The Spillover Effects of Real Estate*

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Current Version: June 2026
First Draft: September 2023

Abstract

We examine the spillover effects of the "Three-Red Lines" policy, a Chinese regulatory measure in 2020 that imposed leverage reduction requirements on the real-estate sector. Using a firm-level exposure measure, we find that higher exposure to real estate leads to larger adverse effects on firms' financing costs and real economic activity. Moreover, these spillover effects are transmitted through the production network, affecting both upstream and downstream sectors closely connected to real estate. Trade credit plays a significant role in explaining the observed spillover effects. We provide a simple framework to rationalize the empirical results.

Keywords: Spillover, Real Estate, Production Network, Trade Credit

*For helpful comments, we thank Mikael Juselius, Erica Li, Xiaoji Lin, Simona Malovana, Shang-Jin Wei, Jing Wu, Yu Zhang, Bo Zhao, and seminar participants at ABFER Annual Conference, AEA meeting, Bank of Finland, CFRC, CICF, CKGSB, Econometric Society Meeting, Fudan University, and Peking University. All errors are our own.

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1 Introduction

Real estate is central to macroeconomic fluctuations because it is closely linked to households, banks, local governments, and firms outside the property sector. A collapse in real-estate prices can affect the rest of the economy through collateral, wealth, and balance-sheet channels (e.g., Gan 2007, Iacoviello and Neri 2010, Mian, Rao, and Sufi 2013). In China, these concerns are especially salient. Real estate has been a major component of investment demand, local-government revenue, household wealth, and corporate balance sheets. Defaults by developers such as Evergrande and Country Garden have therefore raised a broader question: when stress originates in the developer sector, how large are its effects, and how far do they propagate through the rest of the economy?

In this paper, we address this question using a unique Chinese policy announcement: the Three-Red-Line policy. China's recent regulation of the real-estate sector provides a well-suited quasi-experiment for two reasons. First, real estate is an important part of the Chinese economy. As of 2022, for example, the real-estate industry accounted for 26% of China's GDP (Rogoff and Yang 2022). Moreover, land-sale income amounted to 6.7 trillion RMB, equivalent to 61% of total local-government revenues.

Second, the Three-Red-Line policy was unexpected and unprecedented. It was announced on August 20, 2020, by the Ministry of Housing and Urban-Rural Development and the People's Bank of China (PBOC). Based on the liability structures of real-estate firms, the policy imposed restrictions on three accounting variables. Violating each threshold is referred to as crossing a red line. Depending on the number of red lines crossed, the policy grouped firms into four categories: red, for firms crossing three lines; orange, for firms crossing two lines; yellow, for firms crossing one line; and green, for firms crossing no lines. Real-estate firms faced caps on the annual growth rate of interest-bearing liabilities of 0%, 5%, 10%, and 15%, respectively, depending on their categories. Although many housing regulations—such as purchase restrictions, increases in minimum down-payment ratios, and restrictions on bank lending to the real-estate sector—had previously been imposed on households and banks, the Three-Red-Line policy was the first major regulatory policy to directly constrain the liabilities of real-estate developers as a means of containing housing speculation.

The policy was binding for much of the large-developer sector: in our sample of listed developers, most firms violated at least one red line before the policy. Commentators and researchers have linked the subsequent wave of developer defaults and the housing-market slump to this deleveraging rule, while also noting that the policy interacted with deeper forces such as overbuilding, demographics, and weakened expectations (Huang, 2023, Rogoff and Yang, 2026). Whether, and to what extent, this policy contributed to the subsequent economic slump requires further investigation, especially a proper identification strategy that can disentangle spillovers from real estate

from broader macroeconomic conditions. We exploit the policy's direct targeting of the real-estate sector, together with pre-existing links between real-estate developers and non-real-estate firms, to identify the policy's spillover effects.

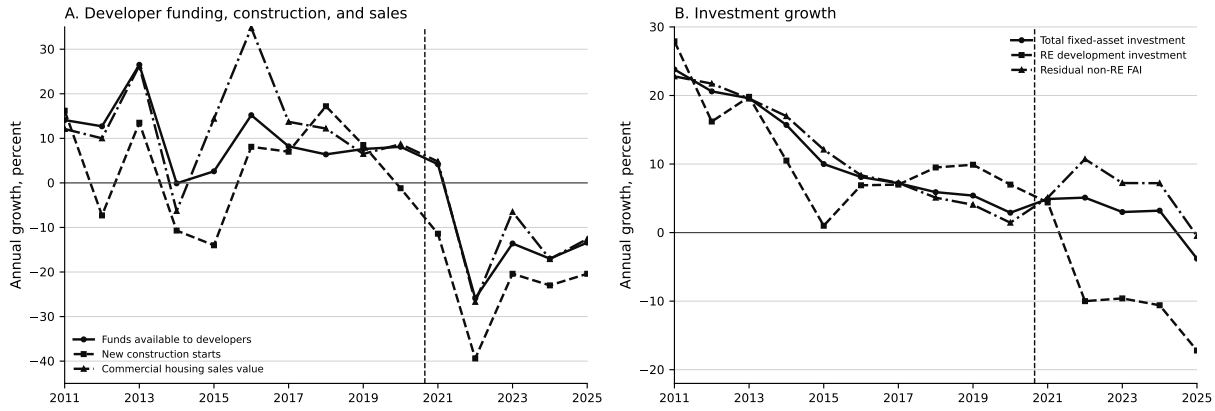
Our identification begins with the fact that the policy generated negative direct effects on real-estate developers. At the aggregate level, the Three-Red-Line policy created visible pressure within the real-estate sector. Figure 1 documents the timing and aggregate scale of the real-estate contraction. Real-estate development investment fell by 10.0 percent in 2022, 9.6 percent in 2023, 10.6 percent in 2024, and 17.2 percent in 2025. Developer funding, new construction starts, and commercial housing sales also declined sharply. Because aggregate investment also reflects infrastructure spending, manufacturing upgrading, COVID disruptions, and policy responses, our empirical analysis turns to firm-level exposure to developer stress. The firm-level design asks whether otherwise similar non-real-estate firms reduced investment more when their pre-policy links connected them to developers more constrained by the Three-Red-Line policy.

To identify the causal effects of the Three-Red-Line policy, we construct a firm-level exposure measure for non-real-estate listed firms in China, following the methodology of Chodorow-Reich (2014). Our exposure measure combines information on the cross-sectional intensity of the policy shock among real-estate firms with pre-shock stock-return correlations between non-real-estate firms and the real-estate sector. We then estimate both the financial and real spillover effects on non-real-estate firms using a difference-in-differences specification.

Our identification exploits two sources of variation. First, the policy generated heterogeneous negative effects on Chinese real-estate developers, depending on the number of red lines they violated when the policy was announced. Indeed, we find that more constrained developers reduced growth in interest-bearing liabilities, net debt issuance, and inventory accumulation after the policy. The policy therefore generated both a financing shock and a real-activity shock within the developer sector, consistent with the macro-level evidence in Figure 1.

Second, non-real-estate firms differed in their pre-existing exposure to troubled real-estate developers, as captured by the correlation between their stock returns and those of individual real-estate developers. Stock-return correlations are intended to capture economic links between real-estate and non-real-estate firms, but they may also capture other sources of comovement, such as common exposure to macroeconomic shocks, that are unrelated to direct links with real-estate developers. We therefore validate the robustness of our results using invoice links between mainland real-estate developers and non-real-estate firms, and obtain consistent results. Because the invoice-based measure captures only links to mainland developers, whereas many large real-estate developers are listed in Hong Kong, we prefer the stock-return-based exposure measure as our baseline specification. In our data, Hong Kong-listed real-estate firms account for 72.6% of assets among all listed real-estate developers.

Figure 1 REAL-ESTATE CONTRACTION AND AGGREGATE INVESTMENT GROWTH



NOTE. Panel A plots annual growth rates for funds available to real-estate developers, new construction starts, and commercial housing sales value. Panel B plots annual growth rates for total fixed-asset investment, real-estate development investment, and residual non-real-estate fixed-asset investment. The dashed vertical line marks the announcement year of the Three-Red-Line policy. Source: NBS.

Our first set of results concerns financial spillovers. We find that, during the policy period, both stock returns and bond spreads respond more strongly for firms with higher exposure to the policy. Economically, a one-standard-deviation increase in ex ante exposure reduces 10-day cumulative abnormal stock returns by 0.18% and increases bond spreads by 33 basis points in daily data.

We next examine real effects, since the policy may have had persistent effects on the real economy. We find that firms with greater exposure to the policy are affected more negatively. Economically, a one-standard-deviation increase in exposure reduces real investment by 0.29%, sales growth by 2.20%, and net profit by 0.23%. Correspondingly, these firms increase leverage by 0.21%.

One challenge to our empirical design is the possibility of time-varying, firm-specific shocks that are correlated with our measure of policy exposure. We address this challenge by estimating dynamic regressions of firm investment that trace the quarterly coefficient on policy exposure. Across our regressions, the estimated coefficients are statistically insignificant in the pre-policy period, consistent with parallel pre-trends, and display a clear break during the policy period. This evidence supports our empirical design for estimating the causal effects of the Three-Red-Line policy.

Our estimated spillover effects are significant in aggregate. Following Mian and Sufi (2012), we conduct a conservative back-of-the-envelope calculation of the overall investment decline that can be attributed to spillovers from the Three-Red-Line policy. Under the identifying assumption that firms with very low exposure were unaffected by the policy, our estimates account for 42.31% of the total investment decline during 2020Q4–2022Q3. Because this period also includes COVID lockdowns, the magnitude of the estimated spillover effect is economically important.

What explains these results? We hypothesize that the spillover effects operate through production networks. As the policy forced real-estate firms to deleverage, upstream and downstream non-real-estate firms were negatively affected through outstanding trade-credit claims on distressed developers, which became more difficult to collect after the policy was implemented. Indeed, we find that sectors closer to real estate in the production network, as well as sectors more dependent on external financing, experienced larger investment declines. Within these sectors, firms that extended more trade credit to real-estate developers suffered more. We provide a simple framework to rationalize these patterns: a developer financing shock reduces demand and current cash receipts for connected firms, and the effect is amplified when production links are stronger or working-capital constraints bind more tightly.

Our paper has important policy implications, especially for understanding the spillover effects of the real-estate sector on the broader economy. Given the sector's tight connections to other industries, policies targeting real estate can generate significant effects on other sectors. Failing to internalize such spillovers may weaken the effectiveness of policy interventions and generate unintended consequences for the broader economy.

Literature Review Our paper contributes to several strands of the literature. First, our paper belongs to the literature that studies the importance of the real-estate sector for the Chinese macroeconomy, including Fang, Gu, Xiong, and Zhou (2016), Chen and Wen (2017), Glaeser, Huang, Ma, and Shleifer (2017), Rogoff and Yang (2022), Xiong (2023). Different from those papers, we study the spillover effects of the Three-Red-Line policy on other sectors in the production network. A related paper is Gu (2023), which also studies the effect of the same policy. Its focus is on real-estate firms, whereas we study non-real-estate firms.

Second, our paper is related to the literature on shock transmission through production networks, including Di Giovanni and Hale (2022), Lane (2022), and Balboni, Boehm, and Waseem (2023). We focus on a specific policy shock in the real-estate sector. Rather than studying only the input-output channel emphasized in this literature, we show how disruptions in real estate affect upstream and downstream firms through trade-credit links.

Last, our paper is related to the literature on the effects of housing-market regulations. An extensive literature studies regulations that operate through the household sector, including Greenwald (2018), Berger, Turner, and Zwick (2020), Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017), and DeFusco, Johnson, and Mondragon (2020) for the U.S. economy, and Du and Zhang (2015), Deng, Liao, Yu, and Zhang (2022), and Chen, Wang, Xu, and Zha (2020) for the Chinese economy. Another strand focuses on regulations imposed on financial institutions, including Jeske, Krueger, and Mitman (2013), Di Maggio and Kermani (2017) and Favara and Imbs (2015). Different from these papers, we study a regulation that directly constrained the leverage of real-estate developers and then trace its spillovers to firms outside real estate.

This paper is structured as follows. Section 2 provides the institutional background for the Three-Red-Line policy. Sections 3 and 4 describe the empirical strategy and the data, respectively. Section 5 discusses the main empirical results. Section 6 provides evidence on the transmission mechanism. Section 7 presents a simple framework that rationalizes the empirical patterns, with details in the appendix. Section 8 concludes.

2 Institutional Background

In China, there are 99,544 real-estate firms, of which 112 are listed in the A-share market and 267 are listed in the H-share market in 2022. The market capitalization of listed A-share real-estate firms is 1,501.9 billion yuan, roughly 2% of total A-share market capitalization. Real-estate firms play an important role in driving Chinese growth. They are also highly leveraged and tightly connected to other sectors. As a result, a policy that affects the real-estate sector can spill over to other sectors and hence to the broader macroeconomy.

The Three-Red-Line policy was the first major regulatory policy to target real-estate developers directly. It was announced on August 20, 2020, when the Ministry of Housing and Urban-Rural Development and the PBOC held a symposium with representative real-estate developers in China. Regulators were concerned about the highly indebted property-development sector and required developers to meet three balance-sheet thresholds: 1) liabilities should not exceed 70 percent of assets, excluding advance proceeds from projects sold on contract; 2) net debt should not exceed 100 percent of equity; and 3) cash reserves should be at least 100 percent of short-term debt.[1]

Depending on the number of thresholds violated, real-estate firms are grouped into four categories: red, for firms violating three thresholds; orange, for firms violating two thresholds; yellow, for firms violating one threshold; and green, for firms violating no threshold. Violations restrict firms' ability to increase interest-bearing liabilities. Firms in the red category are not allowed to increase interest-bearing liabilities, while orange, yellow, and green firms face annual growth caps of 5%, 10%, and 15%, respectively.

Table 1 reports the distribution of red-line violations among listed developers in 2020Q2. The policy affected most listed real-estate firms in China. At the end of 2020Q2, there were 209 listed real-estate firms in the combined A-share and H-share markets. Based on their 2020Q2 balance sheets, only 12 of 209 listed developers satisfied all three thresholds before the policy; 77 were red firms, 36 were orange, and 84 were yellow. The third red line was the most frequently violated threshold: 197 of 209 listed developers failed the cash-to-short-term-debt condition. This pattern is consistent with liquidity pressure among developers, although it is not by itself evidence of a trade-credit channel.

[1] See https://www.gsm.pku.edu.cn/thought_leadership/info/1007/2273.htm.

Table 1 THE IMPACT OF THE THREE-RED-LINE POLICY ON REAL-ESTATE FIRMS

# of Violation	H share	A share	Combined	Percentage
0	3	9	12	6
1	39	45	84	40
2	19	17	36	17
3	46	31	77	37
Total	107	102	209	100
	H share	A share	Combined	Percentage
1^{st} Line Violation	56	46	102	49
2^{nd} Line Violation	55	33	88	42
3^{rd} Line Violation	104	93	197	94

Before turning to non-real-estate firms, we first ask whether the policy affected the directly regulated developers. Table 2 uses A-share listed developers because quarterly accounting data are available for these firms; H-share developers report at a semiannual frequency. We estimate

$$Y_{jt} = \beta \left(Violation_j \times Post_t \right) + \Gamma X_{jt} + \alpha_j + \lambda_t + \varepsilon_{jt}.$$

Here Y_{jt} is a developer outcome, $Violation_j$ is the number of red lines violated by developer j before the policy, and $Post_t$ equals one from 2020Q4 onward. The preferred specification includes developer fixed effects and time fixed effects. The vector X_{jt} contains log assets, Tobin's Q, operating cash flow scaled by assets, and listed age. The preferred specification also allows developers with different pre-policy COVID exposure and different pre-policy inventory-growth histories to follow different time paths. These controls absorb differential shocks related to pandemic exposure and pre-policy overbuilding without using post-policy developer outcomes. We do not control for initial leverage interacted with Post in the baseline because leverage is part of the policy assignment rule: the number of red lines violated is constructed from leverage-related thresholds.

The policy was announced in 2020Q3, so the post period starts in 2020Q4, the first quarter after the announcement. Although the main first-stage analysis uses A-share developers because of data frequency, H-share developers are economically important. In the available 2020H1 balance-sheet data, Hong Kong-listed developers account for 72.6% of assets among listed real-estate developers. Evergrande, for example, was listed in Hong Kong.

