Nighttime Light and the Construction Financing Channel of Monetary Spillovers

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Question

- **Question**: How do U.S. monetary policy shocks transmit internationally to real economic activity, and through which channel?
- **Challenge**: The identification of causal spillover effects and specific transmission mechanisms.
  - **Temporal dimension**: Standard measures of real activity (e.g., GDP) are low-frequency, making it difficult to isolate causal effects from other confounding macro forces.
  - **Spatial dimension**: Aggregate data confound trade, exchange-rate, and financial channels, obscuring heterogeneity across locations and sectors.
- **Requirement**: To identify a specific channel, we need high-frequency real activity measured at flexible spatial units that can be linked to specific economic agents and their financing choices.

This paper

- We address these challenges using nighttime light (NTL) data along two dimensions.
  - Daily NTL aligns closely with FOMC announcement windows.
  - NTL can be aggregated flexibly across spatial units.
- We identify an emerging-market construction-financing channel.
  - Construction is highly capital-intensive and financing dependent.
  - Construction and real estate account for a large share of EME real economic activity (15% to 25% of GDP).
  - EME developers increasingly rely on offshore U.S. dollar bond markets (nearly 30% by the early 2020s).

Use China as a laboratory

- Construction and real estate account for roughly 25% of China's GDP.
- Post-2009 credit tightening pushed developers toward alternative financing than domestic loans.
- By the mid-2010s, Chinese developers had become among the largest issuers of dollar-denominated high-yield debt globally.
- Dollar debt creates direct exposure to Federal Reserve policy.
- The "three red lines" policy further tightened financing constraints.

Use China as a laboratory

Figure 1: Construction Activities at Night: An Illustration

What do we do?

- **Data**: Combine high-frequency NTL data with transaction-level land-parcel records, bonding issuing data and firm-level financial information.
  - We map satellite pixels to geocoded land transactions to measure parcel-level construction activity.
  - We link each parcel to the developer's exact financial structure.
- **Empirical Strategy**: Local Projection approach to do event-study in a short time window
  - Firm-level analysis to quantify the role of financing channels.
  - Parcel-level analysis to explore the interaction of such channels with local demands.
- **Key findings**: U.S. monetary tightening reduces construction activity, with larger effects for firms more exposed to foreign bond financing and tighter balance sheet constraints, and with amplification following the "three red lines" policy.

Datasets

- High-frequency monetary policy shocks (Jarociński, 2024)
  ▸ Baseline: MP1
  - Extracted from the 30-minute high-frequency changes in FFR around FOMC meetings
  - Frequency: daily, 2012-2023 (Covering 96 FOMC meetings)
- **Nighttime light (NTL)** ▸ Summary Statistics: MPS and NTL
  - Source: NASA Black Marble (Frequency: daily, 2012-2023)
- Listed firm balance-sheet data
- **Land auction transaction**
  - Source: Land China website (2000-2020)
  - Land parcels are geocoded and matched to NTL grid cells.
  - connect each transaction with a listed firm
- **Bond issuance** (Huang et al., 2024), 2000-2015
  - Indicators: Issuer name, Industry, Pricing date, Maturity date, Currency, Value
  - Connect each transaction with a potentially listed real estate firm

Validation: NTL Tracks Real Activity

- NTL correlates strongly with GDP at the city level.
  - ▸ GDP-NTL by Sector
  - ▸ GDP-NTL by Period
  - ▸ Trade and Construction
  - ▸ Urbanization Growth
- The relation is especially relevant in developing economies, where lights capture urban expansion, industrial production, and construction activity. ▸ GDP-NTL at economy-level

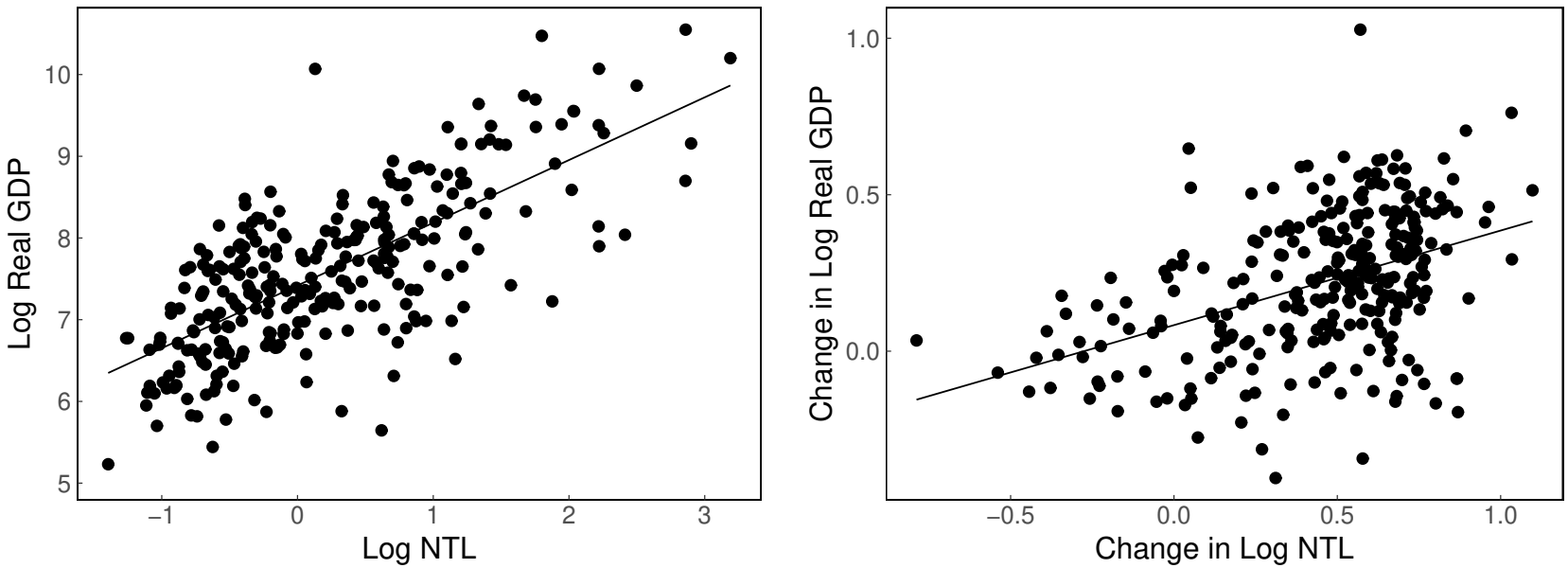


Figure 2: NTL and GDP by City

Aggregate Effects

Estimate using Local Projection (LP) approach (Jordà, 2005)

$$y_{t+h} - y_{t-1} = \alpha^{(h)} + \sum_{q=1}^{Q} \phi_q^{(h)} \Delta y_{t-q} + \beta^{(h)} x_t + \gamma^{(h)} W + u_{t+h|t}$$

- x_t: high-frequency U.S. monetary policy surprise.
- y: log(NTL) at the relevant aggregation level.
- $\beta^{(h)}$: dynamic response after the shock.
- AIC criteria to choose lag Q
- Weekly frequency in baseline

Aggregate Effect: U.S. Tightening Reduces NTL

- A tightening shock generates a persistent decline in China's NTL.
- Responses occur several weeks after the shock.

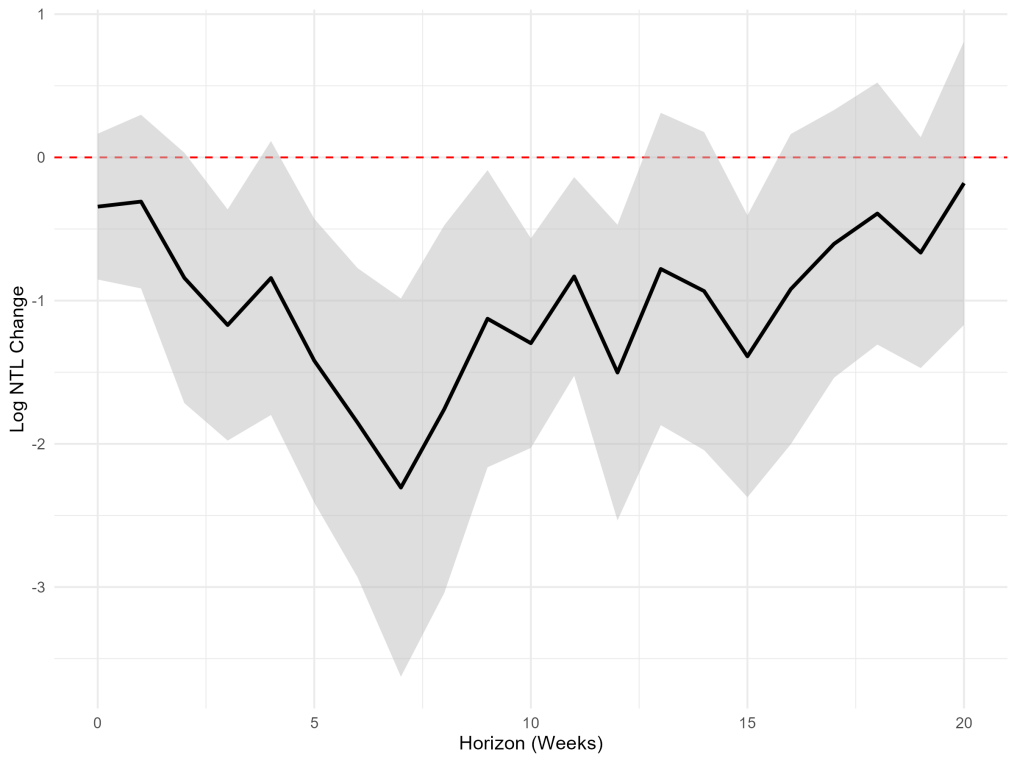


Figure 3: Response of NTL to U.S. MPs: National Aggregate, Baseline

Heterogeneity across subareas within a city

- To what extent do construction activities matter?
- Decompose each city into sub-areas to identify sectors exposed to U.S. MP shocks
- City center (service), Suburb (manufacturing) or Non-built-up Area (construction)
- City center: built-up area before 1990; Suburb: area built up from 1990 to 2010, Non-built-up Area: not built-up before 2010.

Within-city evidence: non-built-up areas drive the NTL declines

- The decline is concentrated in non-built-up areas, where new construction is most likely to occur.
- Center and suburb responses are much weaker.

