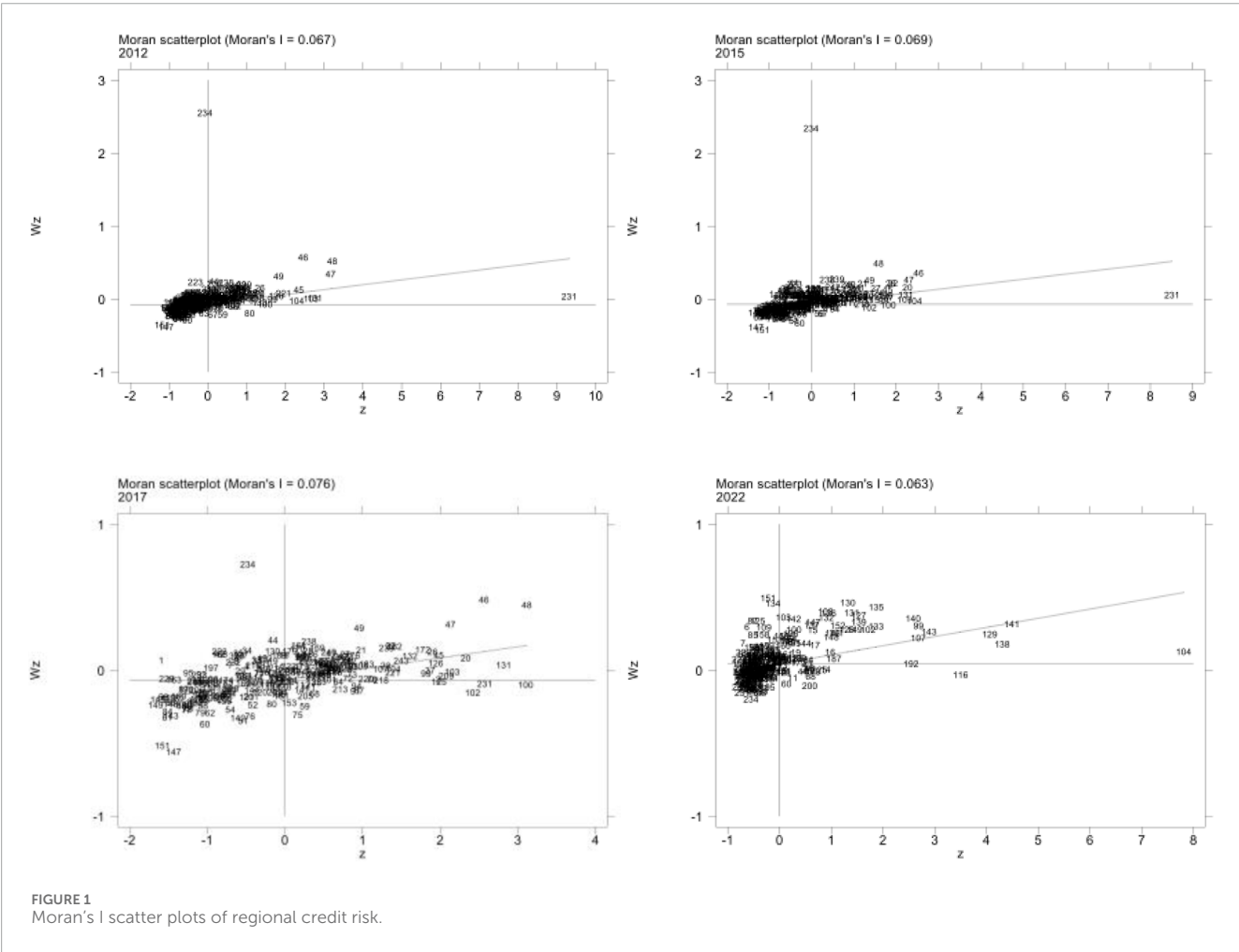


TABLE 6 Spatial Durbin Model (SDM) Regression Results of shadow lending and SMEs mortality rate.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Distance matrix (W1)		Adjacency matrix (W2)		Economic matrix (W3)	
	Random effect	Fixed effect	Random effect	Fixed effect	Random effect	Fixed effect
SL	−0.033***	−0.040***	−0.041***	−0.029**	−0.053***	−0.047**
	(−2.58)	(−3.22)	(−3.31)	(−2.53)	(−2.70)	(−2.47)
WSL	−0.201***	−0.959***	−0.076***	−0.048**	−0.420***	−0.399***
	(−3.41)	(−6.54)	(−3.56)	(−2.21)	(−8.96)	(−7.82)
PopDen	0.120	1.003**	1.333***	0.962**	1.773***	3.231***
	(0.39)	(2.33)	(4.05)	(2.35)	(3.76)	(4.94)
PerGDP	2.697***	2.897***	−1.272**	2.373***	1.776**	4.925***
	(4.67)	(4.10)	(−2.40)	(3.61)	(2.17)	(5.02)
Edu	0.333	0.178	0.065	−0.515	−1.141	−2.045**
	(0.66)	(0.26)	(0.14)	(−0.83)	(−1.59)	(−2.01)
FD	−0.688*	−0.563	−1.787***	−1.064**	−2.085***	−0.562
	(−1.69)	(−1.00)	(−4.58)	(−2.05)	(−3.58)	(−0.66)
Gov	−1.364	1.203	9.426***	0.677	4.442**	−1.593
	(−0.98)	(0.78)	(7.22)	(0.48)	(2.20)	(−0.72)
Service	0.020	−0.012	−0.072***	−0.022	−0.048*	−0.009
	(1.02)	(−0.57)	(−3.75)	(−1.13)	(−1.65)	(−0.29)
ρ	0.945***	0.894***	0.626***	0.492***	0.367***	0.171***
	(57.85)	(29.14)	(42.31)	(26.13)	(18.68)	(7.89)
σ^2	17.360***	14.951***	16.721***	12.853***	42.718***	34.686***
	(34.65)	(36.57)	(33.67)	(35.70)	(34.56)	(36.54)
Constant	−55.410		65.410***		109.220***	
	(−1.56)		(9.02)		(7.20)	
WControls	Yes	Yes	Yes	Yes	Yes	Yes
City FE	No	Yes	No	Yes	No	Yes
Year FE	No	Yes	No	Yes	No	Yes
Obs	2,673	2,673	2,673	2,673	2,673	2,673
R ²	0.486	0.502	0.457	0.012	0.380	0.131
Hausman Test	29.1858		1149.028		614.4279	
	P-value = 0.0001		P-value = 0		P-value = 0	

