

# The Impact of Monetary Policy Innovations on Firm Investment: The Role of Intangible Assets in China

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## Abstract

This paper studies the effects of monetary policy innovations on firm investment in China and the role of intangible assets in shaping monetary policy transmission. We construct a composite monetary policy index and extract policy innovations to study firm-level investment responses. The results show that expansionary monetary policy increases firm investment on average, but the response is significantly weaker for firms with higher intangible asset intensity. A one standard deviation increase in the intangible asset ratio reduces the investment response to a one standard deviation expansionary policy innovation by 23 to 39 basis points. A simple dynamic investment model, along with supporting evidence, highlights the financing and depreciation channels. Additionally, the moderation effect differs across ownership types, strategic industries, and regional financial development. These findings suggest that the rising importance of intangible capital dampens monetary policy transmission through the investment channel.

**JEL Classification:** E22, E52, G11, G32

**Keywords:** Monetary Policy, Intangible Assets, Firm Investment, Ownership Structure

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# 1 Introduction

Investment is crucial for both business-cycle fluctuations and long-term economic growth. The literature has shown that aggregate investment responds strongly to monetary policy (Christiano et al., 2005). In recent years, China has experienced substantial structural changes, with the government emphasizing innovation and technology advancement. Initiatives such as “Made in China 2025” highlight the importance of research and development (R&D), advanced manufacturing, and innovation to China’s long-term economic competitiveness (Wübbeke et al., 2016). The World Intellectual Property Organization reports that China has advanced in the Global Innovation Index, ascending from 34<sup>th</sup> position in 2012 to 11<sup>th</sup> position in 2024. Its leadership in global patent applications, filings, and trademark registrations indicates a shift towards an innovation-driven growth strategy. Consequently, intangible assets, encompassing intellectual property, economic competencies, and digitized information as classified by Corrado et al. (2022), have become essential to China’s economy. Understanding how firms with varying levels of intangible assets respond to monetary policy innovations is essential for implementing policies that support sustainable economic growth and stabilize economic fluctuations.

Central banks conduct expansionary monetary policy to stimulate economic activity by increasing the money supply and lowering interest rates. In classical textbook economic theory, such as the IS-LM model, the equilibrium in the financial market associates money supply with bond prices, hence linking the quantity of money to interest rates and affecting firms’ borrowing costs. Rising interest rates reduce investment by increasing borrowing costs, as the firms make their investment decisions on the expected returns from the marginal benefit of capital relative to the cost of borrowing. Nevertheless, empirical evidence shows that the effectiveness of the policy varies, and actual investment behavior may be unresponsive to interest rate adjustments due to the existence of frictions (Chirinko, 1993; Ottonello and Winberry, 2020; Sharpe and Suarez, 2015). The discrepancy is frequently attributed to factors such as capital adjustment costs and financial frictions, among others. So firms with a larger proportion of intangible capital, which tend to have the characteristics of low collateral value, dependence on internal financing, high depreciation rates and adjustment costs, may exhibit reduced responsiveness to monetary policy relative to those with a higher amount of physical capital. This study examines whether firms with more intangible capital exhibit reduced sensitivity to the monetary policy innovations in an emerging

economy with underdeveloped financial market and an evolving monetary policy framework. It also investigates whether the effect varies among different firms with distinct characteristics and identifies the underlying mechanisms using data from China.

In contrast to an advanced economy such as the United States, which primarily employs price-based monetary policy, China’s monetary policy is shifting from quantity-based instruments to price-based instruments and currently operates under a dual-track system that is opaque and less well understood. As [El-Shagi and Jiang \(2023\)](#) document, these dual channels operate through segmented bond markets and generate heterogeneous effects across firms depending on their access to financing. This institutional feature implies that the impact of monetary policy on investment cannot be fully understood without considering firm characteristics that shape their sensitivity to these policy changes. Building on this insight, we study how intangible asset intensity influences the transmission of monetary policy to firm-level investment in China.

China’s monetary system applies many instruments (People’s Bank of China (PBoC) 7-day reverse repo rate, Open Market Operations (OMO), Deposit rates, Medium-term Lending Facility (MLF) rate, Required Reserve Ratio (RRR)) and operational targets (Monetary base, 7-day interbank pledged repo rate (DR007), Loan prime rate (LPR)) to achieve its objectives ([Fernald et al., 2014](#)). These attributes complicate the investigation of its monetary system. However, examining the efficacy of monetary policy in an emerging economy that emphasizes innovation and economic competencies, under a developing monetary framework, has wider implications for other countries experiencing a comparable phase. Moreover, China is the world’s second-largest economy. Its monetary policy could potentially affect global trade, commodity prices, and business cycles, and potentially have international transmission.