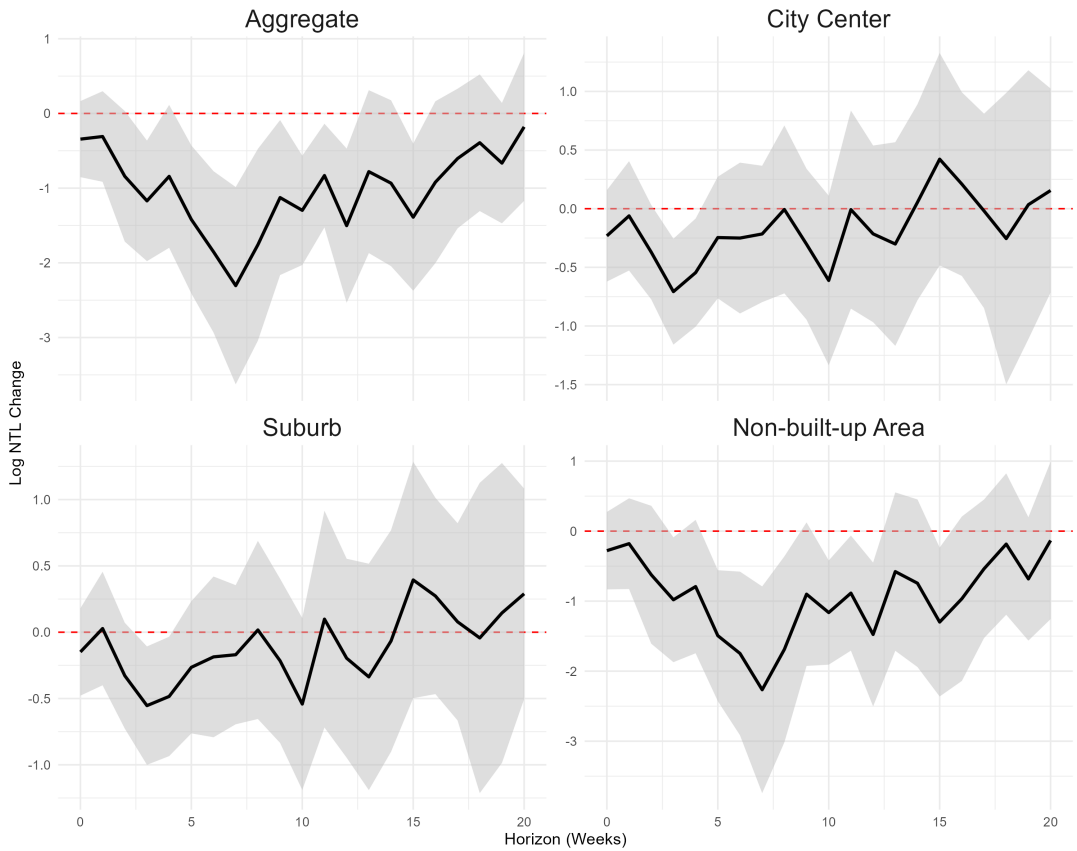


Figure 4: Response of NTL to U.S. MPs: City Areas Decomposition

Construction-Financing Channel

1. U.S. tightening raises the cost of offshore dollar financing.
2. Developers with weaker balance sheets or offshore bond exposure cut construction more in expectation of increasing financing costs.
3. This decline appears in parcel-level NTL.
4. especially for projects located in cities where housing demand shrank much.

Central prediction

The NTL response should be largest for construction parcels associated with financially constrained developers, especially those exposed to foreign bonds.

From Areas to Land Parcels

- About 86 percent of geolocated land transactions of RE firms are in non-built-up areas.
- This makes parcel-level NTL a direct measure of construction-site activity.

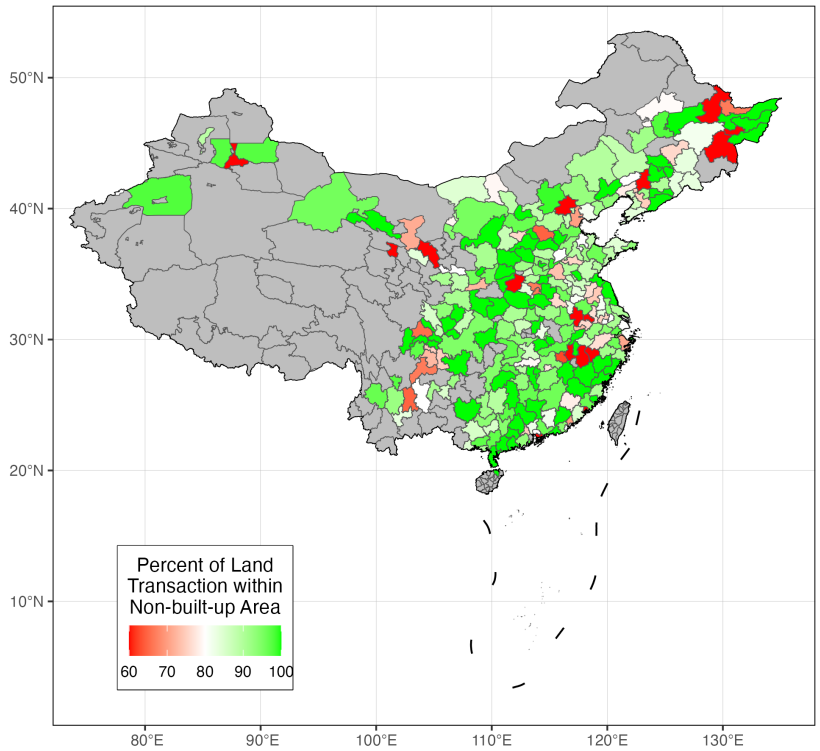


Figure 5: Percent of Transacted Lands in the Non-Built-up Area by City

From Areas to Land Parcels

- We aggregate NTL across parcels linked to listed real estate developers.
- NTL at these parcels declines significantly after U.S. monetary tightening.

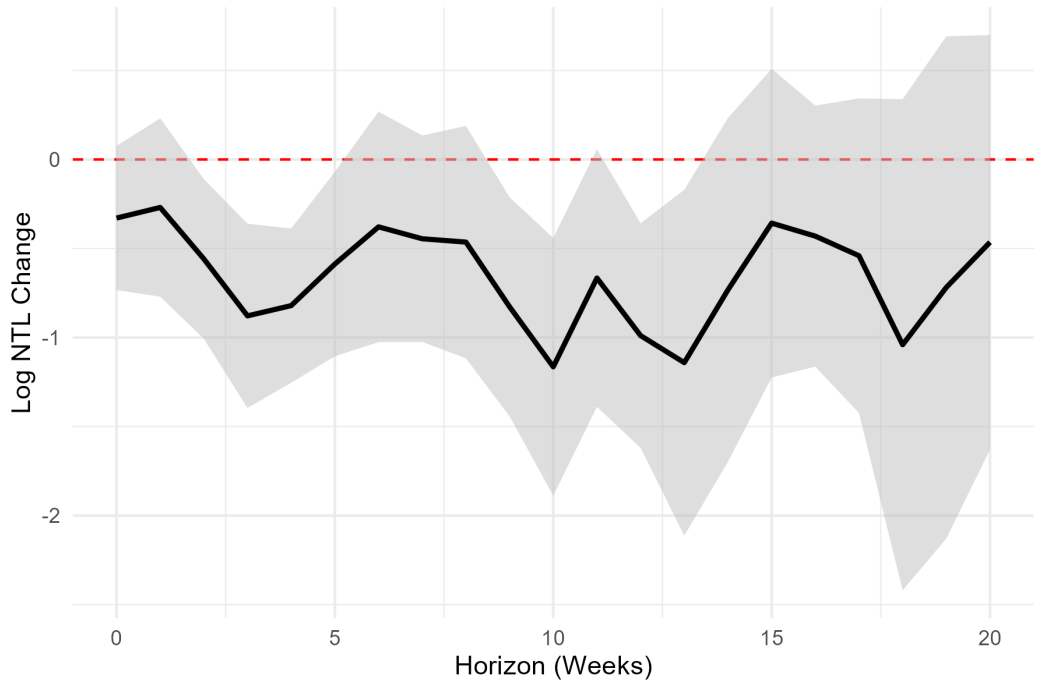


Figure 6: Response of NTL to U.S. MPs: Transacted Lands by Real Estate Firms

First Stage: U.S. Tightening Impairs External Financing

$$\left(\frac{\text{Net Bond Standing Value}}{\text{Operation Indicator}}\right)_{i,t} = \beta x_t + \alpha_i + \varepsilon_{i,t}.$$

- Foreign bond financing of real estate firms falls after U.S. tightening.
- Domestic bond financing does not show a comparable response. ▸ Domestic Bond Issue Standing ▸ Interest Expense

Table 1: Real Estate Firm Foreign Bond Issue Net Standing Value (Scaled by Operation Indicator) Responses to MPs

	/ Asset	/ Liability	/ Current Liability	/ Long-term Liability
MPs	-0.0598***	-0.0801***	-0.1298***	-0.6261^{+}
	(0.0140)	(0.0199)	(0.0362)	(0.3868)
Firm FE	Yes	Yes	Yes	Yes
N	2,238	2,238	2,238	2,226
R^2	0.3390	0.3371	0.3616	0.1860

First Stage: U.S. Tightening Impairs External Financing

Table 2: Real Estate Firm Domestic Bond Issue Net Standing Value (Scaled by Operation Indicator) Responses to MPs

	/ Asset	/ Liability	/ Current Liability	/ Long-term Liability
MPs	-0.0143	0.0891	0.0238	-1.9571
	(0.0819)	(0.2804)	(0.2952)	(1.6913)
Firm FE	Yes	Yes	Yes	Yes
N	3,955	3,955	3,955	3,862
R^2	0.4900	0.5744	0.5388	0.2400

◂ Return

Second Stage: High-Debt Developers Cut Construction More

$$y_{i,t+h} - y_{i,t-1} = \alpha_i^{(h)} + \sum_{q=1}^{4} \phi_q^{(h)} \Delta y_{i,t-q} + \beta_1^{(h)} x_t + \beta_2^{(h)} x_t s_{i,t-L} + \beta_3^{(h)} s_{i,t-L} + \gamma^{(h)} W_{i,t-L} + u_{i,t+h|t}$$

- Baseline effect for low-debt firms is close to zero.
- The interaction with high debt is negative: financially weaker firms drive the decline.
- $s_{i,t-L}$ is a dummy variable equal to 1 if firm i's debt ratio in the previous quarter is above the median.