This table reports the results of our main regression model of Equation 1. See Table 3 for detailed variable definitions. The dependent variable is the micro and small enterprises mortality rate (*MSEMR*), while the independent variable is shadow lending by local non-financial listed firms (*SL*). The results are reported under different spatial weighting matrices: distance matrix [Column (1)–(2)], adjacency matrix [Column (3)–(4)], and economic matrix [Column (5)–(6)], each under both random and fixed effects models. Two-way fixed effects are included where applicable. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3 Analysis of decomposed effects

As discussed in Section 3.2, regional credit risk exhibits spatial contagion. When shadow lending by non-financial enterprises in one city affects the credit risk in other cities, the resulting spillover effects may in turn influence the originating city. Therefore, although the regression coefficients reported in Table 6 provide useful insights, they cannot be directly interpreted as the total or spillover effects of the explanatory variables on the dependent variable. To more accurately assess the spatial spillover effects of shadow lending of non-financial enterprises on both local and neighboring SME mortality, this section adopts the methodological framework proposed by [28]. Specifically, the SDM estimation results under the two-way fixed effects specification reported in Table 6, including Models (2), (4), and (6), are decomposed into direct effects, indirect effects, and total effects. The decomposition results for each variable are presented in Table 7.

Regarding the direct effects, the non-financial enterprises' shadow lending activities exhibit significantly negative direct effects under all three spatial weight matrices ($W1$, $W2$, and $W3$), with coefficients of -0.088 , -0.039 , and -0.054 respectively, all statistically significant at the 1 percent level. This indicates that shadow lending of non-financial enterprises have a favorable direct impact on the local survival environment of SMEs, providing further support for Hypothesis H1a, which posits that such activities reduce local SME mortality. Among the control variables, population density (*PopDen*) and economic development (*PerGDP*) show predominantly positive direct effects, suggesting that higher levels of economic activity and population density may intensify market competition, thereby increasing pressure on SME survival. Turning to the indirect effects, the spatial spillover effects of shadow lending (*SL*) are also significantly negative across all three spatial weight matrices. Notably, under the distance matrix ($W1$), the coefficient is -10.911 with a t -value of -2.04 , indicating that shadow banking activities in neighboring regions exert a statistically significant spillover effect by reducing local SME mortality. This finding supports Hypothesis H2, which states that shadow banking generates significant spatial spillover effects.

Interestingly, among the control variables, educational expenditure (*Edu*) and financial development (*FD*) exhibit significantly positive indirect effects. This suggests that, through mechanisms such as intensified interregional competition, resource reallocation, and uneven financial access, these factors may inadvertently increase SME mortality in neighboring regions. While typically associated with economic growth, in this context, such variables may raise survival pressure on SMEs. For instance, a financial system biased toward large enterprises may increase financing costs for smaller firms, or a concentration of public resources in more developed areas may weaken the competitiveness of less developed regions, ultimately affecting the survival of local SMEs.

Regarding the total effects, shadow banking by non-financial enterprises exhibits significantly negative total effects under all three spatial weight matrix specifications. This finding further confirms that shadow banking not only directly improves the local survival environment of SMEs but also benefits SMEs in neighboring regions through spatial spillover effects. Among the control variables, the significantly positive total effects of educational expenditure and

financial development reinforce their role in increasing the survival pressure faced by SMEs.

In summary, both the direct and indirect effects of shadow banking by non-financial enterprises are significantly negative. This indicates that such activities not only enhance the survival environment for local SMEs but also improve the survival conditions of SMEs in neighboring regions through spatial spillovers. These results suggest that shadow lending helps alleviate financing constraints faced by SMEs, strengthens their resilience against risk, and enhances their competitiveness in the market. The shadow banking system provides a more flexible source of financing for these firms, especially in contexts where formal financial institutions are unable to fully meet their funding needs. As a result, shadow banking contributes to extending the life cycle of SMEs and reducing their mortality. Our findings align with prior research indicating that shadow banking activities can alleviate financing constraints for SMEs, thereby reducing their mortality rates [7, 12]. Additionally, the observed spatial spillover effects are consistent with studies highlighting the role of informal financial channels in facilitating inter-regional capital flows and influencing neighboring regions' economic dynamics [26, 27].