Table 2 shows that the policy reduced developer financing and real activity. A one-line increase in the violation count predicts an 11.76 percentage point decline in interest-bearing-liability growth after the policy, consistent with the policy's liability-growth caps. Net debt issuance falls by 0.92 percentage points of lagged assets, indicating tighter access to formal debt financing. Inventory

growth falls by 15.12 percentage points, suggesting that constrained developers scaled back real-estate development activity. Cash paid to suppliers also falls, while the estimated effect on cash received from sales is negative but imprecise. These responses show that the policy affected the regulated sector directly and created potential channels through which developer stress could reach suppliers, buyers, and other non-real-estate firms.

Panel B shows that the balance-sheet adjustment also appears in working-capital positions. Supplier credit, buyer credit, receivable positions, and net working-capital financing all decline in same-quarter year-over-year changes. In plain terms, constrained developers not only reduced formal borrowing and inventory growth; they also adjusted the payment and contracting positions that connect them to suppliers and customers. This evidence motivates the spillover analysis below, while leaving open whether the non-real-estate firm response operates mainly through real demand, delayed payments, or broader liquidity conditions.

3 Empirical Strategy and Identification

The Three-Red-Line policy directly affected the real-estate sector. Even if a firm was classified as green, its growth in interest-bearing liabilities was capped at 15%. Because real-estate firms are highly leveraged, the regulation could affect both their financing and investment decisions. Given the sector's role in the economy, firms linked to real estate may also be affected. To estimate the spillover effect of the policy on non-real-estate firms, we construct an *exposure* measure for non-real-estate firms as follows.

$$\text{expo}_i = \frac{1}{H} \sum_{h=1}^{H} \text{corr}_{i,h} * N_h \tag{1}$$

where N_h is the number of violations of the Three-Red-Line thresholds for real-estate firm h as of August 20, 2020, H is the total number of listed real-estate firms in both the A-share and H-share markets, and $\text{corr}_{i,h}$ is the correlation between non-real-estate firm i and real-estate firm h. Ideally, we want to use an "intrinsic" correlation to capture the relationship between a non-real-estate firm and a real-estate firm. A natural candidate is the stock-return correlation, assuming that stock prices reflect information about the economic relationship between the two firms. We use daily stock returns between 2010 and 2019, the pre-policy period, to calculate the correlation. We also use invoice-level data in robustness exercises to capture direct business links.

Our identification of spillover effects on non-real-estate sectors relies on the exogeneity of the exposure measure. We assume that it captures the policy effect of the Three-Red-Line policy on non-real-estate firms through their linkages with the real-estate sector. This assumption is plausible because the policy was unexpected and because the policy's direct impact varied across real-estate

Table 2 DIRECT EFFECTS AND WORKING-CAPITAL ADJUSTMENT OF REAL-ESTATE DEVELOPERS

Panel A. Direct effects of the Three-Red-Line policy

	(1) IBL growth	(2) Net debt issuance	(3) Inventory growth	(4) Supplier cash	(5) Sales cash
Violation count × Post	-11.76**	-0.92***	-15.12**	-0.51*	-0.45
	(5.02)	(0.26)	(6.57)	(0.30)	(0.36)
Developer FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
COVID exposure × Time FE	Yes	Yes	Yes	Yes	Yes
Overbuilding × Time FE	Yes	Yes	Yes	Yes	Yes
Observations	1,569	1,664	1,662	1,664	1,664
Developers	96	99	99	99	99
R-squared	0.43	0.23	0.42	0.49	0.69

Panel B. Working-capital adjustment

	(1) ΔSupplier credit	(2) ΔBuyer credit	(3) ΔReceivable position	(4) ΔNet WC financing
Violation count × Post	-0.84***	-1.76**	-0.36*	-1.88**
	(0.25)	(0.79)	(0.21)	(0.88)
Developer FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
COVID exposure × Time FE	Yes	Yes	Yes	Yes
Overbuilding × Time FE	Yes	Yes	Yes	Yes
Observations	1,664	1,619	1,619	1,619
Developers	99	99	99	99
R-squared	0.35	0.35	0.39	0.42

NOTE. The table reports quarterly difference-in-differences estimates for A-share listed real-estate developers. The key regressor is the number of red lines violated before the policy interacted with Post, which starts in 2020Q4. Panel A reports formal financing and real-activity outcomes. Net debt issuance, supplier cash, and sales cash are normalized by lagged assets. Panel B reports same-quarter year-over-year changes in working-capital positions, all normalized by lagged assets. Supplier credit is notes payable plus accounts payable. Buyer credit is advance receipts plus contract liabilities. The receivable position is notes receivable, accounts receivable, receivables financing, and contract assets. Net working-capital financing is supplier credit plus buyer credit minus the receivable position and prepayments. All columns include developer fixed effects, calendar-quarter fixed effects, controls, COVID-exposure-by-quarter effects, and pre-policy overbuilding-by-quarter effects. Standard errors are clustered by developer and reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels. Variable definitions are in Appendix Table A1.

firms according to pre-policy red-line violations. The stock-return correlation is estimated using

Table 3 CORRELATES OF EXPOSURE MEASURES

	Coefficient	t-stats	R^2 Decomposition	Obs
Size	0.0232***	8.67	0.08	2567
Leverage	-0.0003	-0.22	0.01	2567
ROA	-0.0033	-0.95	0.01	2567
SOE	0.0591***	11.91	0.08	2567
Sales growth	-0.0007	-1.09	0	2567
Cash flow	-0.0010	-0.36	0.01	2567
EBIT	0.0879	0.75	0.01	2567

NOTE. The table presents the potential correlates of the exposure measure in our sample using linear regressions of the exposure measure on firm characteristics including firm size, leverage, ROA, state ownership, cash flow, and EBIT. T-statistics are reported in the parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

the pre-policy period, which reduces endogeneity concerns. The exposure measure then weights this pre-policy correlation by the number of policy violations, an exogenous source of variation in the policy's impact on real-estate firms.

We also investigate potential firm-level correlates of our exposure measure in 2020Q2 in Table 3. The reported R2s for each variable are additive Shorrocks-Shapley decompositions of the overall R2 of the regression, which reflect the relative importance of each variable in explaining our exposure measure. We find that only firm size and state ownership are statistically positive. We carefully control for these variables in our regressions.

With the exposure variable, our empirical analysis investigates the financial and real effects of the Three-Red-Line policy on non-real-estate firms. Specifically, we estimate the following difference-in-differences specification:

$$y_{it} = \beta * \text{Expo}_i \times \text{Post}_t + \text{Control}_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{2}$$

where y_{it} is either a financial or real outcome for non-real-estate firm i at time t, Expo_i is constructed as in equation (1), Post_t flags the post-policy period centered at August 2020, and Control_{it} includes firm-level controls. We include time and firm fixed effects to absorb common shocks and time-invariant firm heterogeneity. Our key coefficient is β, which captures the spillover effect of the Three-Red-Line policy on non-real-estate firms.

4 Data

We collect data from several sources. Stock returns and balance-sheet information are from China Stock Market & Accounting Research (CSMAR). Bond prices and credit-rating data are from WIND. We also use the 2018 Input-Output table published by the National Bureau of Statistics to construct sector-level measures of upstream and downstream distance to the real-estate sector. Finally, for robustness, we use invoice-level transactions between mainland listed developers and mainland non-real-estate listed firms to construct direct invoice-link exposure measures.

We first exclude firms in the finance and utility sectors, following common practice. We also require firms to satisfy the following conditions: 1) they must be listed at least one year before 2020Q3; 2) they must have information for at least two quarters before or after the policy shock; and 3) their stock status must be labeled as normal, excluding firms such as *ST firms. Our sample consists of 2,609 non-real-estate firms. The distribution of the sample is reported in Appendix Table A2.

We focus on several dependent variables. Abnormal stock returns are constructed by subtracting predicted returns based on a factor model from individual stocks' raw returns, where the factor loadings are estimated using daily returns over the 126 trading days before the event window. Yield spreads are constructed as the daily yield difference between each bond traded on the market and a China Development Bank bond with similar maturity. Corporate investment is measured as total capital expenditure over the past four quarters divided by book assets at the end of the previous quarter. Sales growth is measured as the firm's year-over-year sales growth rate. EBIT is constructed as net income plus interest expense and taxes. Leverage is the book value of debt divided by the book value of total assets at quarter end. We also construct firm-level controls, including firm size, Tobin's Q, cash flow, and ROA. The summary statistics for these variables are provided in Table 4.

5 Empirical Results

5.1 Financial Impacts of the Policy Shock

We start our analysis with the financial impacts of the Three-Red-Line policy, focusing on both stock returns and bond spreads. Because the policy was unexpected, financial-market responses provide useful information about perceived spillover effects. We first estimate the following equation for stock returns in a 10-day window [-5, 4] centered on August 21, 2020.

$$\text{CAR}_{it} = \beta * \text{Expo}_i * \text{Post}_t + \gamma * \text{Control}_i * \text{Post}_t + \alpha_i + \alpha_t + \varepsilon_{it} \tag{3}$$

Table 4 SUMMARY STATISTICS

	Obs	Mean	Std.	25%	Median	75%
Exposure	2,567	0.389	0.114	0.32	0.411	0.479
Capex/Asset (%)	33,404	4.716	5.467	1.374	3.331	6.591
Tobin's Q	33,404	2.33	1.976	1.268	1.758	2.635
Cash Flow (%)	33,404	6.431	9.998	3.09	6.261	10.261
Log (Asset)	33,404	22.423	1.322	21.488	22.233	23.129
Leverage	33,404	3.313	3.705	1.773	2.359	3.607
ROA (%)	33,404	2.63	5.535	0.551	2	4.462
Sales Growth (%)	33,404	17.644	46.862	-6.469	9.844	30.693
EBIT (%)	33,404	3.845	6.533	1.051	2.869	5.79
CAR[-5, 4] (%)	2,567	-0.707	9.366	-5.585	-0.76	3.717
Yield Spread (%)	8,608	1.758	2.993	0.394	0.62	1.361

NOTE. Exposure is constructed as in equation (1). Capex/Asset is capital expenditure divided by lagged total assets. Tobin's Q is the book value of total assets minus the book value of equity plus the market value of equity, scaled by the book value of total assets at the end of the quarter. Cash Flow is income before extraordinary items plus depreciation and amortization divided by book assets, measured at the end of the quarter. Leverage is the book value of debt divided by the book value of total assets measured at the end of the quarter. ROA is net income divided by lagged book assets. Sales Growth is a firm's year-over-year sales growth rate. EBIT is earnings before interest and taxes, calculated as net income plus interest expense and taxes. CAR[-5,4] is the cumulative abnormal stock return over the event window, which starts 5 trading days before the event date (August 20, 2020) and ends 5 trading days after the event, including the event day. The daily abnormal return is generated by subtracting each stock return's loading on market return from its raw return, where the market beta is estimated using the 126 trading days before the event window. Yield Spread is the daily yield difference between each bond traded on the market and a China Development Bank bond with similar maturity.

where CAR_{it} is the cumulative abnormal return for non-real-estate firm i at day t, estimated using three alternative models: the classical CAPM (capital asset pricing model), the FF3 model (Fama and French 1992), and the CH4 model (Liu, Stambaugh, and Yuan 2019). $Expo_i$ is our exposure measure to the policy constructed in (1). We standardize the exposure measure for ease of exposition. $Post_t$ equals one after the policy announcement. We also include $Control_i * Post_t$ to control for different sensitivities to the shock in firm size, ROA, and leverage. We include both firm and time fixed effects. Standard errors are clustered as described in the table notes.

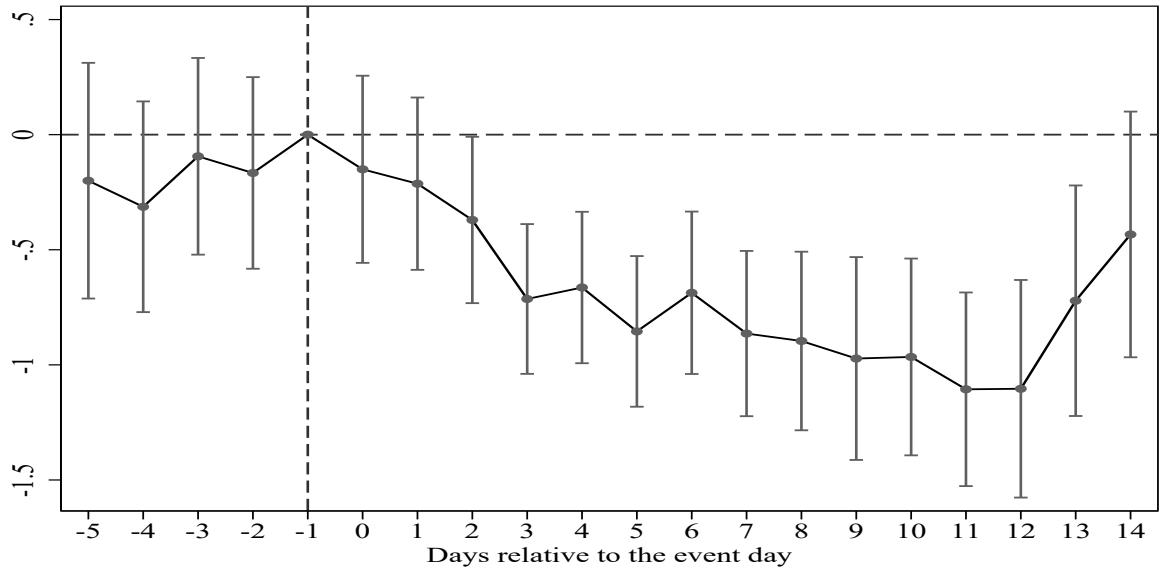
Table 5 presents the estimation results for the policy's spillover effects on stock returns, captured by β, the coefficient on the interaction between our exposure measure and the post dummy. In all specifications, the effects are negative and statistically significant. Using column (2) as an illustration, a one-standard-deviation increase in ex ante exposure to the policy reduces 10-day abnormal stock returns by 0.18%. This suggests that stock returns respond more negatively to the policy for firms more closely related to violating real-estate developers. We also estimate the dynamic effects of the policy to test both the pre-trend assumption for our difference-in-differences estimation and the persistence of the policy shock in Figure 2. We find no significant differential effect before the policy shock. The negative differential effect between high- and low-exposure

Table 5 STOCK RETURN REACTIONS TO THE THREE-RED-LINE POLICY: DIFFERENCE-IN-DIFFERENCES ESTIMATION

	CAPM		FF3		CH4	
	(1)	(2)	(3)	(4)	(5)	(6)
Expo × Post	-0.276***	-0.180***	-0.222***	-0.173***	-0.493***	-0.336***
	(-4.85)	(-3.45)	(-4.16)	(-3.42)	(-8.82)	(-6.24)
Ln (Asset) × Post		-0.410***		-0.208***		-0.472***
		(-5.68)		(-2.97)		(-6.09)
ROA × Post		0.010		0.024**		0.023**
		(1.03)		(2.42)		(2.29)
Leverage × Post		0.010**		0.009**		0.005
		(2.50)		(2.25)		(1.25)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.65	0.65	0.65	0.65	0.65	0.65
Obs.	33,558	33,558	33,558	33,558	33,588	33,588

NOTE. The table reports the difference-in-difference estimation of stock price reactions to the three red-lines policy on 08/20/2020 (day 0). The sample period is from 08/13/2020 to 08/26/2020 and includes 3,355 A-share listed firms. The *Expo* measure is constructed as in equation (1), and normalized by its standard deviation. The dummy *Post* equals one from 08/20/2020. The dependent variables are 10-day cumulative abnormal returns (CAR [-5, 4]) based on CAPM in columns (1)-(2), Fama-French 3-factor model (FF3) in columns (3)-(4), and CH 4-factor model in columns (5)-(6). CARs are estimated using a 126-day window with a minimum observation requirement of 100 days. Firm-level variables on assets, ROA, and leverage are constructed using the balance sheet information in 2020 Q2. Both stock and day fixed effects are included. Standard errors are clustered by industry and date and t-statistics are reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Figure 2 DYNAMIC EFFECTS ON STOCK RETURNS



NOTE. The figure estimates the dynamic effects of the Three-Red-Line policy on stock returns, i.e., $\text{CAR}_{it} = \alpha + \sum_{s=-5}^{14} \beta_s * \text{Expo}_i * 1_{t+s} + \gamma * \text{Control}_{it} + \alpha_i + \alpha_t + \varepsilon_{it}$. The coefficients $\{\beta_s\}_{-5}^{14}$, along with the 95 c.i., are displayed.

firms appears only after the policy and persists until day 14.