Second Stage: High-Debt Developers Cut Construction More

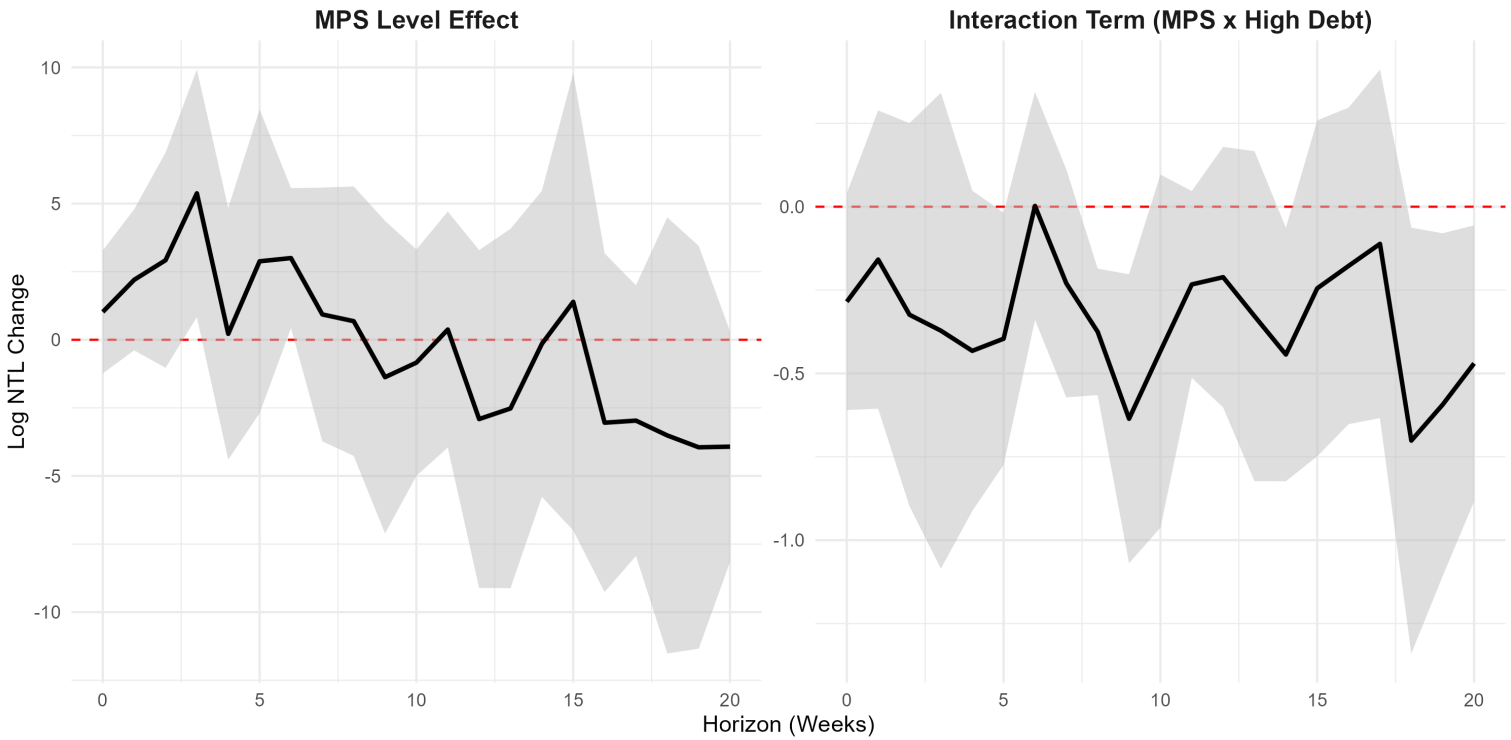


Figure 7: Response of NTL to U.S. MPs: The Role of Firm Debt

Roles of Debt Categories

$$
\begin{aligned}
y_{i,t+h} - y_{i,t-1} = \alpha_i^{(h)} &+ \sum_{q=1}^{4} \phi_q^{(h)} \Delta y_{i,t-q} + \beta_1^{(h)} x_t \\
&+ (\beta_{FB}^{(h)} s_{i,t-L}^{FB} + \beta_{DB}^{(h)} s_{i,t-L}^{DB} + \beta_{DL}^{(h)} s_{i,t-L}^{DL}) x_t \\
&+ \beta_4^{(h)} s_{i,t-L}^{FB} + \beta_5^{(h)} s_{i,t-L}^{DB} + \beta_6^{(h)} s_{i,t-L}^{DL} + \gamma^{(h)} W_{i,t-L} + u_{i,t+h|t}
\end{aligned}
$$

- $s_{i,t-L}^{FB}$, $s_{i,t-L}^{DB}$, and $s_{i,t-L}^{DL}$ are dummies equal to 1 if the ratio of foreign bonds, domestic bonds, and domestic loans to total assets is above the median.

Debt Components: Foreign Bonds Are the Key Margin

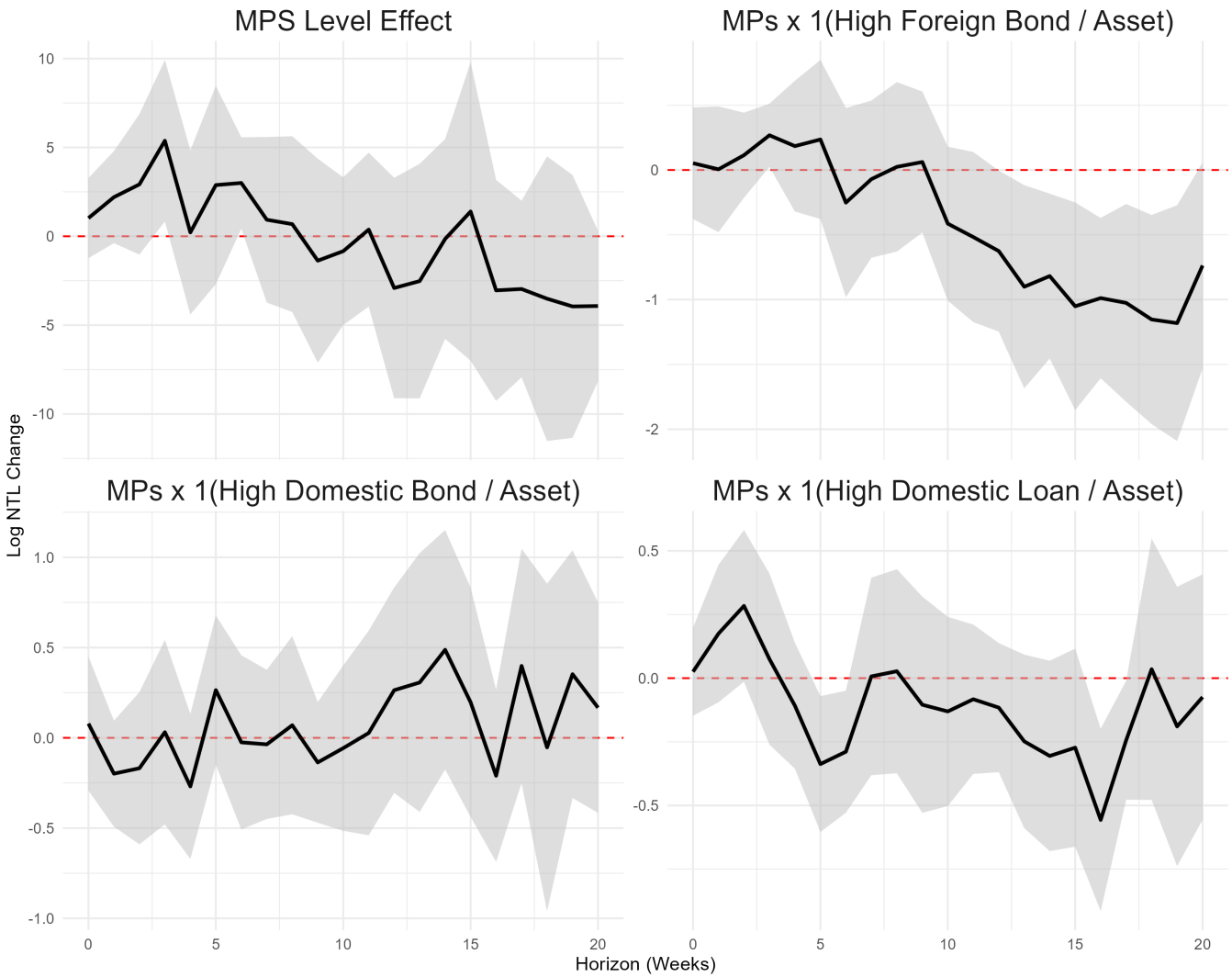


Figure 8: Response of NTL to U.S. MPs: Firm Debt Components

Quantifying the Financing Channel: Coefficient Decomposition

Debt component	Foreign bonds	Domestic bonds	Domestic loans
Share of financing channel	56.89%	0.00%	43.11%

- Which debt component is more important for explaining NTL changes through the financing channel?

$$\text{Share}^{(X)} = \frac{\bar{\beta}_X^{(h)} \cdot \bar{s}^X}{\bar{\beta}_{FB}^{(h)} \cdot \bar{s}^{FB} + \bar{\beta}_{DB}^{(h)} \cdot \bar{s}^{DB} + \bar{\beta}_{DL}^{(h)} \cdot \bar{s}^{DL}}$$

  for $X \in \{FB, DB, DL\}$.

- $\bar{s}^X = \sum_i \omega_i s_i^X$ is the average exposure to external financing via X.
- s_i^X is firm i's average exposure to external financing via X across time.
- ω_i is the share of firm i's land transaction value across the whole period.