From a spatial perspective, the flow of capital and the allocation of financial resources through shadow banking are not confined to individual regions but can cross administrative boundaries, producing significant spatial spillover effects. This reinforces the role of shadow banking in supporting the continuity and development of SMEs. The empirical findings validate Hypotheses H1a and H2, indicating that shadow banking by non-financial enterprises significantly reduces SME mortality within a given region and simultaneously enhances the survival environment of SMEs in adjacent areas through spillover mechanisms. Furthermore, the statistical significance of the distance, adjacency, and economic matrices suggests that the influence of shadow banking activities on regional economies is both extensive and complex. Shadow banking not only plays a positive role in improving the survival prospects of SMEs in the originating region but also generates meaningful indirect effects on neighboring regions through spatial network interactions. Overall, shadow banking has significant direct and indirect effects on SME survival, and these effects extend beyond geographic boundaries.

5 Robustness tests

To ensure the validity of the empirical findings, several robustness checks are conducted in this study. First, by using the distance matrix ($W1$) as the baseline spatial weight matrix and incorporating the adjacency matrix ($W2$) and the economic matrix ($W3$) as alternative specifications, the sensitivity of the results to different spatial structures can be evaluated. The corresponding estimation results have been presented and analyzed in Section 4.

Next, to further test the robustness of the results, the explanatory variable is replaced with the natural logarithm of the sum of credit intermediation-type and credit chain-type shadow banking activities (SL_sum) to capture the scale of shadow banking by non-financial enterprises more comprehensively. The SDM with two-way fixed effects is estimated, and the results

TABLE 7 Spatial Spillover Effects–Decomposition of Effects.

Variables		(1)	(2)	(3)
		Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
Direct effect	<i>SL</i>	−0.088***	−0.039***	−0.054***
		(−3.34)	(−3.02)	(−2.85)
	<i>PopDen</i>	0.672	0.691*	3.199***
		(1.64)	(1.94)	(5.80)
	<i>PerGDP</i>	2.765***	2.463***	5.038***
		(3.88)	(3.61)	(4.86)
	<i>Edu</i>	0.971	0.149	−1.779
		(1.17)	(0.21)	(−1.61)
	<i>FD</i>	0.462	−0.568	−0.661
		(0.52)	(−0.89)	(−0.68)
	<i>Gov</i>	1.568	0.929	−1.573
		(1.11)	(0.68)	(−0.74)
	<i>Service</i>	0.018	−0.009	−0.005
		(0.79)	(−0.49)	(−0.17)
Indirect effect	<i>SL</i>	−10.911**	−0.115***	−0.494***
		(−2.04)	(−3.12)	(−8.61)
	<i>PopDen</i>	−64.523	−2.518**	2.320*
		(−1.20)	(−2.54)	(1.85)
	<i>PerGDP</i>	−41.614	0.466	2.647
		(−0.74)	(0.32)	(1.60)
	<i>Edu</i>	165.659*	6.794***	12.311***
		(1.69)	(4.01)	(5.44)
	<i>FD</i>	257.051*	6.727***	5.608**
		(1.88)	(4.25)	(2.53)
	<i>Gov</i>	69.135	2.263	−3.315
		(0.65)	(0.71)	(−0.83)
	<i>Service</i>	6.468**	0.133***	0.180***
		(2.13)	(3.47)	(3.43)
Total effect	<i>SL</i>	−10.999**	−0.154***	−0.548***
		(−2.04)	(−3.40)	(−8.62)
	<i>PopDen</i>	−63.852	−1.827	5.519***

(Continued on the following page)

TABLE 7 (Continued) Spatial Spillover Effects—Decomposition of Effects.

Variables		(1)	(2)	(3)
		Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
		(-1.18)	(-1.62)	(4.21)
	<i>PerGDP</i>	-38.849	2.930*	7.685***
		(-0.69)	(1.86)	(4.56)
	<i>Edu</i>	166.630*	6.942***	10.533***
		(1.70)	(3.52)	(4.55)
	<i>FD</i>	257.513*	6.159***	4.947**
		(1.88)	(3.19)	(2.03)
	<i>Gov</i>	70.703	3.192	-4.888
		(0.66)	(0.87)	(-1.14)
	<i>Service</i>	6.485**	0.124***	0.175***
		(2.13)	(2.82)	(3.40)

This table decomposes the spatial spillover effects into direct, indirect, and total effects under different spatial weighting matrices: distance matrix, adjacency matrix, and economic matrix. Two-way fixed effects are included. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

are reported in Table 8. The estimated coefficients of the key variable remain consistent in sign with those from the baseline regressions in Tables 6, 7. Across all specifications under the three spatial weight matrices, the direct effects of shadow banking by non-financial enterprises are significantly negative at the 1 percent level. This confirms that, regardless of the spatial weight structure employed, shadow banking consistently improves local credit conditions and reduces SME mortality, thereby supporting Hypothesis H1a.