Similarly, we estimate the spillover effects on bond spreads. Stock returns and bond spreads may provide different information about the policy's impact. Because bond trading is less frequent than stock trading, we estimate the following equation in a 180-day window [-90, 90] centered on August 21, 2020.

$$\text{Spread}_{it} = \beta * \text{Expo}_i * \text{Post}_t + \text{Control}_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{4}$$

where Spread_{it} is the yield difference between the yield of bond i traded on day t and the yield of China Development Bank bond traded on the same day with the same remaining maturity and Control_{it} includes standard controls such as the firm size, ROA, leverage, maturity, and trading volume. We estimate the equation (4) at both the individual bond level and issuer (firm) level and thus include fixed effects at different levels such as credit rating, issuers, bonds, and days. Standard errors are clustered at the firm level.

Table 6 presents the average spillover effects on bond spreads. In all specifications, bond spreads rise more for firms more exposed to violating real-estate developers, as captured by the positive coefficient on the interaction between the exposure measure and the post dummy. The effect is both statistically and economically significant. Using column (2) as an illustration, a one-standard-deviation increase in ex ante exposure to the policy increases the daily bond spread by 33

Table 6 BOND SPREAD REACTIONS TO THE THREE-RED-LINE POLICY: DIFFERENCE-IN-DIFFERENCES ESTIMATION

	(1)	(2)	(3)	(4)
Expo × Post	0.322***	0.333***	0.298***	0.266***
	(3.91)	(3.95)	(7.51)	(6.30)
Expo	0.418***	0.252***		
	(8.81)	(5.05)		
Post	-0.851**	-1.260***		
	(-2.19)	(-2.97)		
Ln (Asset)		0.072		
		(1.25)		
ROA		-0.217***		
		(-8.22)		
Leverage		0.010*		
		(1.89)		
Maturity		-0.412***	-0.431***	-0.720***
		(-8.62)	(-10.30)	(-4.70)
Ln (Trading Volume)		-2.503***	0.221***	0.628***
		(-24.11)	(3.52)	(8.22)
Credit Rating FE	Yes	Yes	Yes	Yes
Issuer FE	No	No	Yes	No
Bond FE	No	No	No	Yes
Date FE	No	No	Yes	Yes
Adj. R^2	0.12	0.27	0.85	0.91
Obs.	9,085	9,085	9,083	9,076

NOTE. The table reports the secondary bond-market yield-spread reaction to the Three-Red-Line policy on 08/20/2020 during the three months before and after the policy. The regression is conducted at the bond level. The regression sample includes 808 bonds issued by 271 A-share listed firms and traded on the secondary bond market during the sample period. The *Expo* measure is constructed as in equation (1) and normalized by its standard deviation. The dummy *Post* equals one from 2020/08/20. The dependent variable is the daily bond yield spread, calculated as the yield difference between bonds in the regression sample and bonds with the same remaining maturity issued by the China Development Bank. Firm-level variables on assets, ROA, and leverage are constructed using balance-sheet information in 2019Q4. Standard errors are clustered by issuer and date, and t-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

basis points.

The spillover effect estimated from the financial market captures the perception of investors within a short period of the policy announcement. However, as time goes on, there might be more effects from the policy which will not be captured by the financial market response. For example, investment slowly responds to policy shocks, which might manifest itself over the years. For this reason, we explore the real effects of the policy shock next.

5.2 Real Effects of the Policy Shock

We estimate the real effects in a 12-quarter window as it takes time for the real effect to materialize. Our focus is the corporate investment but we also look at other real variables such as sales growth, earnings, and leverage. Specifically, we estimate the following equation in the quarterly frequency data at [-4Q, 8Q].

$$y_{it} = \beta * \text{Expo}_i * \text{Post}_t + \text{Control}_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \tag{5}$$

where y_{it} is the corporate investment (Capex/Asset), sales growth, EBIT, and leverage respectively. Expo_i is our exposure measure to the policy constructed in (1). We standardize the exposure measure for ease of exposition. Post_t equals one for quarters after 2020 Q4. Control_{it} includes standard controls such as the firm size, ROA, leverage, Tobin's Q, and cash flow. In addition to firm fixed effects, we also include interactive fixed effects between different size bins and time to control for the different trend growth of large and small firms. We also include an interactive fixed effect between industry and time to control for the different time trends across industries. To control for the contemporaneous effect of COVID-19-related news, we add an interactive fixed effect between a COVID-19 CAR and time, where the COVID-19 CAR is estimated in a 7-day window around the Wuhan lockdown. Standard errors are clustered at the firm level.

Table 7 presents the real spillover effects of the Three-Red-Line policy. Consistent with the financial-market response, firms more exposed to the real-estate sector have lower investment, sales growth, and profits, but higher leverage. The effects are both statistically significant and economically important. A one-standard-deviation increase in exposure to the policy reduces real investment by 0.29%, as in column (3), sales growth by 2.20%, and corporate profits by 0.23%, but increases leverage by 0.21%.

We also estimate the dynamic effects of the policy to test both the pre-trend assumption for our difference-in-differences estimation and the persistence of the policy shock in Figure 3. We find no significant differential effect before the policy shock. The negative differential effect between high- and low-exposure firms appears only after the policy and lasts for eight quarters.

We also explore the robustness of our results using invoice-level data to construct pre-shock links between mainland listed developers and mainland non-real-estate listed firms, rather than relying on stock-return correlations. Using these invoice-level transactions, we replace the stock-return-based exposure measure with three invoice-based alternatives: an equal-weighted measure of links to violating developers, a value-weighted measure that weights links by transaction values, and an indicator for whether a firm has any link to a violating developer. The results are consistent with the baseline stock-return specification, as reported in Appendix Table A3.

We have documented a significant negative effect of the policy shock on corporate investment. The difference-in-differences estimation compares the differential impact on high- versus

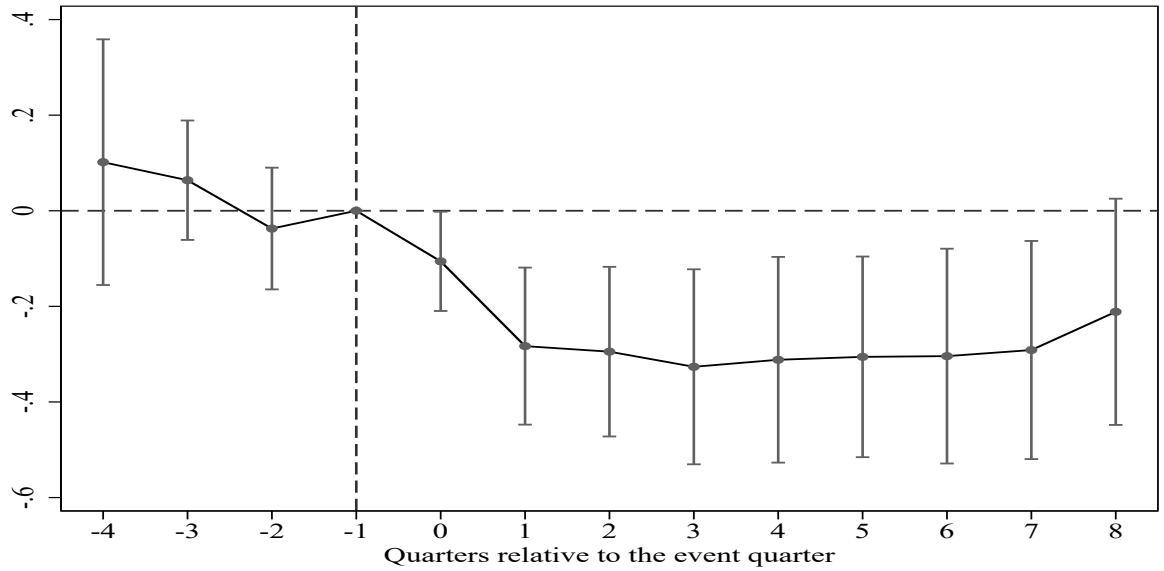
Table 7 REAL EFFECTS OF THE THREE-RED-LINE POLICY: DIFFERENCE-IN-DIFFERENCES ESTIMATION

	Capex /Asset			Sales Growth (%)	EBIT (%)	Leverage
	(1)	(2)	(3)	(4)	(5)	(6)
Expo × Post	-0.423***	-0.432***	-0.291***	-2.204**	-0.229**	0.208***
	(-4.91)	(-4.87)	(-3.47)	(-2.04)	(-2.01)	(5.34)
Size			1.360***	51.351***	-0.815	-0.838***
			(3.61)	(10.03)	(-0.55)	(-6.23)
ROA			-0.01	2.949***		0.019***
			(-1.24)	(19.03)		(5.24)
Leverage			-0.248***	-5.261***	0.110	
			(-6.29)	(-9.73)	(0.88)	
Tobin's Q			0.221***	2.491***	1.222***	-0.029
			(4.48)	(3.74)	(7.97)	(-1.42)
Cash Flow			0.023***			
			(3.20)			
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Size Growth × Time	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Time	No	Yes	Yes	Yes	Yes	Yes
Covid CAR × Time	No	No	Yes	Yes	No	Yes
Adj R^2	0.69	0.69	0.70	0.41	0.43	0.86
Obs	33,522	33,522	33,404	33,202	33,404	33,404

NOTE. The table reports the real impact of the Three-Red-Line policy on firm investment, sales growth, profitability, and leverage. The sample period is from 2019Q3 to 2022Q3 and includes 2,609 A-share listed firms. The *Expo* measure is constructed as in equation (1) and normalized by its standard deviation. The dummy *Post* equals one from 2020Q4. *Capex/Asset* is measured as capital expenditure over the trailing 12 months, normalized by total assets at the end of the previous quarter. *Sales Growth* is measured as year-over-year sales growth at each quarter end. *EBIT* is measured as net income plus interest and taxes, normalized by total assets at the end of the previous quarter. *Size Growth* measures the average total asset growth rate over 12 quarters before 2020Q3. *Covid CAR* is the cumulative abnormal return (CAR [-10, 9]) centered at the outbreak of Covid-19 in China (Wuhan lockdown) on January 23, 2020, based on the Fama-French 3-factor model and estimated using a 126-day window. Standard errors are clustered by firm, and t-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

low-exposure firms. How large is the aggregate effect of the policy? Answering this question is important yet challenging. We make progress following Mian and Sufi (2012). First, we divide firms into deciles based on Three-Red-Line policy exposure and treat the lowest decile as the control group. We then multiply the dynamic coefficients by the difference between each decile's exposure and the control group's exposure. This gives the differential effect of the policy on corporate investment, assuming that low-exposure firms are not affected by the policy. This is a conservative estimate because low-exposure firms may also be affected by the policy. We next convert the foregoing estimate, multiplied by lagged assets, into RMB values and sum across all deciles for each quarter. This gives an estimate of the cumulative decline in investment due to the Three-Red-Line policy of 390.54 billion RMB.

Figure 3 DYNAMIC EFFECTS ON CORPORATE INVESTMENT



NOTE. The figure reports $I_{it} = \alpha + \sum_{s=-4}^{8} \beta_s * \text{Expo}_i * 1_{t+s} + \gamma * \text{Control}_{it} + \alpha_i + \alpha_t + \varepsilon_{it}$. The coefficients $\{\beta_s\}_{-4}^{8}$, along with the 95 c.i., are displayed.

How large is the investment decline compared to overall investment behavior in China? To answer this question, we estimate overall investment dynamics during the same period. We first compute the average quarterly growth rate of investment, 3.84%, for the same non-real-estate firms during 2017Q3–2020Q3, the pre-policy period. We then use 3.84% as the counterfactual trend growth rate of investment during 2020Q4–2022Q3. The difference between actual and counterfactual investment is the overall investment decline, which is 923.118 billion RMB. Based on this calculation, the investment decline due to the Three-Red-Line policy is 42.31% (=390.536/923.118) of the overall investment decline during the same period.

6 Inspecting the Economic Mechanism

How does the Three-Red-Line policy affect non-real-estate firms? We investigate this question through heterogeneity analysis. Specifically, we estimate the investment response to the Three-Red-Line policy across different firm groups.

$$I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_{g} \beta_{t+s}^{g} 1_{g \in G} \right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it} \tag{6}$$

We divide firms into multiple groups based on their pre-policy characteristics. We consider

four dimensions: production networks, external-financing dependence, financial constraints, and ownership structure.

Non-real-estate firms can be affected by the Three-Red-Line policy through production networks. Real-estate firms play an important role in the Chinese economy because they are connected to both upstream and downstream firms. Our estimated spillover effects could therefore be explained by production-network links. To capture this channel, we construct production-network measures using the 2018 Input-Output table as follows. For sector i, its upstream distance to real estate is measured by $\text{Up}_i = \frac{y_{i,\text{RE}}}{\sum_k y_{i,k}}$, where y_{ik} is output supplied by sector i to sector k. Correspondingly, sector i's downstream distance to real estate is measured by $\text{Down}_i = \frac{y_{\text{RE},i}}{\sum_k y_{k,i}}$.

We divide firms into two groups based on their upstream or downstream distance to the real-estate sector. Upstream-high sectors include construction design, construction, and construction materials, while downstream-high sectors include housing sales, room decoration, and property management (see Figure 4).

Figure 4 presents the dynamic effects of the policy shock on the corporate investment of non-real-estate firms based on their distance to the real-estate sector. The spillover effects are concentrated among firms in sectors closer to real estate, either upstream or downstream, consistent with production-network transmission.

We also explore firm heterogeneity by external-financing dependence (EFD). We construct the EFD measure following Rajan and Zingales (1998) and report the estimation in Figure 5. The spillover effect is concentrated among high-EFD firms.

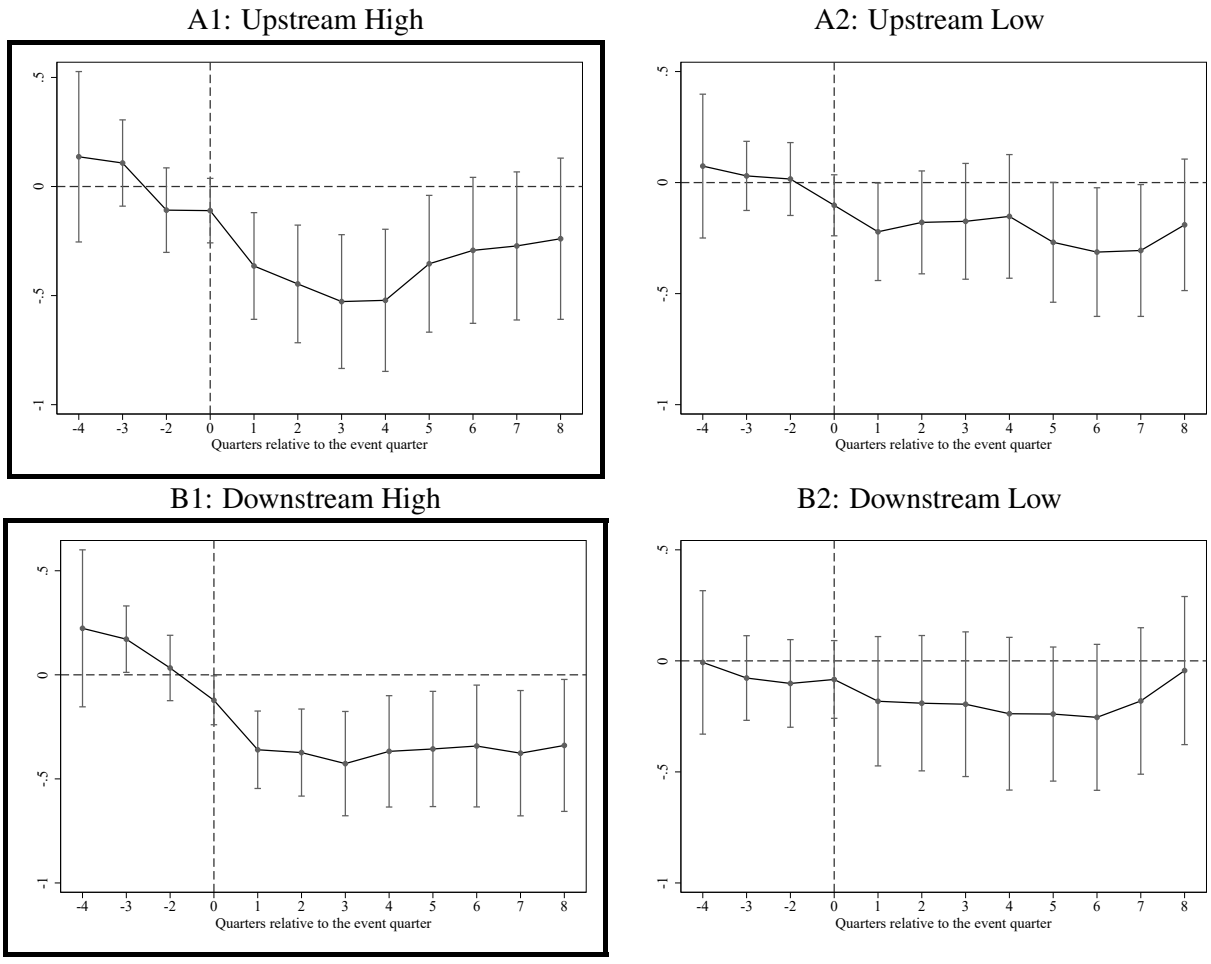
To explore the role of financial constraints, we group firms using the WW index of Whited and Wu (2006) and the SA index of Hadlock and Pierce (2010). Figure 6 presents the estimation results. These standard financial-constraint indexes do not display the same pattern as production-network distance or external-financing dependence, suggesting that our spillover effects are not driven by broad measures of long-term financing constraints.