Quantifying the Financing Channel: Coefficient Decomposition

Table 3: Concentration of Offshore USD Bond Issuers Across Different Market Samples

Sample Definition	% of Total Firms	Total Land Transaction Value (Billion RMB)	FB Issuers' Land Value (Billion RMB)	FB Issuers' Market Share
Strict Regression Sample (A-Share Only, NTL Filtered)	3.54%	836.24	419.72	**50.19%**
Unfiltered Baseline (A-Share Only)	3.12%	2145.76	580.18	**27.04%**
Complete Market (A-Share + HK-Listed, Unfiltered)	14.13%	6107.70	2838.33	**46.47%**

- This table summarizes the extreme concentration of offshore USD debt (Foreign Bonds, FB) in the Chinese real estate market.
- The "Strict Regression Sample" applies the exact econometric filters (requiring continuous NTL observations and sufficient variance).
- The "Complete Market" includes both mainland A-share and Hong Kong-listed (Red Chip) developers without NTL filtering.

Quasi-Natural Experiment: Three Red Lines Policy

- The policy was implemented in August 2020 to constrain leverage in the real estate sector.
- Developers breaching thresholds faced tighter financing restrictions.
  1. $\frac{\text{Liabilities}-\text{Pre-sales revenue}}{\text{Assets}-\text{Pre-sales revenue}} \leq 70\ \%$
  2. $\frac{\text{Total interest-bearing liability}-\text{ Cash holding}}{\text{Equity}} \leq 100\ \%$
  3. $\frac{\text{Cash holding}}{\text{Short-term or maturing interest-bearing liability}} \geq 100\ \%.$
- This creates a sharper test: firms whose *domestic* financing margin becomes constrained due to this policy should become more sensitive to U.S. monetary shocks.

Three Red Lines: Triple-Interaction Design

$$y_{i,t+h} - y_{i,t-1} = \alpha_i^{(h)} + \alpha_t^{(h)} + \sum_{q=1}^{4} \phi_q^{(h)} \Delta y_{i,t-q} + \beta_j^{(h)} x_t \cdot Policy_t \cdot Cross_i^j + \gamma_j^{(h)} x_t \cdot Cross_i^j + \delta_j^{(h)} Policy_t \cdot Cross_i^j + \theta_j^{(h)} W_{i,t-L} + u_{i,t+h|t}$$

- $Cross_i^j$: firm breached red line j in 2019.
- $Policy_t$: post-three-red-line period.
- $\beta_j^{(h)}$: policy impacts on the responses of high-leveraged firmed.

- Before the policy, firms with low cash relative to short-term debts are those having easy access to external finance. After the policy, credit is reversed.

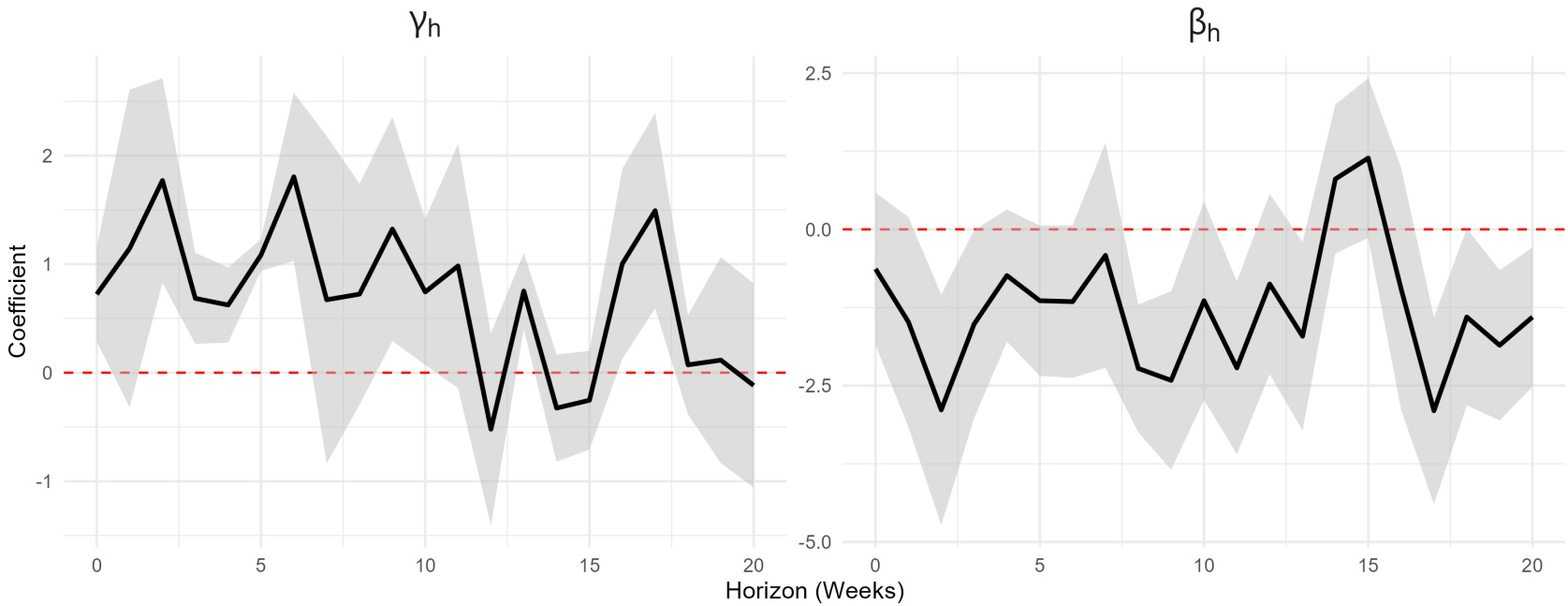


Figure 9: Response of NTL to U.S. MPs: Three Red Line Policy

Alternative Channel: Housing Demand

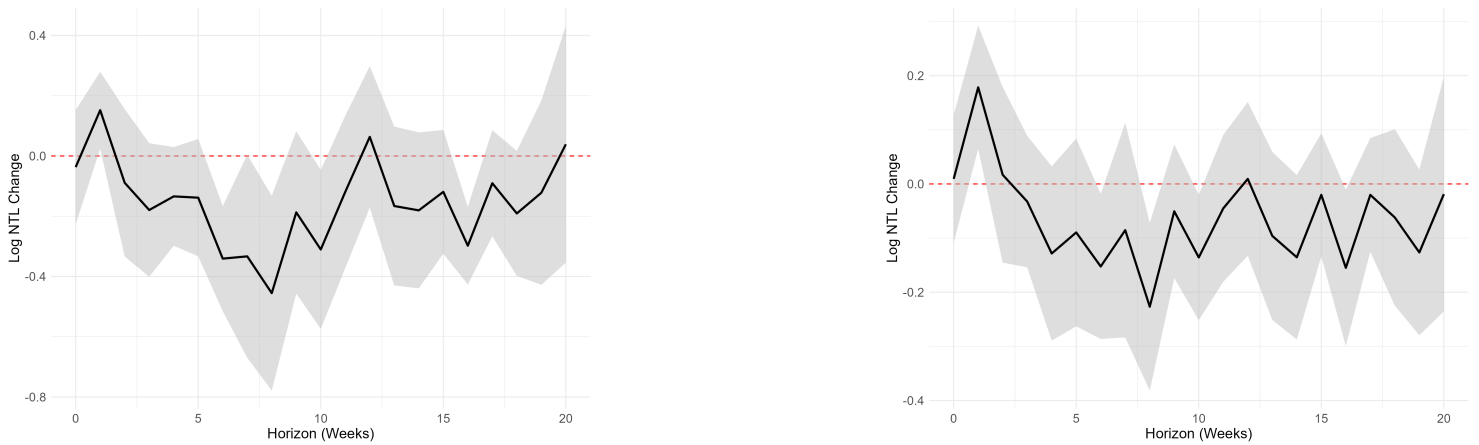
- Alternative story: U.S. tightening reduces local housing demand, and lower demand reduces construction.
- To control for demand factors, use parcel-level regressions
- control for city-level housing demand (e.g. lagged floor spaced sold per capita), or city $\times$ Time FE

Parcel-Level Analysis

$$y_{i,j,c,t+h} - y_{i,j,c,t-1} = \alpha_i + \gamma_t + \beta^{(h)}(x_t \times HighDebt_{j,t-1}) + \delta^{(h)} HighDebt_{j,t-1} + \sum_{p=1}^{4} \phi_p^{(h)} \Delta y_{i,j,c,t-p} + \zeta^{(h)}(x_t \times Demand_{c,t-1}) + \theta^{(h)} Demand_{c,t-1} + \epsilon_{i,j,c,t+h}$$

- $y_{i,j,c,t}$: $log(NTL)$ in land i of firm j in city c at week t
- Parcel fixed effects α_i absorb time-invariant project and location characteristics.
- Week fixed effects (γ_t) absorb time-varying common factors
- $Demand_{c,t-1}$: housing demand in city c in the last year
- We also explore adding city-by-week fixed effects to absorb time-varying local macro shocks.

- $\beta^{(h)}$ is still overall negative with these controls, strengthening the supply side financing channel



(a) Control: Housing Demand (b) Control: City × Time FE

Figure 10: Response of NTL to U.S. MPs: The Role of Firm Debt, Land Parcel Level

Demand as an Amplifier of the Construction-Financing Channel

$$
\begin{aligned}
y_{i,j,c,t+h} - y_{i,j,c,t-1} = & \alpha_i + \eta_{c,t} + \beta_1^{(h)}(x_t \times HighDebt_{j,t-1} \times Demand_{c,t-1}) \\
& + \beta_2^{(h)}(x_t \times HighDebt_{j,t-1}) + \beta_3^{(h)}(HighDebt_{j,t-1} \times Demand_{c,t-1}) \\
& + \delta^{(h)} HighDebt_{j,t-1} + \sum_{p=1}^{4} \phi_p^{(h)} \Delta y_{i,k,c,t-p} + \epsilon_{i,j,c,t+h}
\end{aligned}
$$

- $\eta_{c,t}$: city-time fixed effect, to absorb time-varying local factors
- The triple interaction term captures how city-level housing demand influences the transmission of U.S. MP shocks into highly-leveraged RE firms.