The results for the indirect and total effects further demonstrate that the expanded measure of shadow banking activity (*SL_sum*), which encompasses a broader scope of financial operations, has a significantly negative effect at the 1 percent level across all spatial weight matrices. This indicates that shadow banking by non-financial enterprises affects not only local SME survival but also exerts spatial spillover effects on neighboring regions. These findings provide additional empirical support for Hypothesis H2.

In addition, to further examine the long-term impact of shadow lending of non-financial enterprises on the survival of SMEs, a two-way fixed effects panel regression is employed to assess the effect of shadow banking on local SME mortality in periods $t + 1$ and $t + 2$. The results of the robustness check for lagged effects are presented in Table 9.

The regression coefficients of shadow lending are consistently and significantly negative across the models estimating its impact on SME mortality in periods t , $t + 1$, and $t + 2$, with significance levels at the 1 percent or 5 percent thresholds. These results indicate that the non-financial enterprises' shadow lending activities have a significant and persistent effect in reducing SME mortality over time. This finding provides empirical support for the view that shadow banking alleviates financing constraints

and enhances the long-term survival capacity of local SMEs. Overall, the results from Table 9 suggest that the mitigating effect of shadow banking on local SME mortality is not only significant in the current period but also persists into the subsequent 2 years. However, the effect becomes statistically insignificant beyond period $t + 2$. These findings further confirm the robustness of the long-term positive impact of shadow banking on SME survival.

6 Further analysis

6.1 Regional heterogeneity analyses

To examine whether the impact of shadow banking by non-financial enterprises on regional SME mortality varies across different regions, we further divide the sample of 243 cities into two groups based on the “Hu Huanyong Line”² (“Hu line”), which geographically separates China into the southeastern and northwestern regions. The southeastern region is characterized by higher population density, greater urbanization, and more dynamic financial markets and business activities. In contrast, the northwestern region features lower population

2 The Hu Huanyong Line, first proposed by Chinese demographer Hu Huanyong in 1935, is a demographic and economic dividing line that runs diagonally from Heihe in Heilongjiang province to Tengchong in Yunnan province. The southeastern side of the line contains approximately 94% of China's population and economic activity, while the northwestern side is sparsely populated and less economically developed [34].

TABLE 8 Robustness tests: alternative measurements of independent variables.

Variables	(1)	(2)	(3)
	Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
<i>SL_sum</i>	−0.064***	−0.054***	−0.053***
	(−3.23)	(−2.74)	(−2.70)
<i>WSL_sum</i>	−1.775***	−0.176***	−0.371***
	(−7.76)	(−4.73)	(−6.63)
<i>PopDen</i>	3.450***	3.186***	3.193***
	(5.20)	(4.70)	(4.87)
<i>PerGDP</i>	5.707***	6.016***	4.854***
	(5.24)	(5.54)	(4.94)
<i>Edu</i>	−1.520	−1.594	−2.109**
	(−1.46)	(−1.55)	(−2.07)
<i>FD</i>	−0.265	−0.112	−0.595
	(−0.31)	(−0.13)	(−0.70)
<i>Gov</i>	−0.359	−1.891	−1.750
	(−0.15)	(−0.81)	(−0.78)
<i>Service</i>	−0.008	−0.003	−0.009
	(−0.25)	(−0.09)	(−0.30)
ρ	0.461***	0.191***	0.166***
	(6.03)	(9.90)	(7.54)
σ^2	35.593***	35.256***	34.896***
	(36.34)	(36.50)	(36.54)
<i>WControls</i>	Yes	Yes	Yes
Direct effect	−0.077***	−0.064***	−0.060***
	(−3.81)	(−3.16)	(−3.01)
Indirect effect	−3.459***	−0.221***	−0.459***
	(−5.01)	(−5.58)	(−7.49)
Total effect	−3.536***	−0.285***	−0.519***
	(−5.09)	(−5.82)	(−7.66)
City FE	Yes	Yes	Yes

(Continued on the following page)

TABLE 8 (Continued) Robustness tests: alternative measurements of independent variables.

	(1)	(2)	(3)
	Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
Year FE	Yes	Yes	Yes
Obs	2,673	2,673	2,673
R ²	0.358	0.011	0.135

This table reports the results of regressions including alternative proxies for the independent variables under different spatial weighting matrices: distance matrix, adjacency matrix, and economic matrix. The independent variable is replaced by *SL_{sum}*, refers to the sum of *SL*, and the amount that listed companies indirectly involving in shadow banking activities through purchasing trust products, bank WMPs, and internet financial products. Two-way fixed effects are included. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 9 Robustness tests: the time-lagged effects.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	<i>MSEMR_t</i>		<i>MSEMR_{t+1}</i>		<i>MSEMR_{t+2}</i>	
<i>SL</i>	−0.035**	−0.041***	−0.042***	−0.049***	−0.027**	−0.031**
	(−2.44)	(−2.92)	(−3.01)	(−3.66)	(−2.11)	(−2.54)
<i>PopDen</i>		0.552		−0.012		0.254
		(1.16)		(−0.03)		(0.68)
<i>PerGDP</i>		4.721***		6.167***		5.610***
		(7.26)		(10.08)		(9.77)
<i>Edu</i>		2.623***		1.990***		0.623
		(3.71)		(3.02)		(1.01)
<i>FD</i>		1.222**		0.509		0.191
		(1.99)		(0.87)		(0.35)
<i>Gov</i>		−0.956		−1.922		−1.366
		(−0.60)		(−1.27)		(−0.97)
<i>Service</i>		0.059***		0.035*		−0.015
		(2.89)		(1.85)		(−0.85)
Constant	22.877***	−121.424***	20.782***	−101.835***	17.685***	−60.386***
	(72.66)	(−6.57)	(73.00)	(−5.78)	(71.40)	(−3.61)
City FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	2,673	2,673	2,430	2,430	2,187	2,187
City	243	243	243	243	243	243
R ²	0.703	0.717	0.707	0.726	0.738	0.738