One unique feature of Chinese firms is their ownership structure. We group firms into private and state-owned firms and conduct the difference-in-differences estimation in Figure 7. The spillover effects are concentrated among private firms. State-owned firms, by contrast, are not significantly affected by the Three-Red-Line policy.

Because production-network distance, external-financing dependence, and state ownership all matter, we also conduct a horse-race test to assess whether they capture the same information. Specifically, we group firms into four cells based on whether they are in high- or low-distance sectors relative to real estate and whether they have high or low EFD, or private versus state ownership. We do not include the financial-constraint measures because they do not appear to explain our spillover effects, as shown in Figure 6.

We delegate the detailed analysis to the Appendix to save space. The key message is that the

Figure 4 DOWNSTREAM AND UPSTREAM

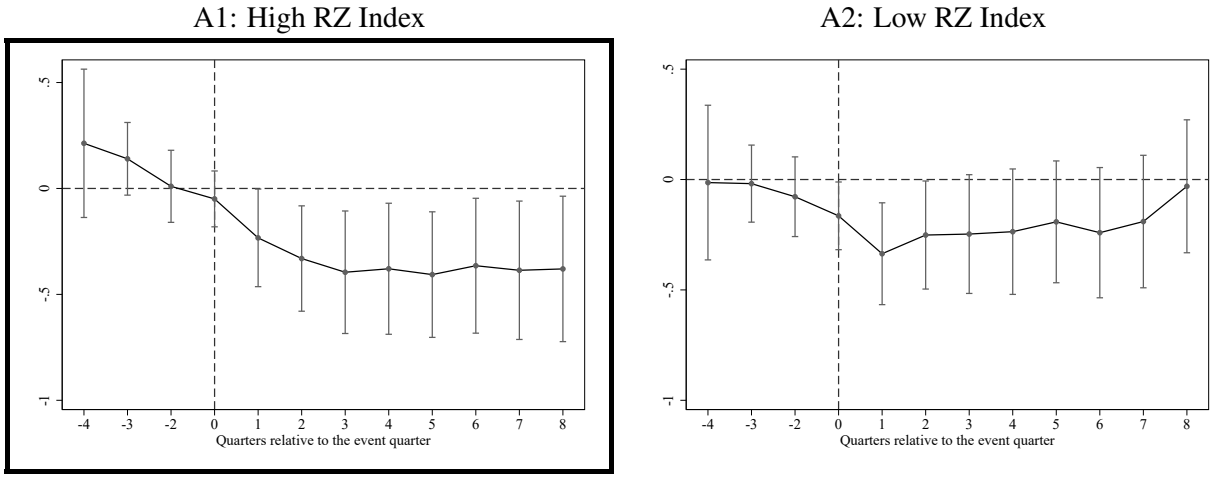


NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A1 and A2 group firms based on the upstream distance to the RE sector, Up_i and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for upstream high and upstream low groups respectively. Panel B1 and B2 group firms based on the downstream distance to the RE sector, Down_i and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for downstream high and downstream low groups respectively.

results are strongest for firms in sectors close to real estate and for firms with high EFD or private ownership. In particular, firms with high upstream or downstream distance to the real-estate sector and high EFD or private ownership are more affected by the Three-Red-Line policy.

How can we rationalize these results? We conjecture that when real-estate firms reduce leverage because of the policy, they affect non-real-estate firms through a trade-credit channel. Because trade credit operates through the production network, firms closer to the real-estate sector, either upstream or downstream, should be more affected. To test this hypothesis, we construct a firm-level measure of net trade credit, $\text{TC}_i \equiv \frac{\text{Account Receivables} + \text{Pre-paid Sales} - \text{Account Payables}}{\text{Asset}}$, following Cun et al. (2022). We estimate our dynamic effects by grouping firms based on production-network distance and the net trade-credit measure in Figures 8 and 9. Consistent with our prior, firms closer to real

Figure 5 External Financing Dependence



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A1 and A2 group firms based on the EFD measure as in Rajan and Zingales (1998) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for EFD high and EFD low groups respectively.

estate in the production network and with higher net trade credit are more affected by the policy shock.

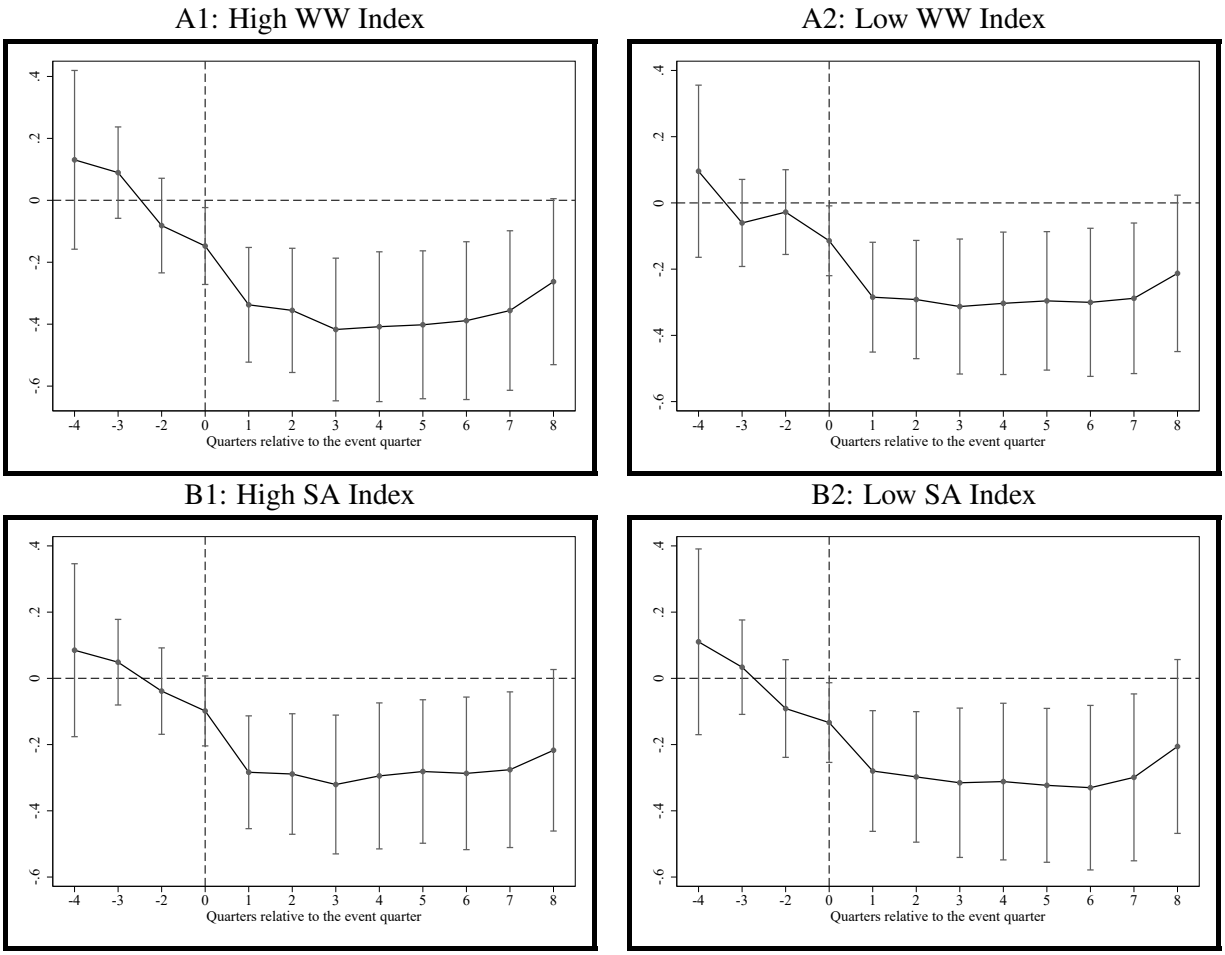
Why do external-financing dependence and ownership matter more than standard financial-constraint indexes? We conjecture that the answer lies in the nature of the shock. The Three-Red-Line policy affects non-real-estate firms through production-network links and tightens short-term cash flow for upstream and downstream firms, creating a working-capital constraint. This interpretation is consistent with our results on external-financing dependence, private firms, and trade-credit measures. Standard financial-constraint indexes may matter less because they capture the difficulty of raising funds for long-term investment rather than short-term working-capital pressure.

7 A Framework for Real-Estate Spillovers

Appendix Section A develops a simple framework to interpret the empirical results. The model is not intended to provide a complete quantitative description of the Chinese economy. Its purpose is narrower: it clarifies how a financing shock that originates in real-estate developers can affect firms that are not directly regulated by the Three-Red-Line policy.

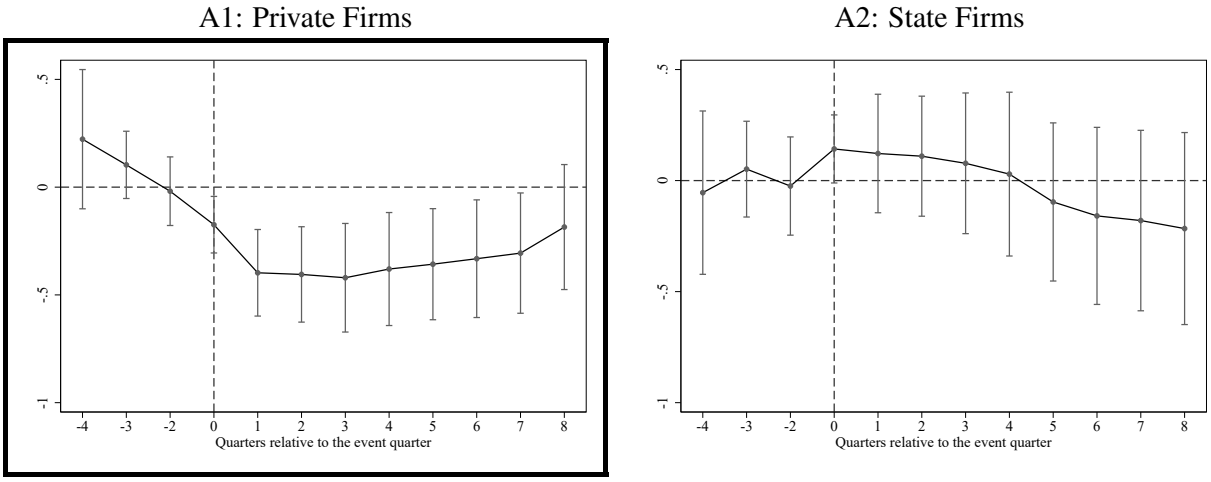
The economy has a real-estate sector and a non-real-estate sector connected through input-output relationships and trade credit. Developers use capital and intermediate goods supplied by non-real-estate firms. They finance these purchases with intra-period borrowing and can also delay part of their payments to suppliers through trade credit. The Three-Red-Line policy is represented

Figure 6 FINANCIAL CONSTRAINT



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A1 and A2 group firms based on the WW-index in Whited and Wu (2006) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for high and low WW index groups respectively. Panel B1 and B2 group firms based on the SA-index in Hadlock and Pierce (2010) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for high and low SA index groups respectively.

Figure 7 STATE OWNERSHIP



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A1 and A2 group firms based on the state ownership and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. for private and state firms respectively.

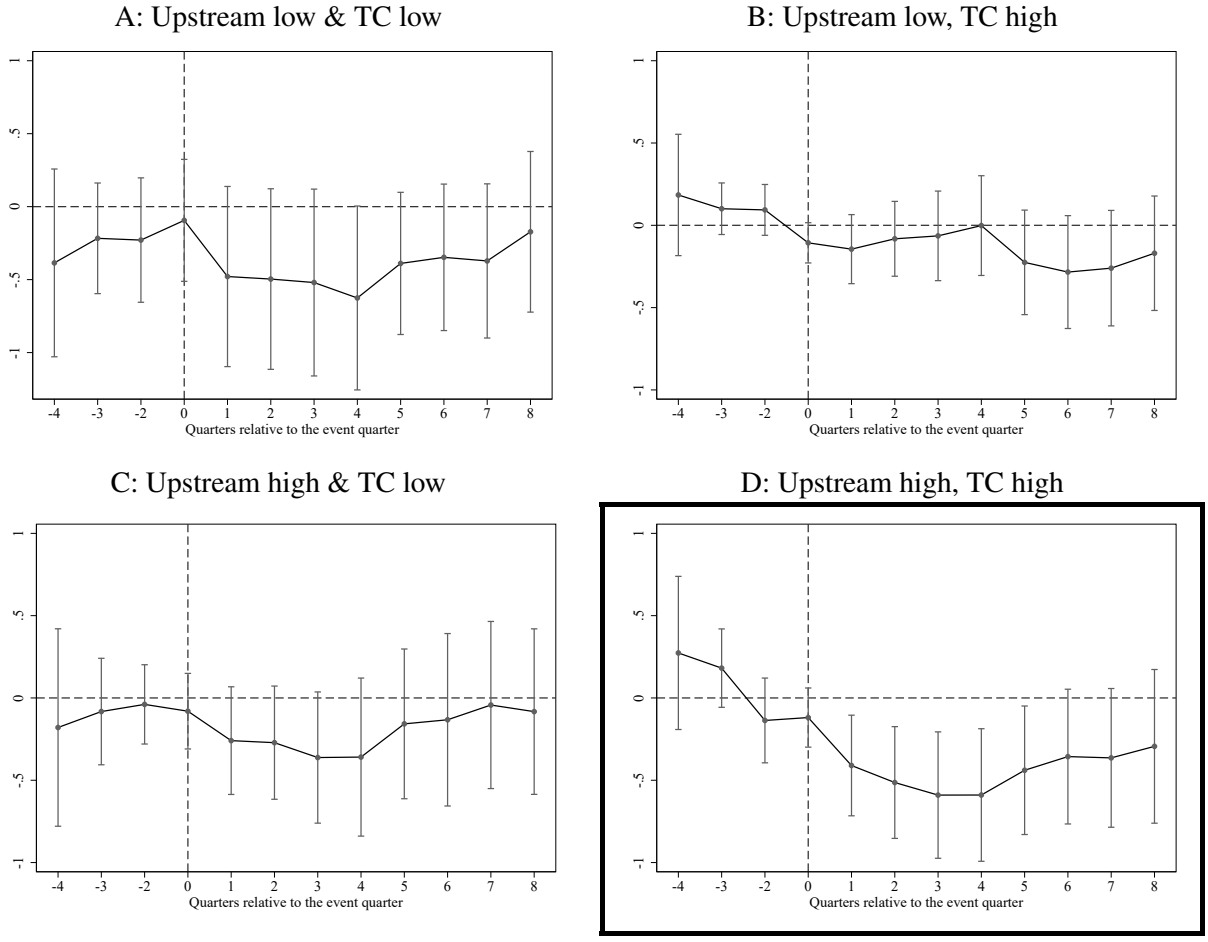
as a tightening of developers' borrowing capacity. When this constraint tightens, developers reduce capital and intermediate-input demand. They also have stronger incentives to rely on trade credit because delayed payments reduce the amount of cash that must be paid up front.