Demand as an Amplifier of the Construction-Financing Channel

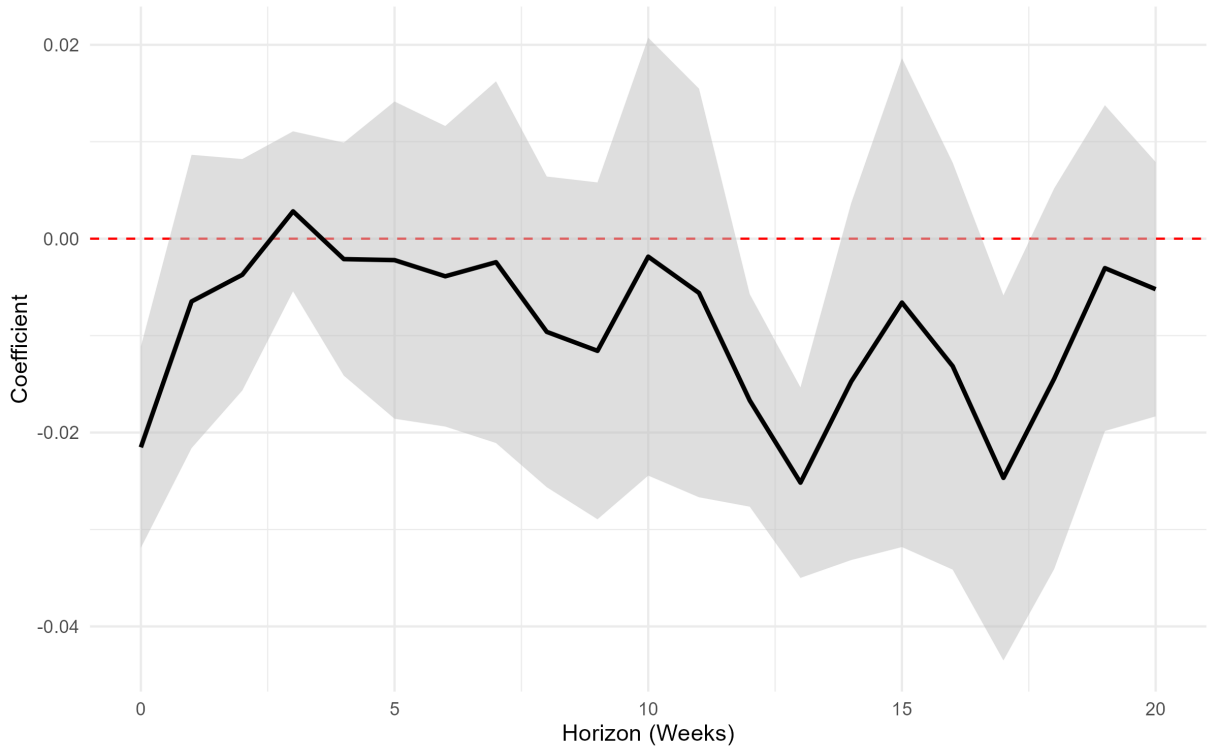


Figure 11: Triple Interaction among MP shocks, Debt Ratio and Housing Demand

- Interpretation: the negative effect of monetary tightening on construction is amplified in *previously* high-demand cities.

Local Spillover Effect from High FB Firms

We restrict the parcel-level sample to firms never issuing FB:

$$\begin{aligned} y_{i,c,t+h} - y_{i,c,t-1} =& \alpha_i + \tau_t + \beta^{(h)} \Big(MPS_t \times HighFb_c \Big) \\ &+ \sum_{p=1}^{4} \psi_p^{(h)} \Delta y_{i,c,t-p} + \varepsilon_{i,c,t+h} \end{aligned} \tag{1}$$

Where:

- α_i is the parcel fixed effect; τ_t is the week fixed effect
- $HighFB_c = 1$ if the land transaction share of FB firms are above medain
- $\beta^{(h)}$ captures the additional negative penalty specifically suffered by domestic firms operating in high-exposure cities.

Local Spillover Effect from High FB Firms

- Parcel of non-FB firms are more responsive in higher FB exposure cities

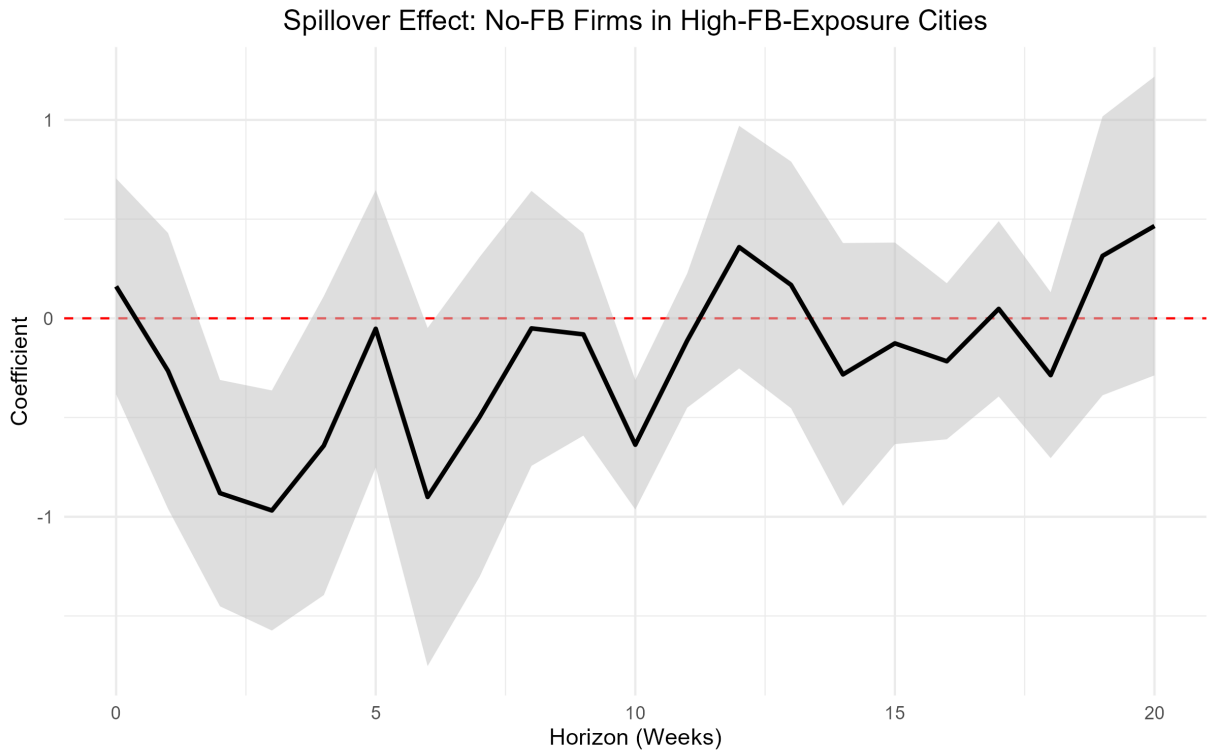


Figure 12: Triple Interaction among MP shocks, Debt Ratio and Housing Demand

External Validity: Cross-Country NTL Responses

- **Consistent measurement**: NTL provides a consistent aggregate comparison across countries, independent of national statistical systems.
- **Scope and limitations**: The lack of micro linkages prevents direct mechanism identification. Differences in responses between emerging and advanced economies may also reflect how NTL maps to real activity (e.g., construction/industrial vs. service/consumption).
- **Suggestive evidence**: Emerging economies show stronger NTL declines after U.S. tightening, consistent with the construction-financing channel.

External Validity: Cross-Country NTL Responses

- Weekly responses by economy: emerging economies are more affected

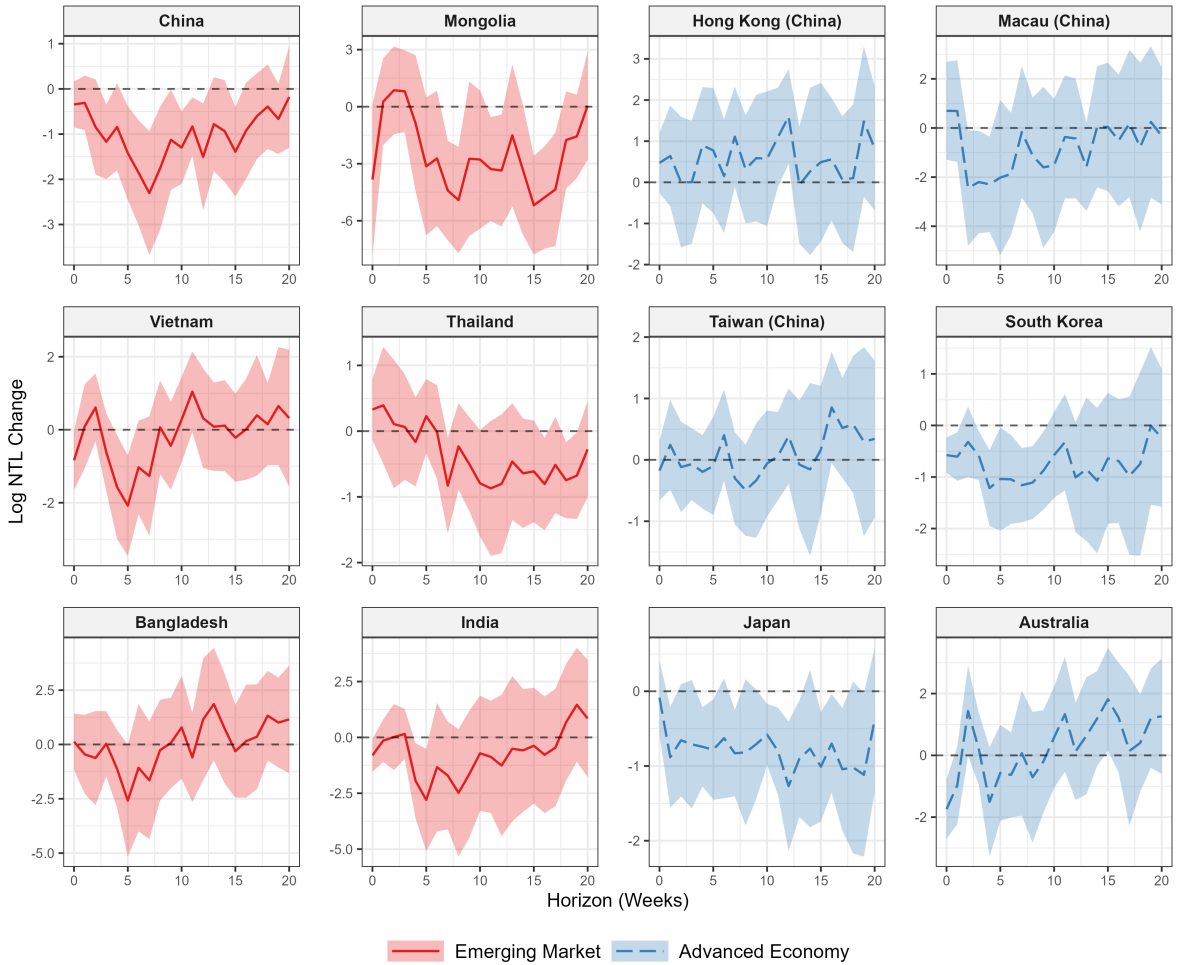


Figure 13: Response of NTL to U.S. MPs: Across Economies

Conclusion

1. We identify a construction-financing channel of international monetary policy spillovers: tighter U.S. monetary policy reduces local construction activity through developers' financing constraints.
2. China provides an ideal laboratory to isolate this mechanism using granular land, firm, and financing data.
3. Methodologically, the paper shows how NTLs combined with granular microdata can identify macro-financial spillovers at high spatial resolution.
4. This NTL-based framework can be extended to study geographically granular responses to trade shocks, industrial policy, and other macroeconomic disturbances.