This table presents the time-lagged effects of shadow lending on the micro and small enterprises mortality rate across contemporaneous and lagged periods (*t*, *t*+1, and *t*+2). The panel regression models include two-way fixed effects. Standard errors clustered at the firm level. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

density, slower economic development, and relatively unbalanced financial growth.

As shown in the subgroup regression results in Table 10, the impact of shadow banking by non-financial enterprises on SME mortality is more pronounced in southeastern regions, while it is relatively insignificant in northwestern regions. In the southeast, the coefficient of shadow lending (SL_sum) is significantly negative under both the distance matrix ($W1$) and the adjacency matrix ($W2$), suggesting that shadow banking activities contribute to reducing SME mortality and generate positive spillover effects across neighboring areas. In contrast, although the coefficients of shadow lending in northwestern cities are also negative, most regressions fail to reach statistical significance. This reflects the weaker effectiveness of shadow banking in improving the survival environment of SMEs in less developed financial markets with lower capital mobility, such as those in the northwest.

Moreover, the spatial lag term of shadow lending (WSL_sum) is significantly negative in both the southeastern and northwestern regions, indicating that shadow banking activities produce positive spillover effects across regions. In the northwest, these spatial lag effects are significant under the geographic matrices ($W1$ and $W2$), suggesting that when local capital is limited, shadow banking can influence SME survival through spillovers from adjacent areas. However, under the economic matrix ($W3$), the effect is not significant, indicating that economically similar cities do not exhibit strong financial transmission effects in the northwest. By contrast, the southeastern region shows significant negative effects in both the direct and spatial lag terms, highlighting the important role of shadow banking in supporting SME survival in more developed economic environments. Using the Hu Line as a basis for regional division, this heterogeneity analysis further validates that the effects of shadow banking on SME mortality and its spatial spillovers vary significantly across regions.

6.2 The impact of shadow banking by non-financial enterprises on regional firm survival

To further investigate the impact of shadow lending of non-financial enterprises on the regional business environment and its spatial spillover effects, this section expands the sample to include all enterprises. The estimation results of the SDM with two-way fixed effects under the three spatial weight matrix specifications are reported in Table 11.

The regression results indicate that shadow lending of non-financial enterprises continue to have a statistically significant effect on the mortality of all firms. The coefficient for shadow lending is negative and significant at the 5 percent level under all three spatial weight matrix specifications, suggesting that shadow banking significantly reduces overall firm mortality. This finding is consistent with the earlier results based on the SMEs subsample and further supports the positive role of shadow banking in enhancing firm survival and reducing firm exits. However, the decomposition of spatial effects reveals that the impact of shadow banking on overall firm mortality resembles that of SMEs only under the distance matrix ($W1$). Under the alternative spatial weight specifications,

the influence of shadow lending on overall firm mortality is comparatively weaker.

Overall, the effect of shadow banking by non-financial enterprises on the survival of all firms appears to be less pronounced than its effect on SMEs. Both the direct effects on local firms and the indirect effects on firms in neighboring regions are relatively limited in magnitude.

6.3 Mechanism analysis: the impact of shadow banking by non-financial enterprises on the survival of micro and small enterprises

This section employs a difference-in-differences (DID) approach to evaluate the impact of the 2018 *New Asset Management Regulations*³, which sought to curb systemic financial risks by regulating shadow banking activities. The policy serves as an exogenous shock, allowing us to causally evaluate its effectiveness in reducing regional credit risks associated with shadow lending by non-financial enterprises.

As an informal financing channel, shadow banking serves as an important source of capital for SMEs that face difficulties in accessing traditional credit. However, the tightening of financial regulation directly affects the scale and liquidity of shadow banking. In particular, the implementation of the *New Asset Management Rules* had a direct impact on both the volume and flow of funds within the shadow banking system. While the primary objective of the policy tightening was to curb high-risk activities in shadow banking, which may have constrained credit supply in the short term, it also aimed to enhance long-term financial stability by reducing systemic risk through stricter oversight of risk-prone financial operations. To explore the underlying mechanism in greater depth, this section adopts a difference-in-differences (DID) approach combined with the Spatial Durbin Model (SDM) to examine the effects of the New AM Rules on shadow banking activities and their subsequent influence on SME survival. The SDM-DID model is specified as shown in Equation 5:

$$\begin{aligned} SMEMR_{it} = & \alpha + \rho \sum_{j=1}^n W_{ij} SMEMR_{jt} + \beta_1 (Treat_i \times Post_t) \\ & + \beta_2 Controls_{it} + \theta_1 \sum_{j=1}^n W_{ij} (Treat_i \times Post_t) \\ & + \theta_2 \sum_{j=1}^n W_{ij} Controls_{jt} + City_i + Year_t + \varepsilon_{it} \end{aligned} \quad (5)$$