This creates a spillover to non-real-estate firms. In the model, non-real-estate firms rely on current cash receipts from real-estate customers to finance capital and wage bills. A developer financing shock therefore affects these firms through two related margins. First, weaker developer activity lowers demand for their goods and services. Second, greater reliance on trade credit reduces current cash receipts from developers. Both margins tighten the working-capital position of connected firms and can reduce their own investment.

The model yields two predictions that organize the empirical evidence. Proposition 1 shows that a tighter developer borrowing constraint lowers activity in both the real-estate and non-real-estate sectors. Proposition 2 shows that, under a linear trade-credit cost, the non-real-estate response is stronger when the sector is more closely linked to real estate. This result gives a simple foundation for the production-network heterogeneity tests in Section 6: firms in sectors closer to real estate should respond more negatively to the same developer shock.

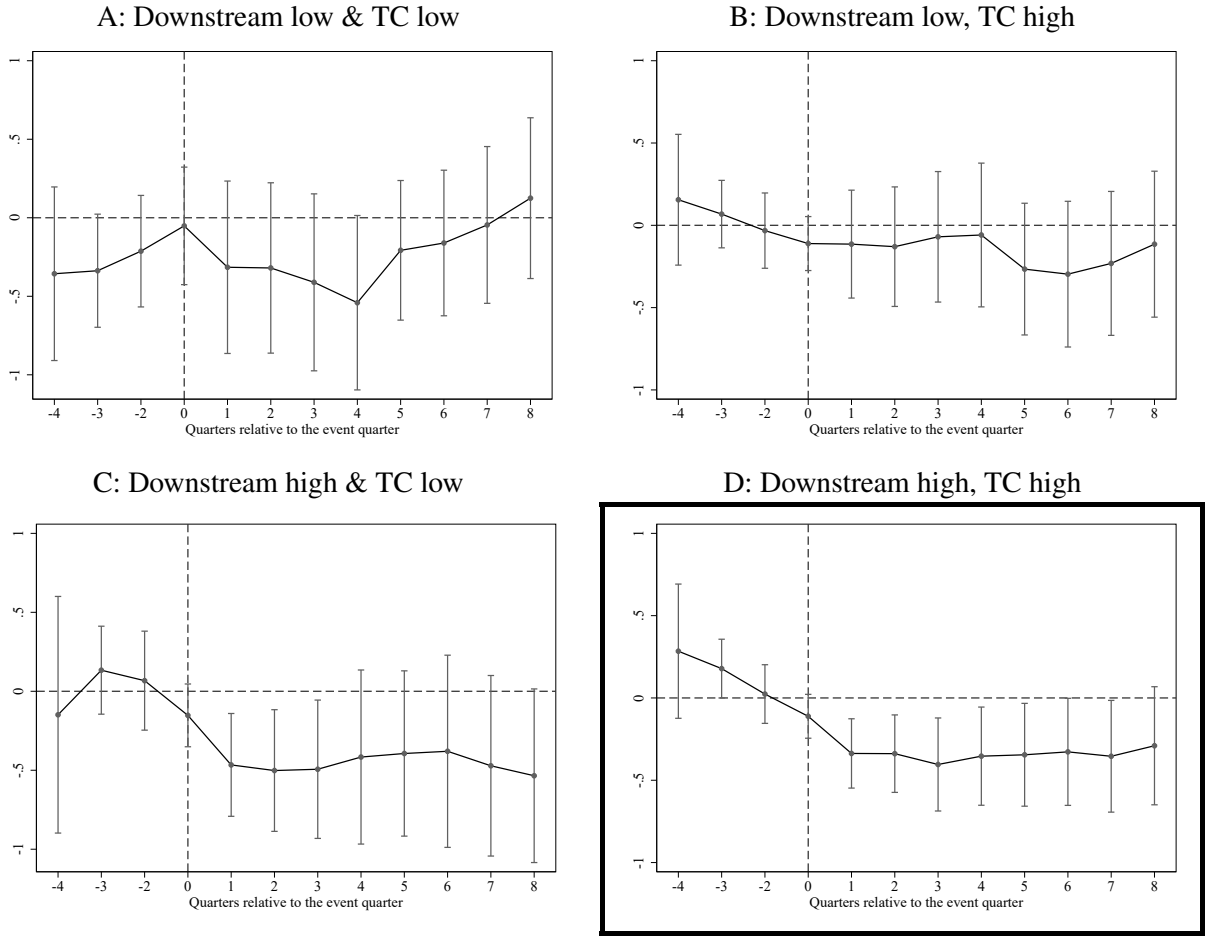
The framework also helps interpret the exposure measure used in the main empirical design. The baseline exposure measure uses stock-return correlations because it can capture broader connections to both mainland and Hong Kong-listed developers. The invoice-link measures provide a more direct but narrower validation of business relationships. In the model, both measures are proxies for the same economic object: the extent to which a non-real-estate firm is exposed to constrained developers before the policy shock.

Figure 8 Upstream Distance to the RE Sector and Trade Credit



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G} \right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the upstream distance to the RE sector and the net trade credit and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure 9 Downstream Distance to the RE Sector and Trade Credit



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the downstream distance to the RE sector and the net trade credit and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Finally, the framework rationalizes the liquidity patterns in the mechanism tests. If firms must finance investment before receiving future returns, payment delays and reduced cash receipts are more costly for firms with weaker working-capital positions, high external-financing dependence, or less access to state-related financial support. The empirical patterns in Section 6 are consistent with this interpretation: the investment response is stronger for firms in sectors closer to real estate and for firms more exposed to working-capital or financing frictions. Thus, the model links the main spillover estimates to two reinforcing channels: real input-output exposure and liquidity pressure through trade credit.

Our hypothesized mechanism also has implications for credit demand. When the Three-Red-Line policy hits real estate, other sectors are negatively affected and reduce their demand for credit. A credit-supply story is also possible: banks may anticipate that firms closer to real estate are more affected and reduce credit supply to those firms. We differentiate these two channels by investigating the policy effects on both interest rates and debt. The response of interest rates is key: lower credit demand reduces interest rates, while lower credit supply increases interest rates. Table 8 presents the estimation results. Interest rates fall after the Three-Red-Line policy, especially for firms closer to the real-estate sector. Debt also falls, which is consistent with both credit-supply and credit-demand channels. The response of interest rates therefore suggests that our documented effects are more likely driven by the credit-demand channel than by the credit-supply channel.

Table 8 EFFECTS OF THE THREE-RED-LINE POLICY ON INTEREST RATES AND DEBT: DIFFERENCE-IN-DIFFERENCES ESTIMATION

	Interest Rate (%)		Debt/Liability (%)	
	(1)	(2)	(3)	(4)
Expo × Post	-0.125**	-0.136**	-1.121***	-0.461*
	(-2.01)	(-2.23)	(-4.41)	(-1.80)
Size		-0.388**		-1.961**
		(-2.13)		(-1.99)
ROA		-0.042***		-0.293***
		(-5.73)		(-9.66)
Leverage		0.088**		-3.244***
		(2.50)		(-8.00)
Tobin's Q		-0.063*		-0.207
		(-1.92)		(-1.25)
Cash Flow		0.014***		0.068***
		(2.93)		(2.87)
Firm FE	Yes	Yes	Yes	Yes
Size Growth × Time	Yes	Yes	Yes	Yes
Industry × Time	No	Yes	No	Yes
Covid CAR × Time	No	Yes	No	Yes
Adj. R^2	0.69	0.70	0.69	0.70
Obs	28,191	28,060	33,404	33,404

NOTE. The table reports the impact of the Three-Red-Line policy on firm interest rates and debt. The sample period is from 2019Q3 to 2022Q3 and includes 2,609 A-share listed firms. The Expo measure is constructed as in equation (1) and normalized by its standard deviation. The dummy Post equals one from 2020Q4. Interest rates are measured as interest expense divided by the average of short- and long-term debt from the beginning to the end of the quarter. Debt is measured as the sum of short- and long-term debt normalized by total liabilities in the previous quarter. Size growth measures the average total asset growth rate over 12 quarters before 2020Q3. Covid CAR is the cumulative abnormal return (CAR [-10, 9]) centered on the outbreak of Covid-19 in China (Wuhan lockdown) on January 23, 2020, based on the Fama-French 3-factor model and estimated using a 126-day window. Standard errors are clustered by firm, and t-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels.

8 Conclusion

In this paper, we study spillovers from real estate to non-real-estate sectors using an important Chinese policy announcement: the Three-Red-Line policy regulating real-estate developers. We find that the policy had unintended negative impacts on both financial markets and the real economy.

Our documented spillover effects are economically significant, accounting for 42.31% of the aggregate investment decline during 2020Q4–2022Q3. The spillover effect transmits through production networks. Sectors closer to real estate, either upstream or downstream, experience sharper declines in investment. Moreover, firms with larger trade-credit exposure are more affected.

Our paper has important policy implications because it documents an unintended consequence of sectoral regulatory policies. The simple framework in the paper rationalizes the empirical results through production-network and working-capital channels. A useful follow-up is to ask whether similar exposure measures can be constructed at the regional level to study local real effects, but that question is beyond the scope of this paper.

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Internet Appendix

‘The Spillover Effects of Real Estate Sector’

(Intended for online publication only)

by K. Chen, H. Du, and C. Ma

June 2026

Table A1. VARIABLE DEFINITIONS

Variable	Sample	Definition
Panel A. Policy and exposure variables		
Violation count	Developers	Number of Three-Red-Line thresholds violated before the policy announcement. The thresholds are liability/assets excluding advance proceeds below 70 percent, net debt/equity below 100 percent, and cash/short-term debt above 100 percent.
Post	All regressions	Indicator equal to one from 2020Q4 onward. The policy was announced in 2020Q3, which is the omitted announcement quarter in the event-study specifications.
Invoice EW exposure	Non-real-estate firms	Average red-line violation count among developers linked to firm *i* in the pre-policy invoice data. The value is set to zero for firms with no observed developer invoice link.
Invoice VW exposure	Non-real-estate firms	Invoice-value-weighted average red-line violation count among linked developers, using pre-policy transaction values as weights.
Stock-return exposure	Non-real-estate firms	Pre-policy stock-return comovement with listed real-estate developers interacted with developer violation intensity. We construct separate measures for all, mainland, and Hong Kong developer sets.
Panel B. Developer outcomes		
IBL growth	Developers	Year-over-year growth in interest-bearing liabilities. IBL equals short-term borrowing, one-year noncurrent liabilities due within one year, long-term borrowing, bonds payable, and lease liabilities.
ΔIBL/A	Developers	Same-quarter year-over-year change in IBL scaled by previous-year same-quarter total assets.
Net debt issuance/A	Developers	Cash received from borrowing plus cash received from bond issuance minus cash paid to repay debt, scaled by lagged assets.
Inventory growth	Developers	Same-quarter year-over-year growth in inventory.
ΔInventory/A	Developers	Same-quarter year-over-year change in inventory scaled by previous-year same-quarter total assets.

Variable	Sample	Definition
Supplier cash/A	Developers	Cash paid to suppliers and employees for goods and services, scaled by lagged assets. In CSMAR this uses C001014000.
Sales cash/A	Developers	Cash received from sales of goods and services, scaled by lagged assets. In CSMAR this uses C001001000.
Supplier credit/A	Developers	Notes payable plus accounts payable, scaled by lagged assets.
Buyer credit/A	Developers	Advance receipts plus contract liabilities, scaled by lagged assets. This measures financing received from customers, including presale-related liabilities.
Receivable position/A	Developers	Notes receivable, accounts receivable, receivables financing, and contract assets, scaled by lagged assets.
Net WC financing/A	Developers	Supplier credit plus buyer credit minus receivable position minus prepayments, scaled by lagged assets.
Panel C. Non-real-estate outcomes and controls		
Investment	Non-real-estate firms	Trailing-four-quarter capital expenditure divided by lagged total assets, multiplied by 100.
Size	All firm regressions	Natural logarithm of total assets.
ROA	Non-real-estate firms	Return on assets, multiplied by 100.
Leverage	Non-real-estate firms	Total liabilities divided by total assets, multiplied by 100.
Tobin's Q	Non-real-estate firms	Market-value proxy divided by total assets.
Cash flow/A	All firm regressions	Operating cash flow scaled by lagged assets, multiplied by 100.
Lagged net trade credit/A	Non-real-estate firms	Accounts receivable minus accounts payable, scaled by lagged assets and lagged one quarter.
COVID exposure	All firm regressions	Firm-level stock-market exposure to the COVID shock used in the replication code; interacted with calendar-quarter fixed effects in the main specifications.
Oversupply	Developer regressions	Pre-policy overbuilding measure based on developers' pre-policy inventory-growth histories; interacted with calendar-quarter fixed effects.
Panel D. Mechanism variables		

Variable	Sample	Definition
IO closeness	Non-real-estate firms	$Up_j + Down_j$, where Up_j is the share of sector j's intermediate sales absorbed by real estate and $Down_j$ is the share of sector j's intermediate purchases bought from real estate. High IO equals one for above-median IO closeness.
Working-capital buffer	Non-real-estate firms	Receivable and prepayment items minus payable and advance-receipt items, scaled by lagged assets. Weak working capital equals one for below-median pre-policy buffer.
Private firm	Non-real-estate firms	Indicator for non-state ownership.
Interactive fixed effects	Non-real-estate firms	Sector, size-bin, leverage-bin, ownership, and COVID-exposure group interacted with calendar-quarter fixed effects. Size and leverage bins are formed from pre-policy distributions.

NOTE. A denotes lagged total assets unless otherwise stated. Income-statement and cash-flow variables from CSMAR quarterly reports are converted from year-to-date values into current-quarter flows: Q1 uses the reported YTD value, and Q2–Q4 use the difference from the previous quarterly report within the same fiscal year. Growth rates and scaled variables are winsorized at the 1st and 99th percentiles in the estimation files.