Literature: Identifying Real Spillovers of U.S. MP

Macro evidence (VAR / FAVAR):

- Kim (2001), Maćkowiak (2007), Bluedorn and Bowdler (2011), Georgiadis (2016), Bhattarai and Neely (2022).
- **Limitations**: Low-frequency aggregate outcomes, subject to concerns about identification restrictions, model misspecification, and confounding shocks.

Our approach: High-frequency identification

- Combine monetary policy surprises in narrow windows (Gürkaynak et al., 2022; Gürkaynaka et al., 2005; Nakamura & Steinsson, 2018; Swanson, 2021) with high-frequency NTL data.
- Tight mapping reduces omitted variables and reverse causality, delivering sharper causal inference on real spillovers.

Literature: Identifying Transmission Channels

Existing channels:

- Trade (Li, Lu, Wei & Yao, 2025), financial conditions (Bräuning & Ivashina, 2020), exchange rate (Uribe & Yue, 2006).
- **Limitations**: Rely on country- or city-level aggregates where multiple channels are jointly embedded, making it difficult to isolate specific mechanisms.

Our approach: Spatially disaggregated and micro-linked data

- Exploit spatial flexibility of NTL data combined with transaction-level land data and firm-level financing information.
- Trace mechanism: U.S. monetary tightening reduces construction, especially for financially constrained, foreign bond–exposed firms.

Literature: Nighttime Light (NTL)

NTL as proxy for economic activity:

- Output proxy at aggregate levels to study growth or broad fluctuations (Henderson et al., 2012; Pinkovskiy & Sala-i-Martin, 2016).
- Recent work using high-frequency NTL for specific shocks (Chor & Li, 2024).

Our approach: A general methodological framework

- High-frequency NTL combined with extreme spatial granularity and micro-level data.
- Moves beyond aggregate proxies to identify exact economic mechanisms.
- Highly adaptable tool for mapping macro shocks to localized, sector-specific real outcomes (e.g., real estate construction).

Appendix

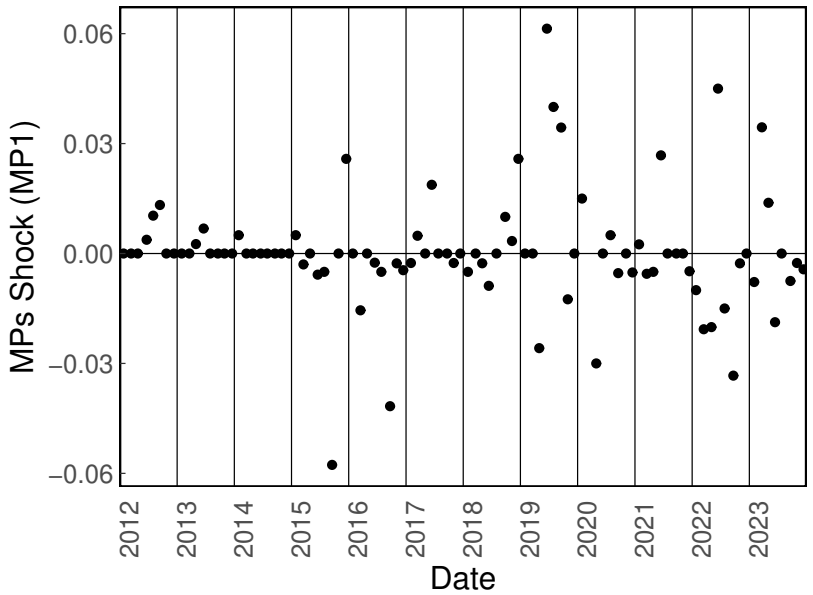


Figure 14: Proxies of Monetary Policy Shock: Baseline

◂ Return

Table 4: Summary Statistics: Weekly NTL and Shocks

	N	Mean	SD	Min	Max
Year	624	2017.51	3.45	2012.00	2024.00
Log NTL	624	0.00	0.17	-0.46	0.50
MPs: MP1	624	0.00	0.01	-0.06	0.06
MPs: Acosta	562	-0.00	0.01	-0.06	0.06
MPs: Target	562	0.01	0.15	-1.48	1.22
MPs: Path	562	0.01	0.31	-2.61	3.39
MPs: Forward Guidance	624	-0.01	0.40	-3.04	3.35
MPs: LSAP	624	-0.01	0.28	-4.13	1.74
MPs: Information	624	0.02	0.24	-1.84	1.92

◂ Return

Table 5: Regression of GDP on NTL: Sector

Dependent Variable:	Log GDP			
Sector:	All	Primary	Secondary	Tertiary
Model:	(1)	(2)	(3)	(4)
Variables (Second stage)				
Log NTL	0.4900***	0.1053	0.8280***	0.4938***
	(0.0793)	(0.0708)	(0.1254)	(0.0866)
Fixed-effects				
City	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
N	2,527	2,293	2,293	2,293
R^2	0.9873	0.9834	0.9676	0.9878
F-test	3,161.7	2,128.7	1,115.1	3,021.7

Return

Table 6: Regression of GDP on NTL: Periods

Dependent Variable:	Log GDP			
Period:	All	Exclude COVID	2012-2016	2017-2023
Model:	(1)	(2)	(3)	(4)
Variables (Second stage)				
Log NTL	0.2559***	0.4900***	0.9435***	0.2802***
	(0.0583)	(0.0793)	(0.1124)	(0.0844)
Variables (First stage)				
Log NTL (Lag 1)	0.7234***	0.6867***	0.5188***	0.5060***
	(0.0135)	(0.0220)	(0.0317)	(0.0627)
Fixed-effects				
City	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
N	3,475	2,527	1,580	947
R^2	0.9861	0.9873	0.9936	0.9953
F-test	2,041.7	3,161.7	10,708.6	21,922.0

◂ Return

Table 7: Regression of GDP on NTL: Trade and Construction Indicators

Dependent Variables:	Urbanization rate	Net export	Export	Import
Model:	(1)	(2)	(3)	(4)
Variables (Second stage)				
Log NTL	0.0433***	7.0013***	14.0010***	7.0535***
	(0.0121)	(1.3456)	(2.4384)	(2.0025)
Variables (First stage)				
Log NTL (Lag 1)	0.8419***	0.6942***	0.6927***	0.6959***
	(0.0141)	(0.0197)	(0.0193)	(0.0199)
Fixed-effects				
City	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
N	2,484	1,414	1,421	1,415
R^2	0.9876	0.8246	0.8472	0.8443
F-test	2,441.4	270.2	317.0	309.6

◂ Return

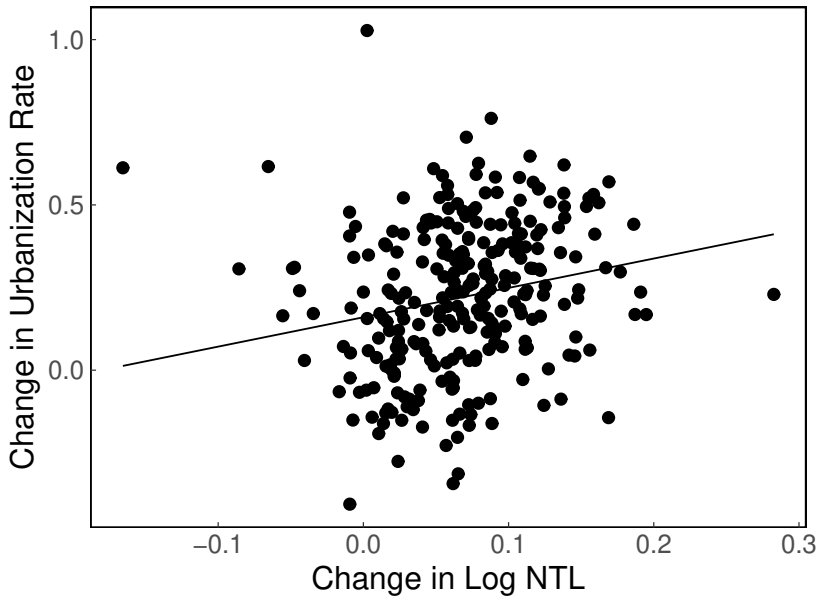


Figure 15: NTL and Urbanization Rate by City

◂ Return

Table 8: Regression of GDP on NTL: Countries by Income Group

Dependent Variable:	Log GDP		
Group:	All	Higher income	Lower income
Model:	(1)	(2)	(3)
Variables (Second stage)			
Log NTL	0.1420***	0.0403	0.1277**
	(0.0444)	(0.0717)	(0.0511)
Variables (First stage)			
Log NTL (Lag 1)	0.7791***	0.6812***	0.7687***
	(0.0407)	(0.0460)	(0.0588)
Fixed-effects			
Country	Yes	Yes	Yes
Year	Yes	Yes	Yes
Fit statistics			
N	1,997	984	1,003
R^2	0.9990	0.9992	0.9986
F-test	19,166.4	11,904.7	7,313.8

◂ Return

Table 9: Real Estate Firm Interest Expense (Scaled by Operation Indicator) Responses to MPs