Using the shadow banking scale of non-financial enterprises at the prefecture-level as a benchmark, this section divides the sample

³ The *New Asset Management Regulations* is short for the "Guiding Opinions on Regulating the Asset Management Business of Financial Institutions" (Yinfa [2018] No. 106) was issued by the People's Bank of China, the China Securities Regulatory Commission, the State Administration of Foreign Exchange, and the China Banking and Insurance Regulatory Commission on 27 April 2018. (please refer to <http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/3529600/index.html> for more details)

TABLE 10 Heterogeneity Analysis: Economic Development (Hu Line).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Distance matrix (W1)		Adjacency matrix (W2)		Economic matrix (W3)	
	Northwest	Southeast	Northwest	Southeast	Northwest	Southeast
<i>SL_{sum}</i>	−0.169*	−0.027**	−0.147	−0.021*	−0.162	−0.015
	(-1.78)	(-2.14)	(-1.46)	(-1.74)	(-1.58)	(-1.25)
<i>WSL_{sum}</i>	−1.095***	−0.672***	−0.297**	−0.049**	−0.192	−0.069*
	(-3.56)	(-4.34)	(-2.35)	(-2.05)	(-1.26)	(-1.77)
<i>PopDen</i>	13.518***	0.635	14.268***	0.497	15.162***	0.709*
	(4.44)	(1.41)	(4.30)	(1.15)	(4.49)	(1.67)
<i>PerGDP</i>	13.010**	1.787**	18.696***	2.233***	21.914***	0.690
	(2.50)	(2.39)	(3.52)	(3.22)	(3.77)	(1.09)
<i>Edu</i>	−20.831***	0.770	−31.496***	0.036	−27.102***	−0.189
	(-2.62)	(1.15)	(-3.61)	(0.06)	(-3.13)	(-0.30)
<i>FD</i>	15.826***	−1.119**	17.507***	−1.715***	16.779***	−2.211***
	(2.83)	(-1.99)	(2.93)	(-3.27)	(2.74)	(-4.20)
<i>Gov</i>	−24.009*	0.916	−24.732*	0.667	−17.654	1.792
	(-1.93)	(0.58)	(-1.85)	(0.46)	(-1.33)	(1.27)
<i>Service</i>	−0.272*	−0.015	−0.171	−0.020	−0.218	−0.036*
	(-1.93)	(-0.66)	(-1.17)	(-0.97)	(-1.40)	(-1.79)
ρ	−0.359***	0.895***	−0.180***	0.505***	−0.135**	0.610***
	(-3.91)	(29.06)	(-3.34)	(24.49)	(-2.39)	(23.00)
σ^2	94.646***	13.927***	105.637***	11.983***	110.374***	12.285***
	(10.95)	(34.80)	(10.93)	(33.99)	(10.97)	(34.41)
<i>WControls</i>	Yes	Yes	Yes	Yes	Yes	Yes
Direct effect	−0.120	−0.065***	−0.119	−0.030**	−0.151	−0.022
	(-1.24)	(-2.71)	(-1.16)	(-2.24)	(-1.45)	(-1.64)
Indirect effect	−0.854***	−7.769*	−0.254**	−0.114***	−0.189	−0.207**
	(-3.77)	(-1.88)	(-2.52)	(-2.72)	(-1.40)	(-2.24)
Total effect	−0.974***	−7.834*	−0.373***	−0.144***	−0.340**	−0.228**
	(-3.99)	(-1.89)	(-2.86)	(-2.84)	(-2.17)	(-2.30)
City FE	Yes	Yes	Yes	Yes	Yes	Yes

(Continued on the following page)

TABLE 10 (Continued) Heterogeneity Analysis: Economic Development (Hu Line).

	(1)	(2)	(3)	(4)	(5)	(6)
	Distance matrix (W1)		Adjacency matrix (W2)		Economic matrix (W3)	
	Northwest	Southeast	Northwest	Southeast	Northwest	Southeast
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	242	2,431	242	2,431	242	2,431
R ²	0.015	0.481	0.008	0.008	0.025	0.232

This table presents the regression results analyzing the impact of economic development on shadow lending activities across different regions divided by the Hu Line. Column (1), (3) and (5) present results for the Northwest, while Column (2), (4) and (6) report results for the Southeast. Two-way fixed effects are included. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

into a treatment group (regions with shadow banking scale above the 50th percentile) and a control group (regions below the 50th percentile). This classification allows for a clearer assessment of how changes in shadow banking activity, before and after the policy implementation, influence SME mortality and provides a theoretical foundation for understanding the underlying mechanism through which shadow banking affects SME survival.

Table 12 reports the regression results from the SDM-DID model estimating the effects of the *New Asset Management Rules*. The key explanatory variable in this section is the interaction term $Treat_i \times Post_t$, indicating whether a region is in the treatment group following the policy implementation. The analysis is conducted using three types of spatial weight matrices: the distance matrix (W1), the adjacency matrix (W2), and the economic matrix (W3). According to the regression results, the coefficients on the policy shock variable $Treat_i \times Post_t$ are 0.0139 (W1), 0.0152 (W2), and 0.0170 (W3), all of which are significantly positive at the 1 percent level.