Table A2 FIRM DISTRIBUTION IN OUR SAMPLE

Year-Quarter	Time	# of firms
2019Q3	-4	2558
2019Q4	-3	2607
2020Q1	-2	2568
2020Q2	-1	2570
2020Q3	0	2567
2020Q4	1	2567
2021Q1	2	2567
2021Q2	3	2544
2021Q3	4	2573
2021Q4	5	2578
2022Q1	6	2579
2022Q2	7	2559
2022Q3	8	2567

Figure A1 UPSTREAM AND DOWNSTREAM

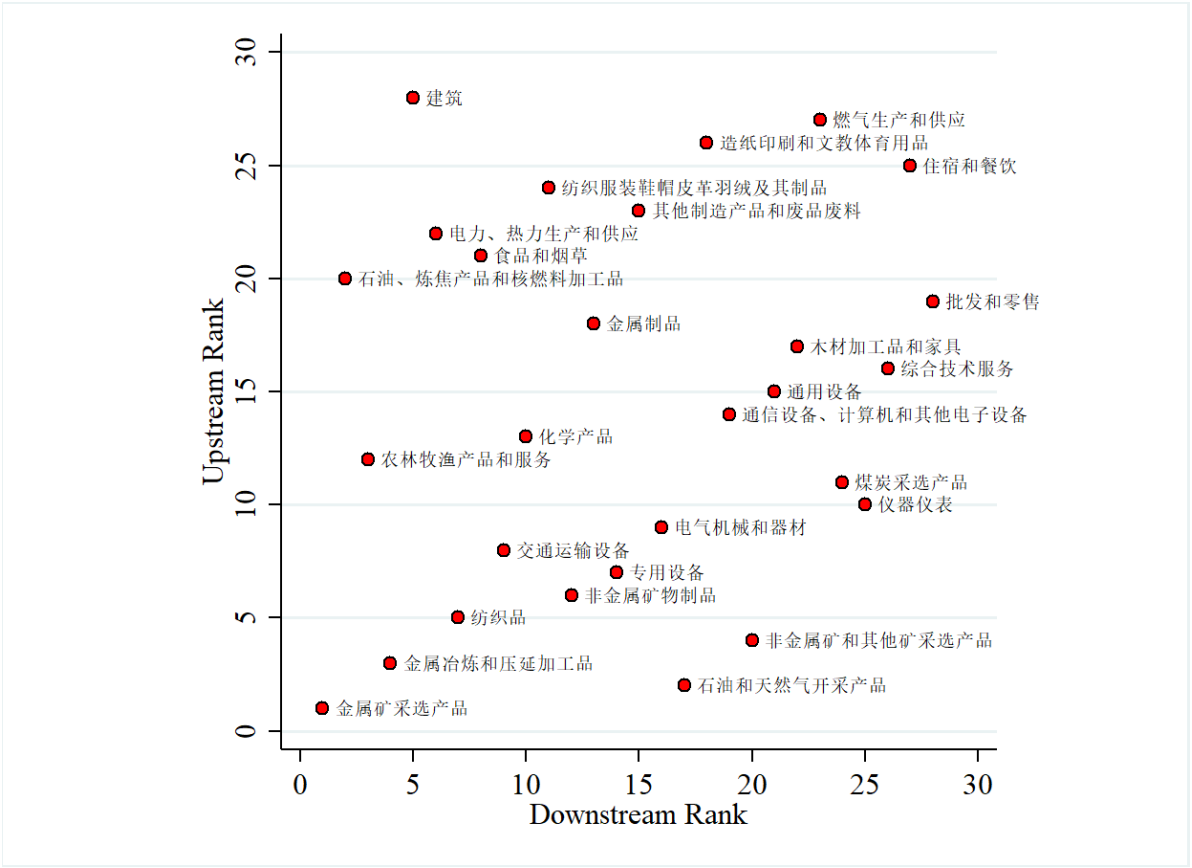
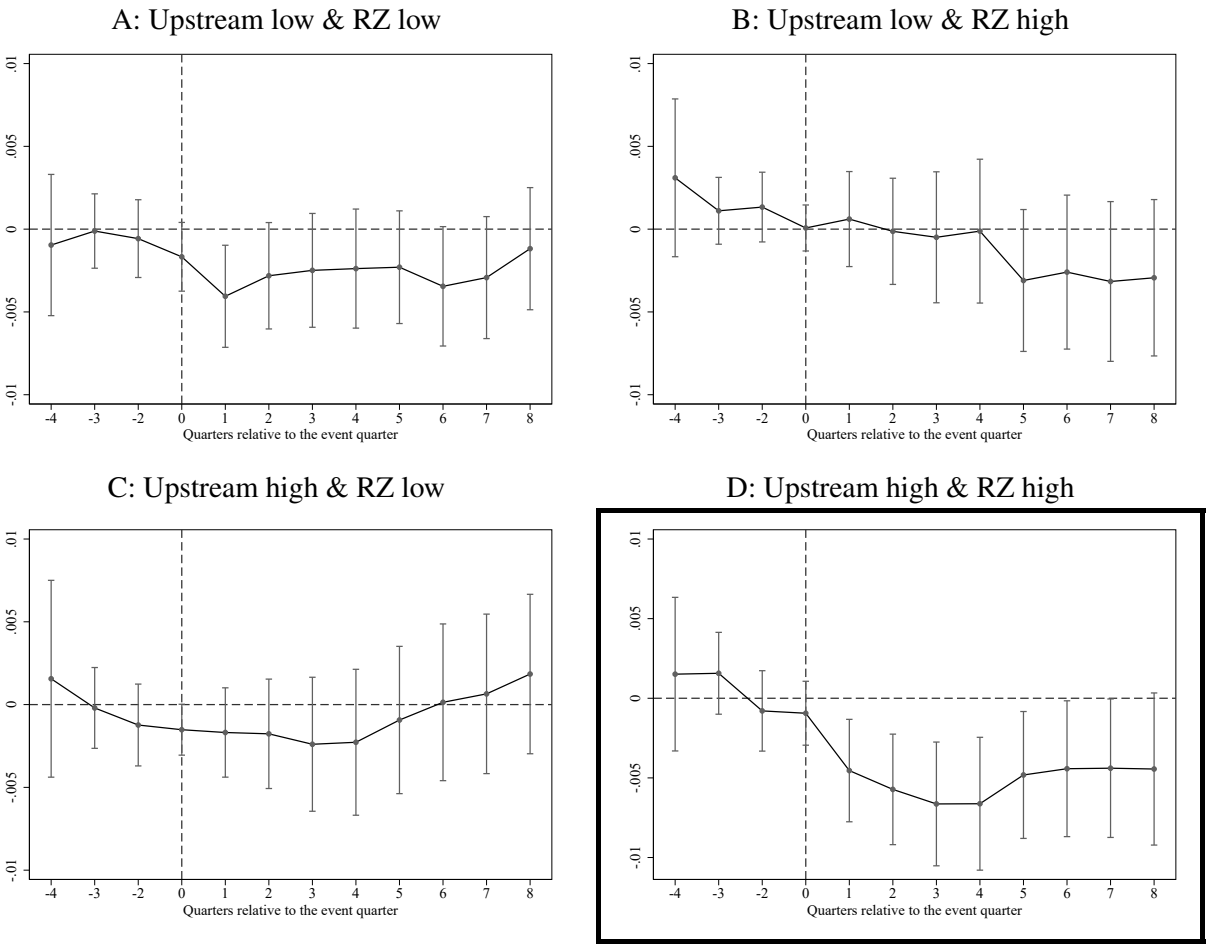
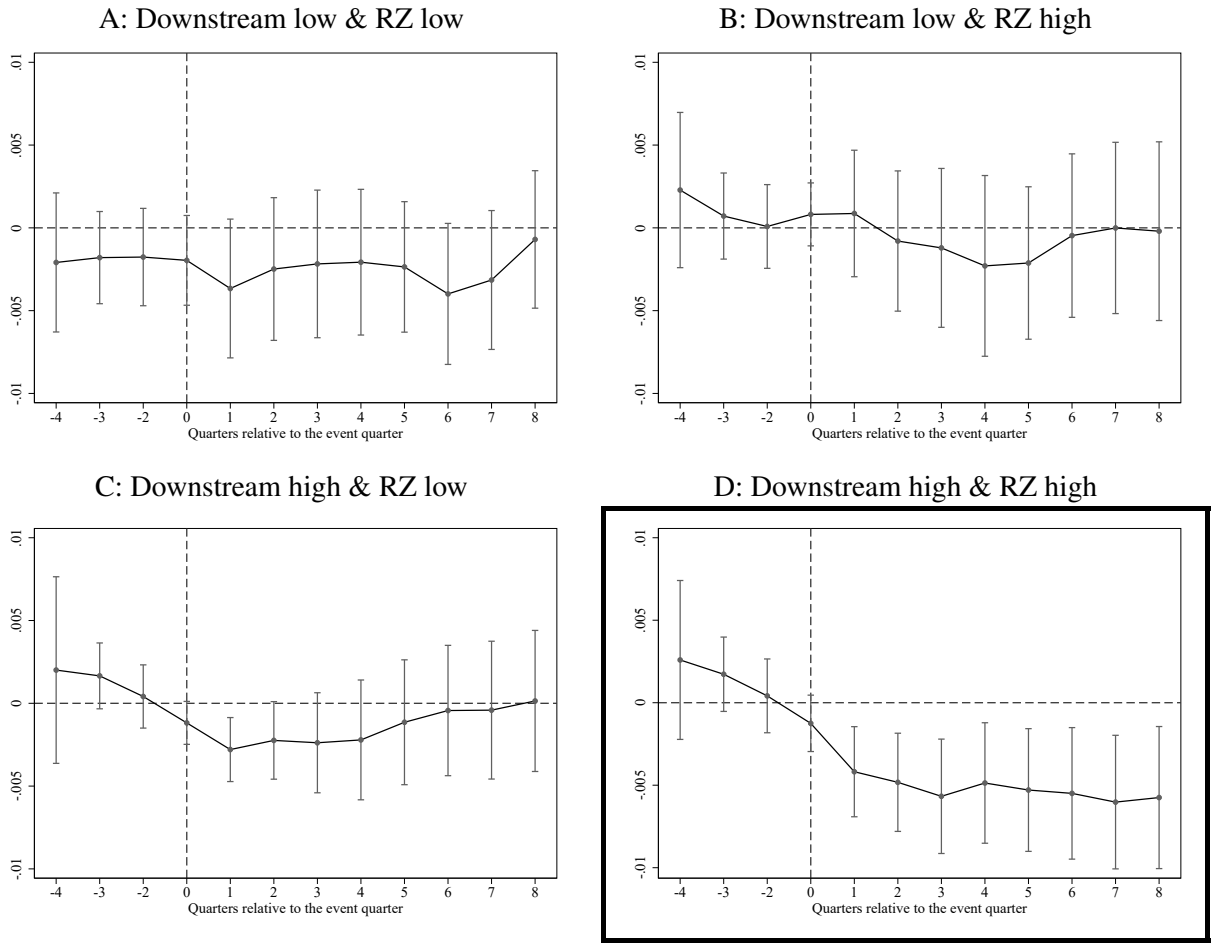


Figure A2 Upstream Distance and EFD



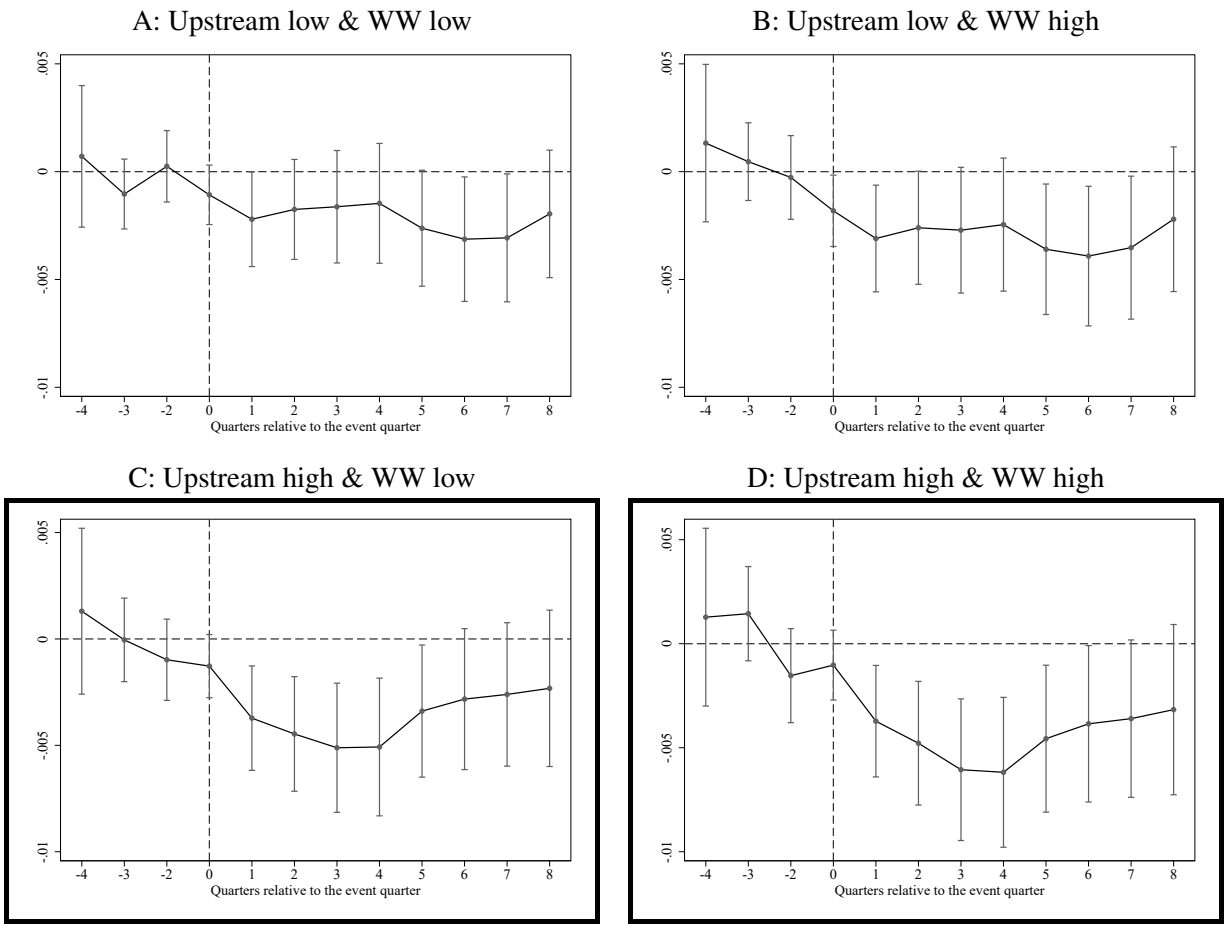
NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the upstream distance to the RE sector and the EFD measure (Rajan and Zingales 1998) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A3 Downstream Distance and EFD



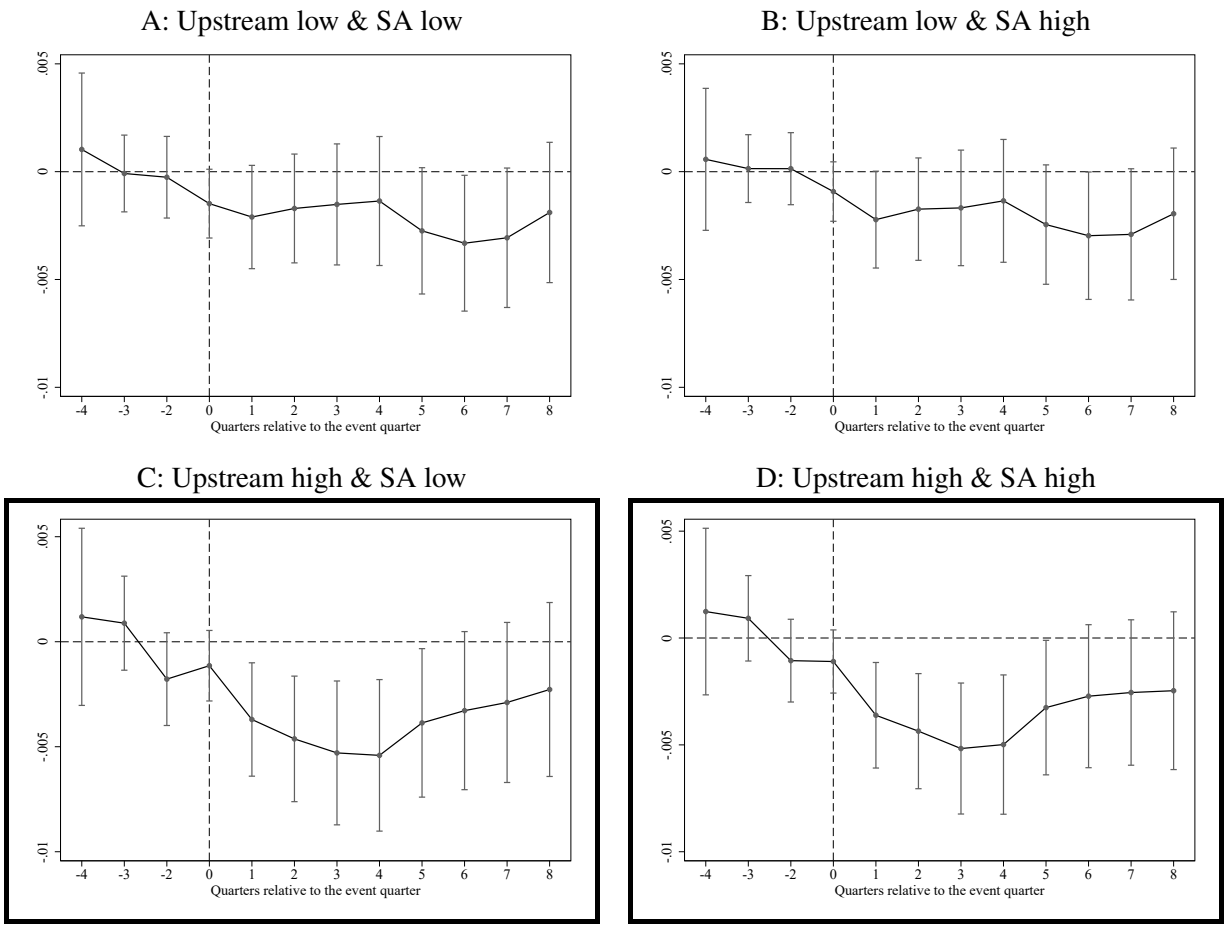
NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the downstream distance to the RE sector and the EFD measure (Rajan and Zingales 1998) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A4 Upstream Distance and WW Index