	Interest Expense / Asset	Interest Expense / Liability	Interest Expense / Current Liability
MPs	3.1900***	3.7483***	2.9784***
	(0.7028)	(0.7870)	(0.7943)
Firm FE	Yes	Yes	Yes
N	4,832	4,832	4,831
R^2	0.8216	0.8175	0.8130

Return

Robustness of Baseline Results

- Different measures of monetary policy shocks (Acosta shocks)
- Alternative inference and estimation
  - Year-Quarter fixed effects
  - Different lags of dependent variables
  - Bootstrap standard errors
- Controlling for confounding factors
  - Economic news shocks: GDP, CPI, PPI, Retail, Employment
  - US industrial production
  - US-China tension index
  - Whether: temperature, visibility, and wind speed
- Alternative samples: pre-Covid, winter/summer, north/south

- Net export mitigates the negative effects
- USD appreciates after a tightening US shock ▸ USDCNY: Daily
- Cities with a more export-oriented economy are less negatively affected as the increase in exports offsets the adverse impacts

▸ Daily Interpolated Trade Exposure ▸ Regions ▸ Control: Weather

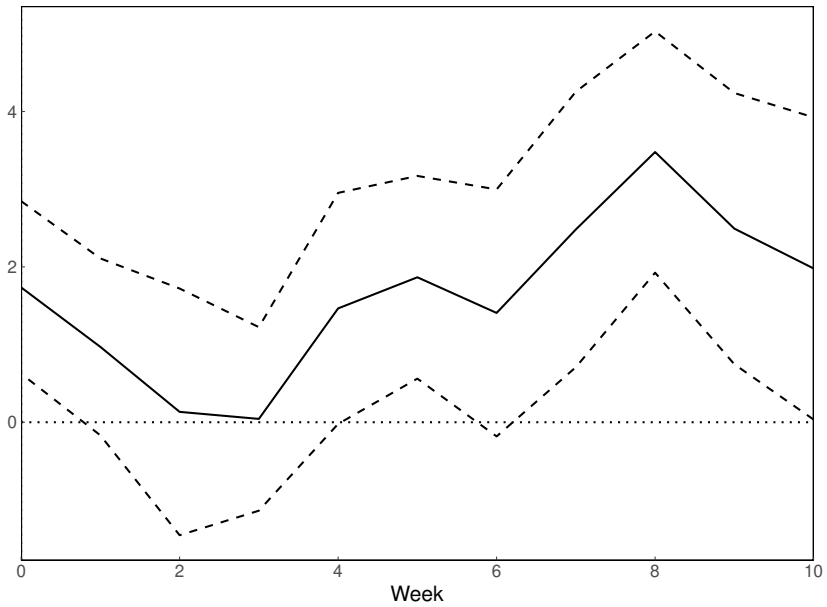


Figure 16: The Interactive Effects of US MPs and Trade Exposure on NTLs, City level

- Conventional and unconventional monetary policy shocks

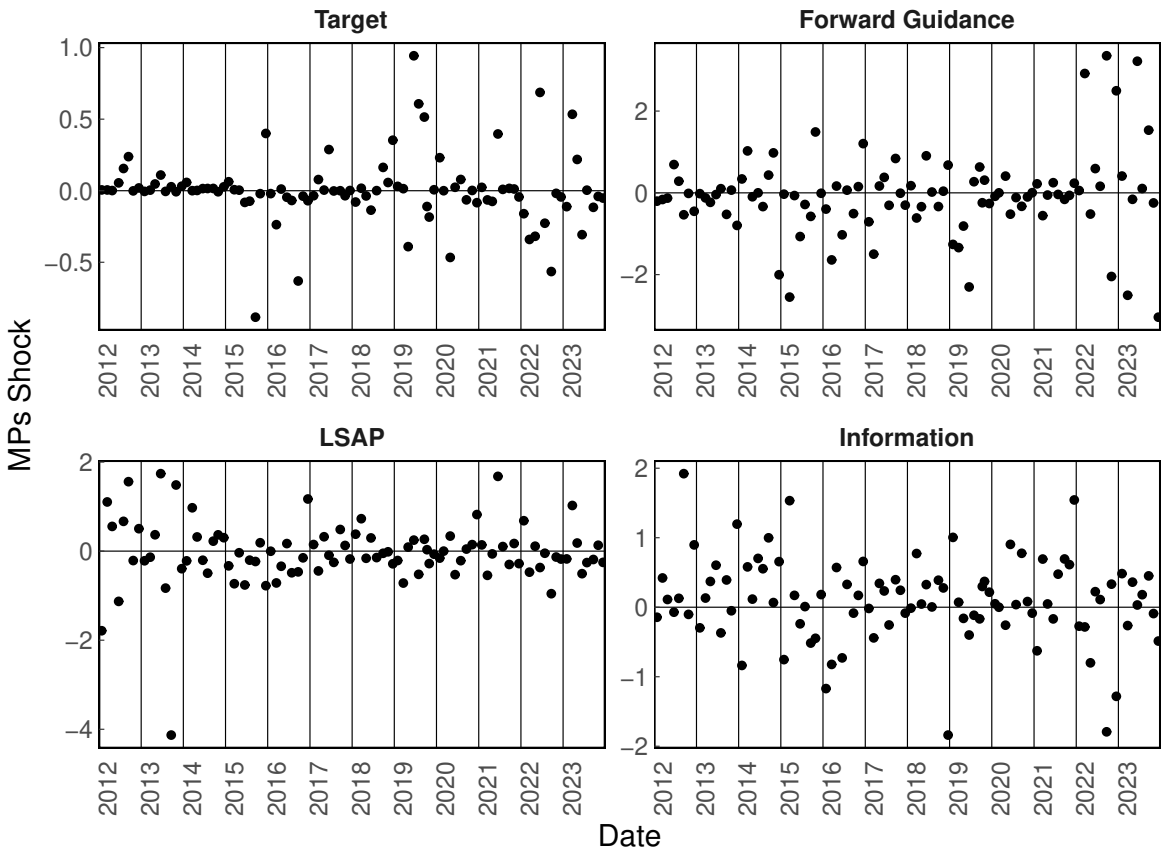


Figure 17: Proxies of Monetary Policy Shock

- Responses to conventional monetary policy shocks are stronger than responses to unconventional monetary policy shocks