These results suggest that following the implementation of the *New Asset Management Rules*, SME mortality increased significantly in regions with larger shadow banking activity (the treatment group). As shown in the earlier sections of this study, shadow banking by non-financial enterprises plays a positive role in supporting the survival of SMEs by alleviating their financing constraints. However, the primary aim of the regulatory tightening was to reduce high-risk operations within the shadow banking system and to mitigate potential systemic financial risks. In the short term, such regulatory tightening may lead to the contraction of certain shadow banking channels, thereby reducing the scale of shadow banking and the volume of capital flowing to SMEs. As a result, SMEs that previously relied on these informal financing sources may face increased financial pressure due to diminished credit availability, ultimately contributing to a rise in their mortality.

Moreover, the impact of the policy is not limited to prefecture-level cities with larger shadow banking activity. It can also extend to neighboring regions through interregional financial linkages. The spatial spillover effect is preliminarily captured by the spatially lagged interaction term $(W_{ij}(Treat_i \times Post_t))$, whose coefficients under the three spatial weight matrices are 0.1675, 0.0545, and 0.0579, respectively. All are significantly positive at the 1 percent level. This indicates that the shock generated by the *New Asset Management Rules* in regions with a high degree of shadow banking activity gradually

spread to adjacent areas through financial market interdependence. Given the high degree of connectivity in financial markets and the close flow of capital across regions, the contraction of shadow banking in the affected areas exerted a secondary influence on neighboring regions, raising financing costs and financial pressure for SMEs in those areas as well. The spatial effect decomposition results in Table 11 further reveal both the direct and indirect effects of shadow banking activity on SME mortality. Under all three spatial weight matrices, the direct effects are significantly positive at the 1 percent level, with coefficients of 0.0145 for W1, 0.0177 for W2, and 0.0177 for W3. This indicates that policy shocks led to increased SME mortality within regions with large-scale shadow banking activity. In addition, the indirect effects are 0.2308 for W1, 0.0644 for W2, and 0.0675 for W3, while the total effects are 0.2453 for W1, 0.0821 for W2, and 0.0852 for W3. All are significantly positive at the 1 percent level. These results provide strong evidence that the impact of the policy shock was transmitted through regional financial networks, thereby influencing the survival of SMEs in neighboring areas. As a result, the mortality rates of SMEs in these surrounding regions also increased following the implementation of the *New Asset Management Rules*.

Overall, the *New Asset Management Rules* reduced the scale of shadow banking financing by strengthening regulatory oversight of high-risk activities. In the short term, this policy exerted considerable pressure on the survival environment of SMEs in regions with a high concentration of shadow banking activity and their neighboring areas, leading to increased financing costs and heightened financial stress for affected firms. However, the long-term objective of the policy is to safeguard the stability of the financial system by curbing excessive risk-taking and preventing systemic financial risks. As the policy continues to advance, the financial environment is gradually being cleansed, creating a healthier and more stable market foundation for the sustainable development of SMEs. In addition, the policy has effectively guided SMEs to reduce their dependence on shadow banking and to transition toward more sustainable and transparent financing channels. It has also contributed to a more efficient market selection process, enabling firms with sounder financial structures and stronger adaptive capacity to survive and grow. Although the mortality rate of SMEs has increased in the short term, the surviving firms are generally more resilient and competitive, thereby promoting sustained development within a more regulated financial system. In the long run, the *New Asset Management Rules* have laid

TABLE 11 Additional tests: shadow lending and total enterprises mortality rate.

Variables	(1)	(2)	(3)
	Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
SL	−0.014**	−0.013**	−0.014**
	(−2.00)	(−1.99)	(−2.13)
WSL	−0.271***	0.015	−0.009
	(−3.30)	(1.25)	(−0.71)
PopDen	1.203***	1.303***	0.957***
	(5.00)	(5.61)	(4.12)
PerGDP	−0.296	−0.412	0.062
	(−0.75)	(−1.11)	(0.15)
Edu	0.646*	0.703**	0.464
	(1.72)	(2.01)	(1.29)
FD	0.001	0.122	0.150
	(0.00)	(0.42)	(0.50)
Gov	−0.447	−1.297	−0.277
	(−0.52)	(−1.62)	(−0.34)
Service	−0.014	−0.010	−0.018
	(−1.22)	(−0.92)	(−1.59)
ρ	0.893***	0.467***	0.402***
	(28.79)	(23.84)	(18.40)
σ^2	4.681***	4.136***	4.427***
	(36.37)	(35.78)	(36.00)
WControls	Yes	Yes	Yes
Direct effect	−0.028***	−0.012	−0.016**
	(−2.66)	(−1.62)	(−2.26)
Indirect effect	−3.147*	0.012	−0.027
	(−1.85)	(0.64)	(−1.40)
Total effect	−3.175*	0.001	−0.043*
	(−1.86)	(0.03)	(−1.88)
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs	2,430	2,430	2,430
R ²	0.015	0.002	0.017

This table reports the results of regressions including alternative proxies for the dependent variable under different spatial weighting matrices: distance matrix, adjacency matrix, and economic matrix. The dependent variable is replaced by *MR*, refers to total enterprises mortality rate at prefecture-level. Two-way fixed effects are included. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 12 Further analysis: DID Analysis: The Impact of the “New Asset Management Regulations”.