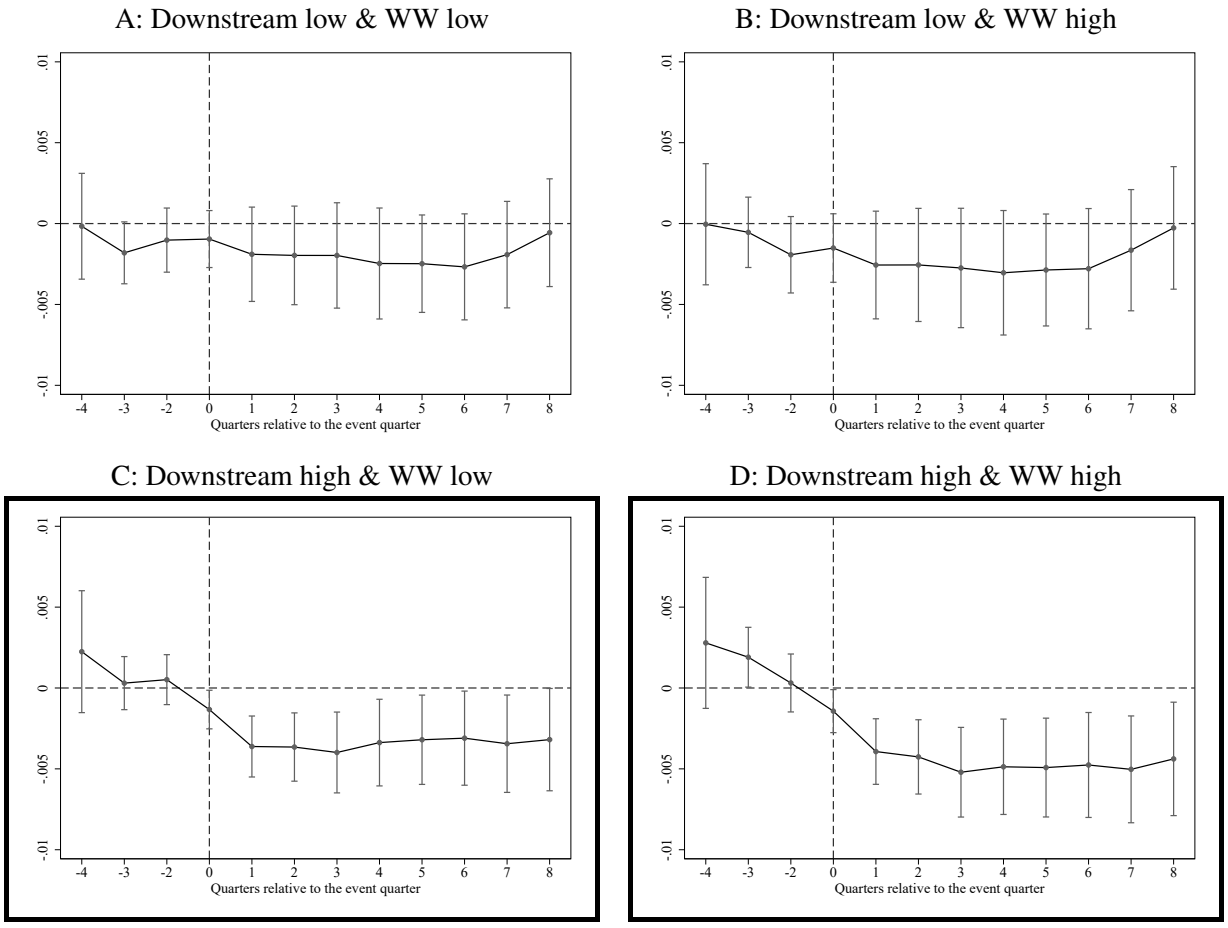
NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the upstream distance to the RE sector and the WW index (Whited and Wu 2006) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A5 Upstream Distance and SA Index



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the upstream distance to the RE sector and the SA index (Hadlock and Pierce 2010) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

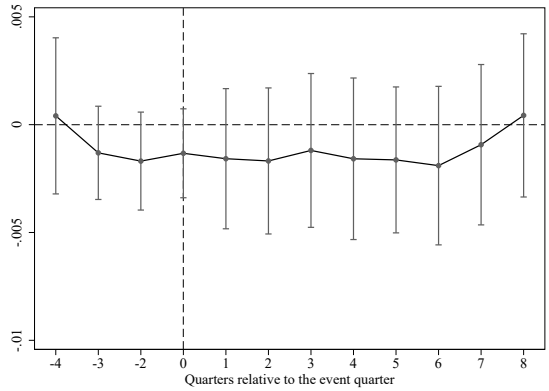
Figure A6 Downstream Distance and WW Index



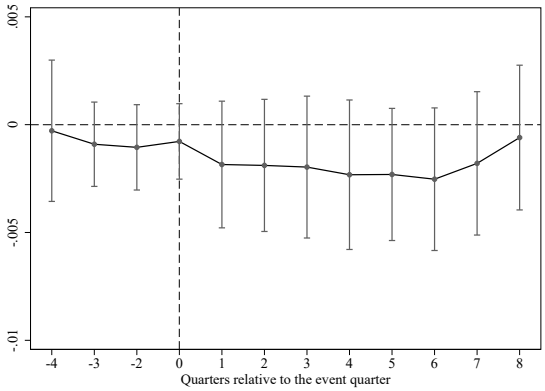
NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the downstream distance to the RE sector and the WW index (Whited and Wu 2006) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A7 Downstream Distance and SA Index

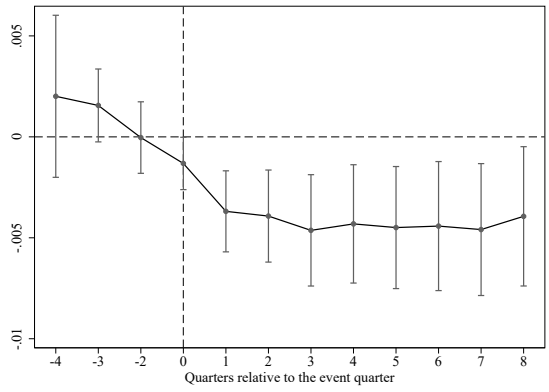
A: Downstream low & SA low



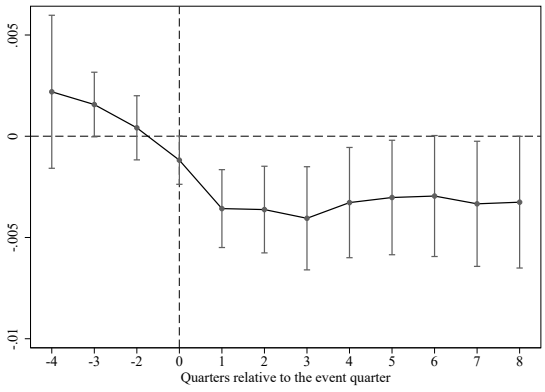
B: Downstream low & SA high



C: Downstream high & SA low

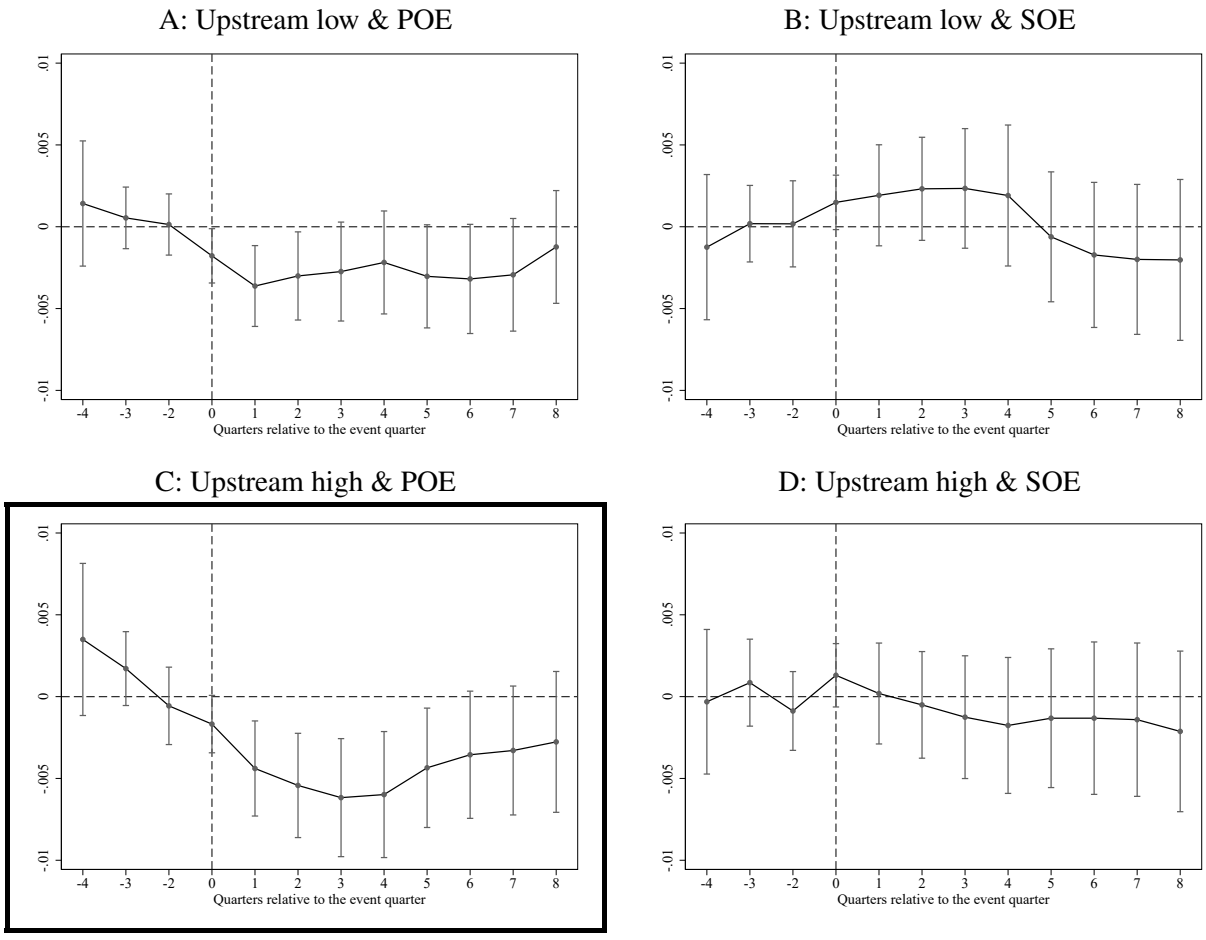


D: Downstream high & SA high



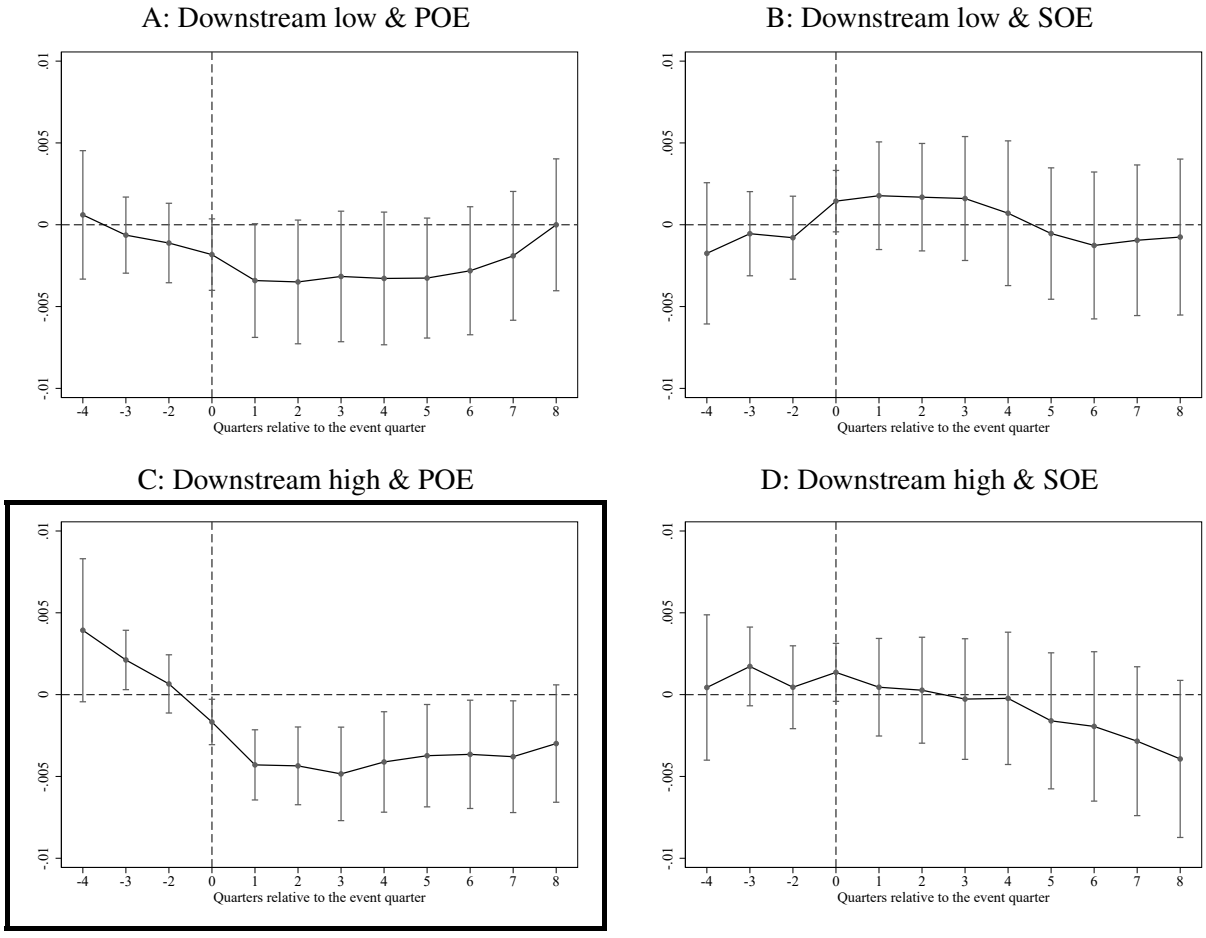
NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the downstream distance to the RE sector and the SA index (Hadlock and Pierce 2010) and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A8 Upstream Distance and Ownership



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the upstream distance to the RE sector and the ownership structure and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Figure A9 Downstream Distance and Ownership



NOTE. This figure estimates the difference-in-differences equation $I_{it} = \alpha + \sum_{s=-4}^{8} \left(\sum_g \beta_s^g 1_{g \in G}\right) * \text{Expo}_i * 1_{t+s} + \Gamma Z_{it} + \varepsilon_{it}$ based on different firm groups. Panel A to D group firms based on the downstream distance to the RE sector and the ownership structure and display the coefficients $\{\beta_s^g\}_{-4}^{8}$ along with the 95 c.i. respectively.

Table A3 REAL-ESTATE EXPOSURE AND NON-REAL-ESTATE FIRM INVESTMENT

	Invoice exposure		Stock-return exposure			Horse race		Extensive
	EW	VW	Full	Mainland	Hong Kong	EW + Stock	VW + Stock	Any link
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Invoice EW exposure × Post	-0.15**					-0.13**		
	(0.06)					(0.06)		
Invoice VW exposure × Post		-0.14**					-0.13**	
		(0.06)					(0.06)	
Stock-return exposure × Post			-0.25***	-0.22***	-0.27***	-0.23***	-0.23***	
			(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	
Any invoice link × Post								-0.34**
								(0.15)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size-bin × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Leverage-bin × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ownership × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COVID exposure × Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	33,404	33,404	33,404	33,404	33,404	33,404	33,404	33,404
Firms	2,609	2,609	2,609	2,609	2,609	2,609	2,609	2,609
R-squared	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73

NOTE. The table reports difference-in-differences estimates for non-real-estate listed firms. The dependent variable is annualized capital expenditure divided by lagged total assets, where annualized refers to the sum of four quarterly flows. Post equals one from 2020Q4 onward. Invoice exposure uses observed pre-policy developer business links; the equal-weight measure averages linked developers' red-line violation counts and the value-weight measure weights violation counts by observed pre-policy invoice transaction values. Stock-return exposure is a market-implied exposure measure and can capture latent exposure as well as exposure to Hong Kong-listed developers. Columns (6)–(7) include invoice exposure and stock-return exposure in the same regression. Column (8) uses an extensive-margin indicator equal to one if the firm has any observed pre-policy developer invoice link. The full sample contains 2,609 firms, of which 1,688 have a positive observed invoice link to developers and 921 have no observed developer invoice link. The correlation between stock-return exposure and value-weight invoice exposure is 0.11; the correlation with the any-link indicator is 0.14. Firm controls are size, ROA, leverage, Tobin's Q, and cash flow. Standard errors are clustered by firm and reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels. Variable definitions are in Appendix Table A1.