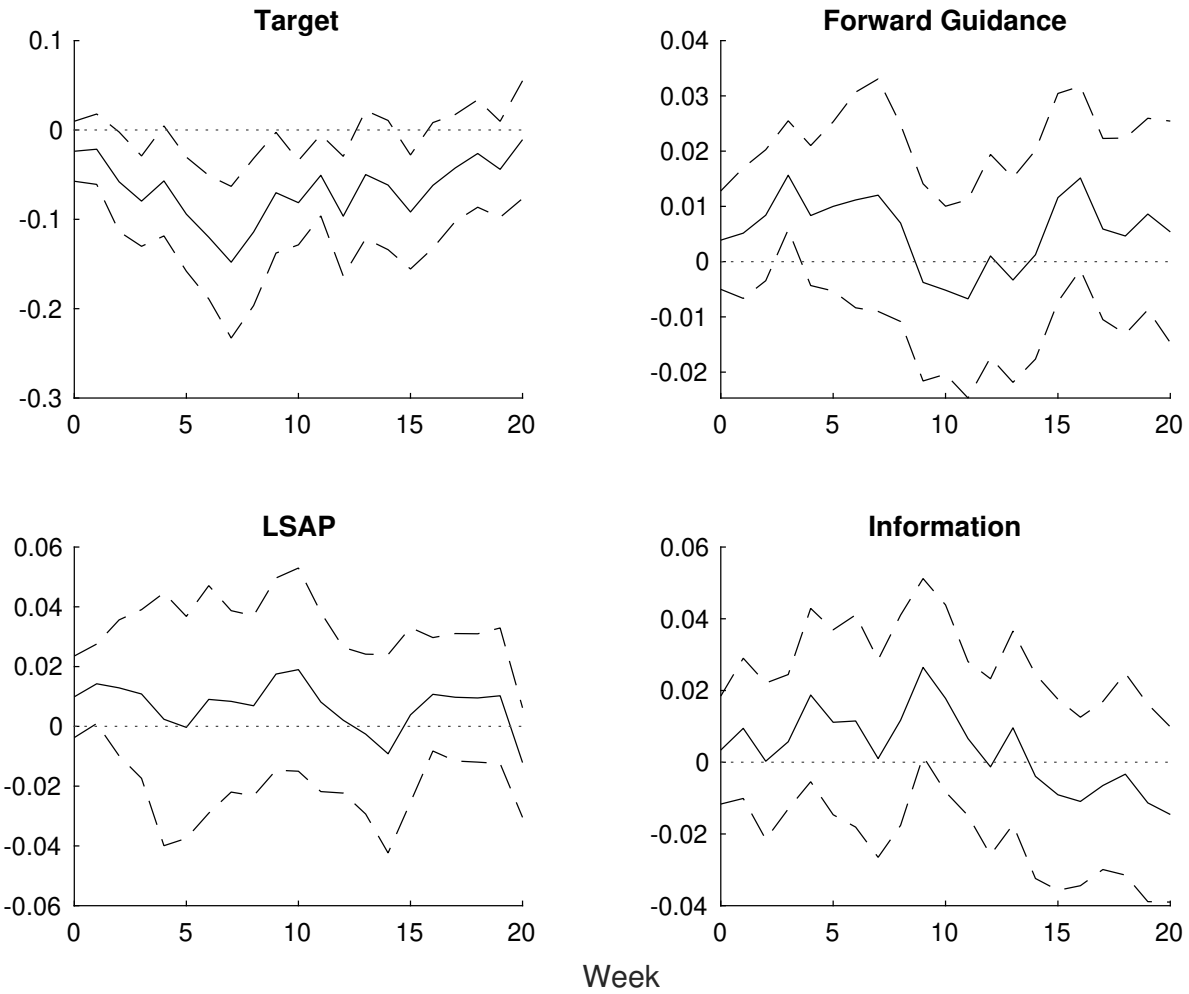


Figure 18: Responses of China's NTL on US MPs: Alternative MPs

- The MPs of ECB and BOJ

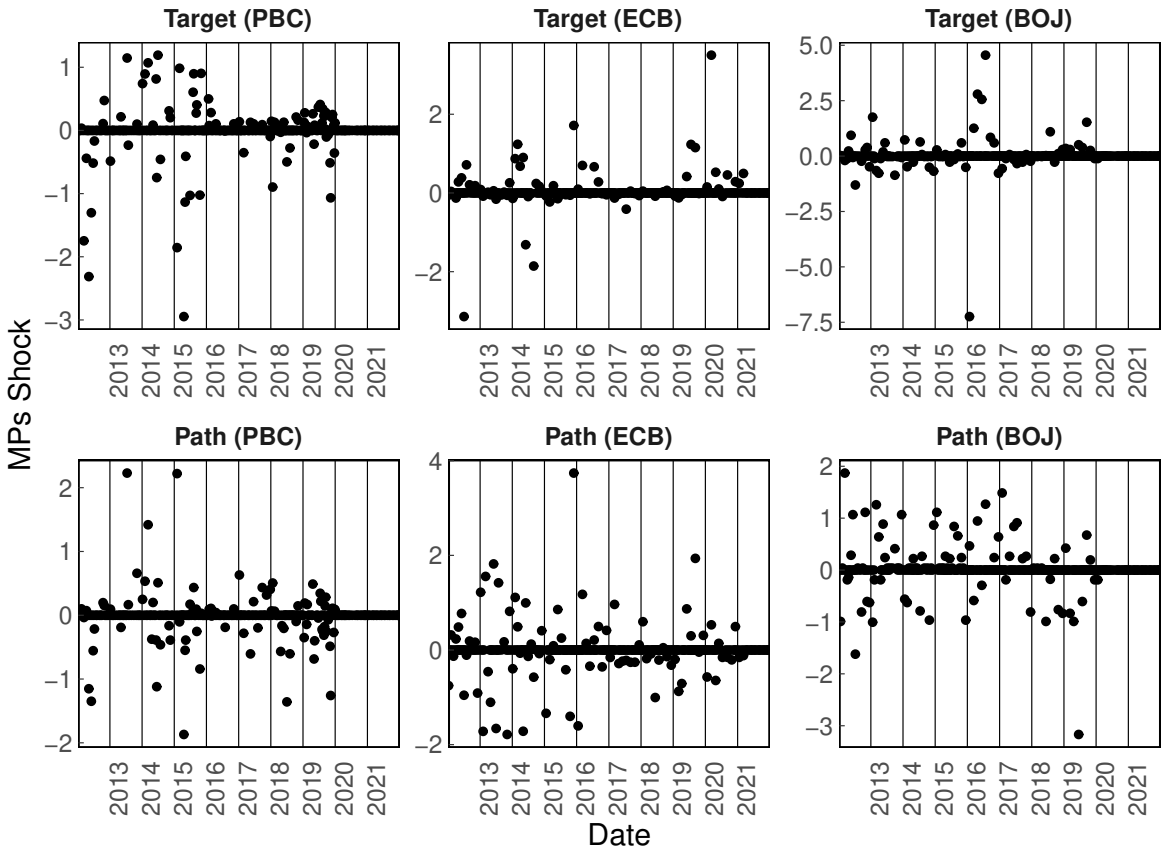


Figure 19: Proxies of Monetary Policy Shock: Other Central Banks

- China's NTL responses stonger to Fed shocks than to ECB or BOJ shocks

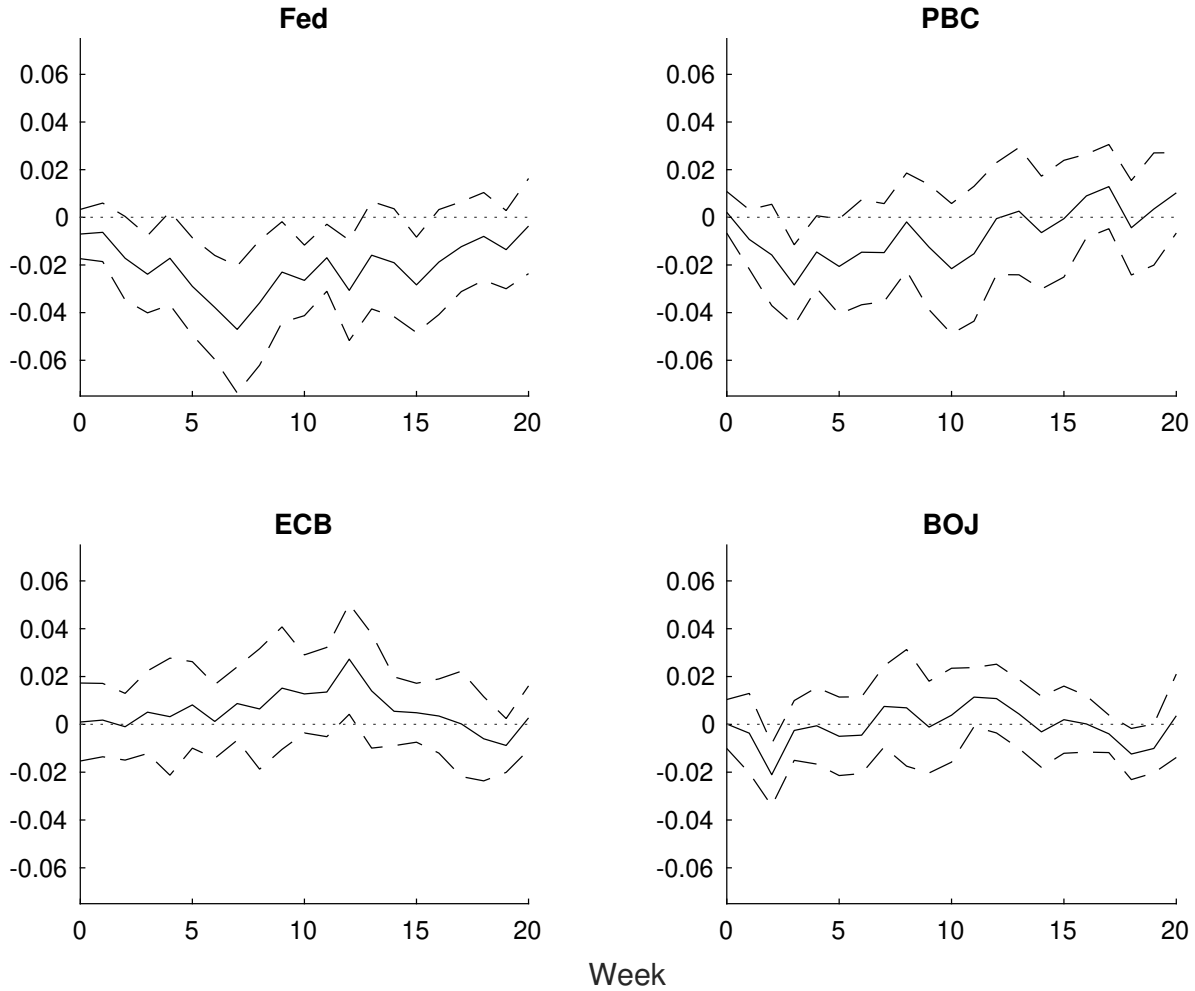


Figure 20: Responses of China's NTL to MPs by Different Central Banks

Quantifying the Financing Channel: Shapley R^2 Decomposition

Debt component	Foreign bonds	Domestic bonds	Domestic loans
Share of interaction variation	66.10%	16.03%	17.87%

- Including the three interaction terms leads to an increase in the overall R^2.
- The Shapley method fairly calculates how much of this increased explanatory power is driven by each debt component.
- It abstracts away from the direction of the effect (whether it exacerbates or mitigates the shock), focusing purely on "how much variation is explained by each component".
- Variance decomposition confirms the coefficient-based result.

Quantifying the Financing Channel: Shapley R^2 Decomposition

- The key result comes from the third red line: low cash relative to short-term debt.

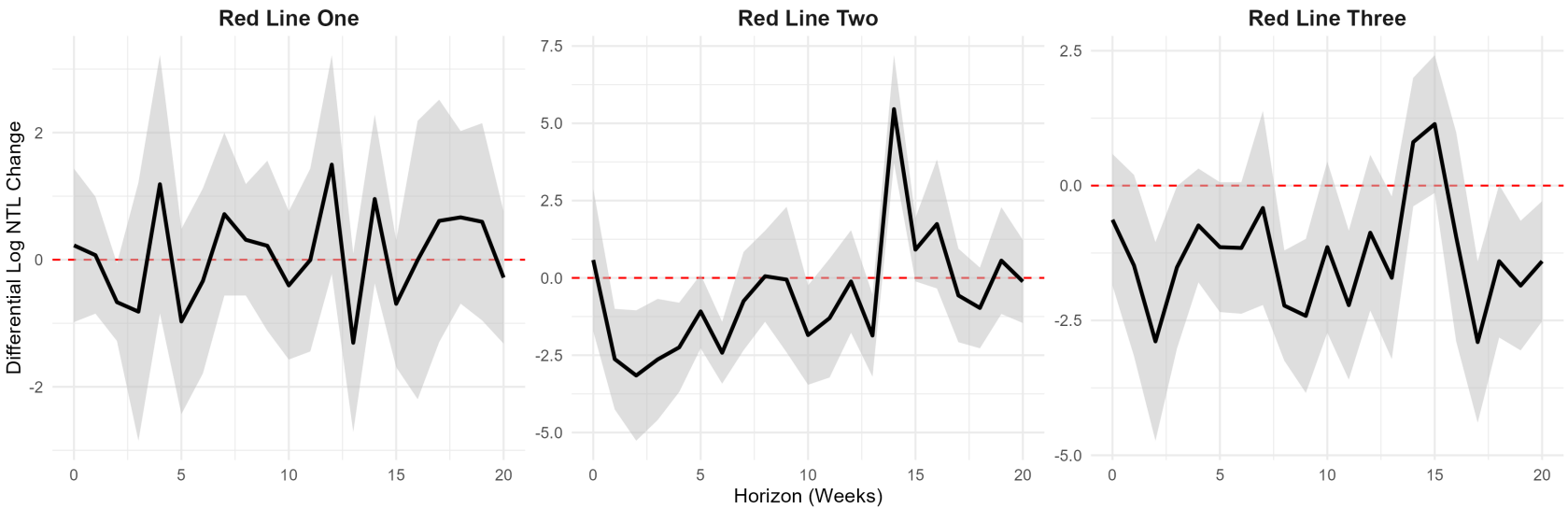


Figure 21: Dynamics of the triple-interaction term