Variables	(1)	(2)	(3)
	Distance matrix (W1)	Adjacency matrix (W2)	Economic matrix (W3)
<i>Treat × Post</i>	0.0139***	0.0152***	0.0170***
	(2.80)	(3.12)	(3.53)
<i>W(Treat × Post)</i>	0.1675***	0.0545***	0.0579***
	(4.13)	(6.76)	(5.70)
<i>PopDen</i>	0.0283***	0.0286***	0.0279***
	(4.40)	(4.33)	(4.36)
<i>PerGDP</i>	0.0528***	0.0576***	0.0513***
	(4.96)	(5.35)	(5.29)
<i>Edu</i>	−0.0282***	−0.0278***	−0.0322***
	(−2.73)	(−2.72)	(−3.17)
<i>FD</i>	0.0383**	0.0705***	0.0451***
	(2.28)	(4.20)	(2.74)
<i>Gov</i>	0.0053	−0.0195	0.0016
	(0.22)	(−0.84)	(0.07)
ρ	0.2577***	0.1706***	0.1184***
	(3.07)	(8.85)	(5.21)
σ^2	0.0034***	0.0034***	0.0034***
	(36.65)	(36.53)	(36.55)
<i>WControls</i>	Yes	Yes	Yes
Direct effect	0.0145***	0.0177***	0.0177***
	(2.94)	(3.73)	(3.70)
Indirect effect	0.2308***	0.0644***	0.0675***
	(3.78)	(7.08)	(5.89)
Total effect	0.2453***	0.0821***	0.0852***
	(4.14)	(9.26)	(7.87)
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Obs	2,673	2,673	2,673
R ²	0.392	0.026	0.183

This table presents the regression results using a DID approach to examine the effect of the *New Asset Management Regulations*, which aimed to reduce systemic financial risks by regulating shadow banking activities. Cities are divided into a treatment group (with shadow banking scales above the 50th percentile) and a control group (below the 50th percentile). The policy is expected to have a more significant impact on cities with larger shadow banking activities. Two-way fixed effects are included. t-statistics are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

an institutional foundation for the healthy growth of SMEs and the high-quality development of the sector as a whole.

7 Conclusion

This study empirically examines the critical role of non-financial enterprises' shadow lending in shaping small and micro enterprises' (SMEs) survival across Chinese regions by adopting the Spatial Durbin Model (SDM). Our findings show that shadow lending by non-financial enterprises significantly reduces local SME mortality, while also generating substantial spatial spillover effects, where credit diffusion through shadow banking activities improves SME survival in neighboring regions. This demonstrates that shadow banking not only supports SMEs in their originating regions but also creates favorable externalities across interconnected regional economies.

Our findings provide significant implications for both academic inquiry and policy design. By revealing that shadow banking significantly lowers SME mortality both locally and through regional spillovers, we provide empirical support to existing theoretical perspectives on the financial intermediation role of non-financial enterprises. Moreover, our results expand upon prior studies that have focused on the spatial distribution of shadow banking activities [17, 18] by demonstrating how such geographic patterns translate into measurable impacts on SME resilience. Our analysis further complements macro-level studies (e.g., [19, 20]) that highlight the role of regulatory arbitrage and systemic risk in shadow banking development. Integrating these insights, our research bridges micro-level firm dynamics with macro-level financial policy debates, offering a geographically grounded understanding of informal finance. These findings underscore the necessity for spatially differentiated regulatory strategies that reflect the uneven role and risks of shadow banking across regions.

In addition, the heterogeneity analysis reveals that the effects of shadow lending by non-financial enterprises are more pronounced in economically developed southeastern regions, with relatively weaker effects observed in the less developed northwest. This highlights the role of regional economic development in shaping the effectiveness of shadow banking as a financing tool for SMEs. Furthermore, robustness checks confirm the persistence of these positive effects over time, with shadow banking continuing to alleviate financing pressures for SMEs over two periods.

However, the informal nature of shadow banking introduces significant systemic vulnerabilities. The unregulated flow of credit can generate financial fragility, particularly in regions where SMEs heavily depend on informal financing channels. As these credit flows deepen, financial stress in one region can spread to others through inter-regional capital linkages, heightening the risk of financial contagion.

Based on these findings, we recommend that financial regulators develop a differentiated regulatory approach. While stricter regulations are needed in economically developed regions to manage the potential risks arising from shadow banking, less developed regions may benefit from more flexible policies that support SME financing. Moreover, cross-regional financial regulatory coordination is essential to manage systemic risks and prevent

the propagation of financial stress between regions. Strengthening regional risk monitoring and establishing early warning systems are critical for mitigating the broader effects of financial contagion.

Overall, this study contributes to the understanding of shadow banking's dual role in supporting SME survival while also exacerbating systemic risks. It highlights the need for tailored regulatory frameworks that consider both regional economic disparities and the cross-regional transmission of financial risks [32, 33].

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://www.cnrds.com/Home/Login>.

Author contributions

CW: Software, Writing – original draft, Methodology. WZ: Writing – review and editing, Supervision. YM: Conceptualization, Writing – review and editing, Project administration. XX: Funding acquisition, Supervision, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The authors declare that Gen AI was used in the creation of this manuscript. During the preparation of this work, the authors used ChatGPT to assist in ONLY language refinement. The authors take full responsibility for the content of this publication.

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