A A Simple Theoretical Framework

We consider a simple static two-sector model to guide the empirical analysis. Sector 1 is the real-estate sector and sector 2 is the non-real-estate sector. Spillovers from sector 1 to sector 2 operate through production-network linkages and trade credit.

Real-estate sector. Firms in the real-estate sector use capital k_1 and intermediate goods x_1, produced by the non-real-estate sector, to produce real-estate output y_1:

$$y_1 = k_1^{\alpha_1} x_1^{\beta_1}, \tag{A1}$$

where $\alpha_1 \geq 0$, $\beta_1 \geq 0$, and $\alpha_1 + \beta_1 < 1$.

Real-estate firms need to finance capital and intermediate-goods purchases with intra-period bank loans before production. They can choose the fraction of intermediate-goods payments made in advance. To capture trade credit between real-estate and non-real-estate firms, we assume that real-estate firms choose the fraction $\gamma \in [0,1]$ of intermediate-goods purchases paid after production. Deferring payment carries a cost $c(\gamma)$ per transaction, with $c'(\cdot) \geq 0$ and $c''(\cdot) \geq 0$. The cost function captures monitoring and reputation costs, as in Cun, Quadrini, Sun, and Xia (2022).

To capture the Three-Red-Line policy, we assume that total external borrowing cannot exceed ϕ, with a lower ϕ representing a tighter leverage constraint:

$$Rk_1 + (1-\gamma)p_2 x_1 \leq \phi, \tag{A2}$$

where R is the gross interest rate and p_2 is the price of intermediate goods.

Facing the financial constraint in equation (A2), real-estate firms choose capital k_1, intermediate goods x_1, and the share of trade credit γ to maximize profits:

$$\pi_1 = p_1 y_1 - Rk_1 - p_2 x_1 [1 + c(\gamma)], \tag{A3}$$

where p_1 is the price of real-estate output, which firms take as given.

Non-real-estate sector. Firms in the non-real-estate sector use capital k_2 and labor l_2 to produce non-real-estate output y_2:

$$y_2 = k_2^{\alpha_2} l_2^{\beta_2}, \tag{A4}$$

where $\alpha_2 \geq 0$, $\beta_2 \geq 0$, and $\alpha_2 + \beta_2 = 1$.

We assume that non-real-estate firms use prepaid sales from real-estate firms, $(1-\gamma)p_2 x_1$, to finance capital Rk_2 and wage bills wl_2:

$$(1-\gamma)p_2 x_1 \geq wl_2 + Rk_2, \tag{A5}$$

where w is the wage rate. We assume that this financial constraint binds in equilibrium.

Facing the constraint in equation (A5), non-real-estate firms choose capital k_2 and labor l_2 to maximize profits:

$$\pi_2 = p_2 y_2 - Rk_2 - wl_2. \tag{A6}$$

Exposure to real estate. We impose the following condition to capture the ex ante linkage between the real-estate and non-real-estate sectors:

$$x_1 = m y_2, \tag{A7}$$

where $m \in (0,1)$ is the fraction of intermediate goods supplied by the non-real-estate sector to the real-estate sector. The parameter m captures the production-network linkage between the two sectors. Condition (A7) is also the market-clearing condition for intermediate goods.

Equilibrium. Given exogenous prices $\{p_1, R, w\}$, a competitive equilibrium consists of an allocation $\{k_1, x_1, \gamma, k_2, l_2, y_1, y_2\}$ such that: (1) firms in the real-estate and non-real-estate sectors maximize profits subject to their constraints; (2) production functions (A1) and (A4) are satisfied; and (3) the intermediate-goods market (A7) clears.

In this framework, the Three-Red-Line policy is modeled as a lower ϕ. We are interested in how this tightening affects both sectors.

Proposition 1. *A leverage-constraint shock, represented by a lower ϕ, lowers activity in both the real-estate and non-real-estate sectors.*

1. *Real-estate firms reduce demand for capital and intermediate goods, increase their use of trade credit, and reduce output. Formally, $\frac{d\gamma}{d\phi} < 0$, $\frac{d\log y_1}{d\phi} > 0$, $\frac{d\log k_1}{d\phi} > 0$, and $\frac{d\log x_1}{d\phi} > 0$.*

2. *Non-real-estate firms reduce demand for capital and labor, and output falls. Formally, $\frac{d\log y_2}{d\phi} > 0$, $\frac{d\log k_2}{d\phi} > 0$, and $\frac{d\log l_2}{d\phi} > 0$.*

Proof. See Appendix Section A.1. □

Direct effects on real-estate firms. A tighter leverage constraint reduces the intra-period loans available to real-estate firms to finance working capital. As a result, they reduce demand for capital and intermediate goods, which lowers real-estate output. Real-estate firms also have an incentive to increase their use of trade credit because delayed payments reduce the amount of cash needed for up-front intermediate-goods purchases.

Spillovers to non-real-estate firms. Non-real-estate firms are indirectly affected by the policy through two channels. The first is lower intermediate-goods demand from the real-estate sector, $p_2 x_1$. The second is greater use of trade credit, γ, which reduces prepaid intermediate-goods purchases. Both channels operate through the binding financial constraint in equation (A5).

Comparative statics and empirical predictions. The parameter m captures the production linkage between the two sectors. We study how m changes the response of non-real-estate firms to a developer leverage shock, summarized by the cross derivative $\frac{\partial}{\partial m}\left(\frac{\partial \log y_2}{\partial \phi}\right)$. It is difficult to sign this expression in full generality, but the following proposition gives an analytical result under a linear trade-credit cost.

Proposition 2. *With a linear cost function, $c''(\cdot) = 0$, non-real-estate firms closer to the real-estate sector, captured by a higher m, are more affected by the leverage-constraint shock. Formally,*

$$\frac{\partial}{\partial m}\left(\frac{\partial \log y_2}{\partial \phi}\right) = \frac{\partial}{\partial m}\left(\frac{\partial \log k_2}{\partial \phi}\right) > 0.$$

Proof. See Appendix Section A.1. □

Exposure variable construction. The model motivates the construction of the exposure measures used in the empirical analysis. We need two pieces of information. The first captures the intensity of the leverage shock to real-estate firms, represented by ϕ. The second captures the production or business linkage between real-estate and non-real-estate firms, represented by m. The spillover effect is larger when m is higher. Thus, two non-real-estate firms can experience different spillovers because they have different links to real-estate developers, and the same link can matter more when the linked developer is more constrained by the policy.

A.1 Proof

Proof. The optimality conditions for real-estate firms are

$$\alpha_1 p_1 y_1 = Rk_1(1+\lambda), \tag{A8}$$
$$\beta_1 p_1 y_1 = p_2 x_1[1+c(\gamma)+\lambda(1-\gamma)], \tag{A9}$$
$$c'(\gamma) = \lambda, \tag{A10}$$

where λ is the Lagrange multiplier on the financial constraint (A2).

Using two equilibrium conditions, we obtain the following four equations in logs:

$$\log y_1 = \alpha_1 \log k_1 + \beta_1 \log x_1, \tag{A11}$$
$$\log \phi = \log\left[\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}\right] + \log p_1 + \log y_1, \tag{A12}$$
$$\log k_1 = \log\left(\frac{\alpha_1 p_1}{R}\right) + \log y_1 - \log[1+c'(\gamma)], \tag{A13}$$
$$\log x_1 = \log\left(\frac{\beta_1 p_1}{p_2}\right) + \log y_1 - \log[1+c(\gamma)+c'(\gamma)(1-\gamma)]. \tag{A14}$$

The optimality conditions for non-real-estate firms are

$$\alpha_2 p_2 y_2 = Rk_2(1+\mu), \tag{A15}$$
$$\beta_2 p_2 y_2 = wl_2(1+\mu), \tag{A16}$$

where μ is the Lagrange multiplier on the financial constraint (A5).

Using the production function and the constant-returns-to-scale assumption $\alpha_2+\beta_2=1$,

$$1+\mu = p_2\left(\frac{\alpha_2}{R}\right)^{\alpha_2}\left(\frac{\beta_2}{w}\right)^{\beta_2}. \tag{A17}$$

Therefore, the endogenous variables $\{y_2, k_2, l_2\}$ are

$$y_2 = (1-\gamma) p_2 x_1 \left(\frac{\alpha_2}{R}\right)^{\alpha_2} \left(\frac{\beta_2}{w}\right)^{\beta_2}, \tag{A18}$$

$$k_2 = \frac{\alpha_2}{R}(1-\gamma) p_2 x_1, \tag{A19}$$

$$l_2 = \frac{\beta_2}{w}(1-\gamma) p_2 x_1. \tag{A20}$$

With the intermediate-goods market-clearing condition, we have

$$\log \phi = \tilde{F}(\gamma) + \frac{\log p_1 + \beta_1 (\log m + \alpha_2 \log \frac{\alpha_2}{R} + \beta_2 \log \frac{\beta_2}{w})}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + \beta_1 \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log y_1 = \tilde{G}(\gamma) + \frac{(\alpha_1+\beta_1) \log p_1 + \beta_1 (\log m + \alpha_2 \log \frac{\alpha_2}{R} + \beta_2 \log \frac{\beta_2}{w})}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + \beta_1 \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log k_1 = \tilde{H}(\gamma) + \frac{\log p_1 + \beta_1 (\log m + \alpha_2 \log \frac{\alpha_2}{R} + \beta_2 \log \frac{\beta_2}{w})}{1-\alpha_1-\beta_1} + \frac{(1-\beta_1) \log \frac{\alpha_1}{R} + \beta_1 \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log x_1 = \tilde{Z}(\gamma) + \frac{\log p_1 + (1-\alpha_1)(\log m + \alpha_2 \log \frac{\alpha_2}{R} + \beta_2 \log \frac{\beta_2}{w})}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + (1-\alpha_1) \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log y_2 = \tilde{Z}(\gamma) + \frac{\log p_1 + \beta_1 \log m + (1-\alpha_1)(\alpha_2 \log \frac{\alpha_2}{R} + \beta_2 \log \frac{\beta_2}{w})}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + (1-\alpha_1) \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log k_2 = \tilde{Z}(\gamma) + \frac{\log p_1 + \beta_1 \log m + (1-\alpha_1-\beta_1\beta_2) \log \frac{\alpha_2}{R} + \beta_1\beta_2 \log \frac{\beta_2}{w}}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + (1-\alpha_1) \log \beta_1}{1-\alpha_1-\beta_1},$$

$$\log l_2 = \tilde{Z}(\gamma) + \frac{\log p_1 + \beta_1 \log m + \beta_1\alpha_2 \log \frac{\alpha_2}{R} + (1-\alpha_1-\beta_1\alpha_2) \log \frac{\beta_2}{w}}{1-\alpha_1-\beta_1} + \frac{\alpha_1 \log \frac{\alpha_1}{R} + (1-\alpha_1) \log \beta_1}{1-\alpha_1-\beta_1}.$$

where

$$\tilde{F}(\gamma) \equiv \log\left[\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}\right] + \tilde{G}(\gamma),$$

$$\tilde{G}(\gamma) \equiv -\frac{\alpha_1 \log[1+c'(\gamma)] + \beta_1 \log[1+c(\gamma)+c'(\gamma)(1-\gamma)]}{1-\alpha_1-\beta_1} + \frac{\beta_1 \log(1-\gamma)}{1-\alpha_1-\beta_1},$$

$$\tilde{H}(\gamma) \equiv -\frac{(1-\beta_1) \log[1+c'(\gamma)] + \beta_1 \log[1+c(\gamma)+c'(\gamma)(1-\gamma)]}{1-\alpha_1-\beta_1} + \frac{\beta_1 \log(1-\gamma)}{1-\alpha_1-\beta_1},$$

$$\tilde{Z}(\gamma) \equiv -\frac{\alpha_1 \log[1+c'(\gamma)] + (1-\alpha_1) \log[1+c(\gamma)+c'(\gamma)(1-\gamma)]}{1-\alpha_1-\beta_1} + \frac{(1-\alpha_1) \log(1-\gamma)}{1-\alpha_1-\beta_1}.$$

We have

$$\begin{aligned}
&\frac{d\gamma}{d\phi} = \frac{1}{\phi\tilde{F}'(\gamma)} < 0,\\
&\frac{d\log y_1}{d\phi} = \frac{\tilde{G}'(\gamma)}{\phi\tilde{F}'(\gamma)} > 0,\\
&\frac{d\log k_1}{d\phi} = \frac{\tilde{H}'(\gamma)}{\phi\tilde{F}'(\gamma)} > 0,\\
&\frac{d\log x_1}{d\phi} = \frac{d\log y_2}{d\phi} = \frac{d\log k_2}{d\phi} = \frac{d\log l_2}{d\phi} = \frac{\tilde{Z}'(\gamma)}{\phi\tilde{F}'(\gamma)} > 0,
\end{aligned}$$

because $\tilde{F}'(\gamma)$, $\tilde{G}'(\gamma)$, $\tilde{H}'(\gamma)$, and $\tilde{Z}'(\gamma)$ are all negative. This proves Proposition 1.

Notice that

$$\frac{d\gamma}{dm} = -\frac{\beta_1}{(1-\alpha_1-\beta_1)m\tilde{F}'(\gamma)} > 0.$$

The sign of the cross derivative is given by

$$\frac{\partial}{\partial m}\left(\frac{\partial \log y_2}{\partial \phi}\right) = \frac{\partial}{\partial m}\left(\frac{\partial \log k_2}{\partial \phi}\right) = \frac{\tilde{Z}''(\gamma)\tilde{F}'(\gamma) - \tilde{Z}'(\gamma)\tilde{F}''(\gamma)}{\phi[\tilde{F}'(\gamma)]^2}\frac{d\gamma}{dm}. \tag{A21}$$

With a linear cost function $c(\gamma)$, we have

$$\tilde{F}'(\gamma) = -\frac{\frac{\beta_1}{1+c(\gamma)+c'(\gamma)(1-\gamma)}}{\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}} - \frac{\beta_1}{(1-\gamma)(1-\alpha_1-\beta_1)}, \tag{A22}$$

$$\tilde{F}''(\gamma) = -\frac{\frac{\beta_1^2}{[1+c(\gamma)+c'(\gamma)(1-\gamma)]^2}}{\left[\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}\right]^2} - \frac{\beta_1}{(1-\gamma)^2(1-\alpha_1-\beta_1)}, \tag{A23}$$

$$\tilde{Z}'(\gamma) = -\frac{1-\alpha_1}{(1-\gamma)(1-\alpha_1-\beta_1)}, \tag{A24}$$

$$\tilde{Z}''(\gamma) = -\frac{1-\alpha_1}{(1-\gamma)^2(1-\alpha_1-\beta_1)}. \tag{A25}$$

Therefore,

$$\begin{aligned}
&\tilde{Z}''(\gamma)\tilde{F}'(\gamma) - \tilde{Z}'(\gamma)\tilde{F}''(\gamma)\\
&= \frac{1-\alpha_1}{(1-\gamma)^2(1-\alpha_1-\beta_1)}\frac{\frac{\beta_1}{1+c(\gamma)+c'(\gamma)(1-\gamma)}}{\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}}\left(1 - \frac{\frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}}{\frac{\alpha_1}{1+c'(\gamma)} + \frac{\beta_1(1-\gamma)}{1+c(\gamma)+c'(\gamma)(1-\gamma)}}\right) > 0.
\end{aligned}$$

We thus have

$$\frac{\partial}{\partial m}\left(\frac{\partial \log y_2}{\partial \phi}\right) = \frac{\partial}{\partial m}\left(\frac{\partial \log k_2}{\partial \phi}\right) > 0. \tag{A26}$$

This proves Proposition 2. □