We study how the mix of a firm’s capital, especially tangible versus intangible assets, influences its investment response to monetary policy innovations in China, thus revealing the importance of intangible assets in this context. We first develop a Composite Monetary Policy (CMP) index that reflects the policy stance by integrating six most salient PBoC tools and intermediate targets into a single factor through principal component analysis (PCA). This method reduces dimensions and extracts key information contained in monetary policy. Central bankers do not alter monetary policy randomly. Therefore, part of the variation in the CMP index represents an endogenous response to the economy and con-

tains information from previous periods. To examine the monetary transmission via investment, we extract unanticipated monetary policy changes from the CMP index, following the method developed in [Chen et al. \(2018\)](#). The innovation series are the residuals from a reaction function that controls for the persistence of the policy, the GDP growth gap, and fluctuations in the exchange rate. This method assumes that firms believe the PBoC follows a monetary policy rule interpreted as a reaction function to key macroeconomic variables, and that unexpected changes are innovations to this policy rule.

This study focuses on a period that featured a dual-track monetary policy system and the rising intangible capital share. From 2016, China's primary economic driver shifted from international trade to domestic investment and innovation, and it experienced supply-side reforms. At the same time, the People's Bank of China continuously reformed its monetary policies. However, recent studies on price-based monetary policy instruments in China have revealed that, so far, the transmission of these interest rates is limited. Our data sample covers quarterly data on listed A-share companies from the first quarter of 2016 to the first quarter of 2024 in China. The baseline result reveals that a one standard deviation expansionary monetary policy innovation raises the investment ratio by approximately two percentage points. However, the increase is 23-39 basis points smaller for each standard deviation increase in a firm's intangible share over the 6- and 10-quarter horizons.

To address concerns that domestic omitted variables influence the empirical results and that unanticipated innovations we construct may not be entirely exogenous for firms, we conduct additional testing on a subsample employing an instrumental variable (IV) strategy. We use the Global Economic Policy Uncertainty (GEPU) index, a GDP-weighted, news-based measure of global policy uncertainty, as an external instrument for monetary policy innovations, assuming that variations in global uncertainty will affect the monetary policy of the People's Bank of China without directly impacting domestic firms' investment decisions. The IV estimates validate the moderating effect of intangibles on the transmission of monetary policy.

We construct a simple two-period firm investment model to demonstrate how intangible assets influence the responses of firms to monetary policy innovations. The model implies that firms with greater financial constraints, higher depreciation rates on capital, and higher capital adjustment costs will exhibit lower responsiveness to changes in monetary policy. These are the aspects through which

intangible assets may differ from tangible assets.

We test these mechanisms using our data sample from China. We find that the investment gap between intangible and tangible firms widens with the increase in financial constraints, proxied by cash holdings and leverage. We also observe that the differential response is more pronounced in less developed cities, suggesting that the market and financial environment determines whether intangible assets mitigate the impact of monetary policy. We illustrate that the influence of intangible assets on reducing the sensitivity of investment to monetary policy innovation is contingent upon the depreciation gap between physical and intangible assets. We interpret these findings as suggestive evidence for financial friction, depreciation rates channels. However, we do not find empirical support for the adjustment cost channel.

The market structure and industrial policy in China significantly influence the economy. We further document heterogeneous effects contingent upon ownership structure and the industries in which the firms operate. Only non-state-owned enterprises (non-SOEs) and firms in strategic-emerging industries increase investment in response to expansionary monetary policy innovations. They are relatively less responsive when possessing a higher share of intangibles. The proportion of intangible capital is irrelevant for state-owned enterprises (SOEs) and firms outside strategic-emerging industries, as they are unaffected by changes in monetary policy in the first place. SOEs have government support and can get sufficient funding regardless of economic conditions, while firms outside strategic-emerging industries struggle to obtain external financing because of the targeted industrial policies.

In contrast to the United States, where only traded intangible capital is recorded on the balance sheets and perpetual inventory methods are employed to estimate intangible capital, firms in China offer a direct measurement of intangible capital in accordance with its accounting principles, allowing for direct examination of the role of intangible capital in monetary transmission. Moreover, China is making progress in patent trade, and around 100 listed firms have started record data assets as components on their balance sheets since 2024. Because of this trend, it is essential to understand how intangible assets affect the economy and financial markets.

We contribute to the literature in three distinct ways. First, we provide new empirical evidence that intangible capital mitigates the investment response to monetary policy in a developing and evolving monetary policy framework. Second,

we show that this dampening effect is not uniform across firms but is shaped by institutional characteristics specific to China, being concentrated among non-state-owned firms, firms in strategic emerging industries, and firms in financially developing regions. This finding highlights that intangibles moderate monetary transmission only where firms can effectively convert these assets into financing capacity or policy support. Third, we develop a dynamic firm investment model to illustrate the mechanism through which intangible capital weakens the sensitivity of investment to movements in the user cost of capital.

**Related Literature.** This paper contributes to three strands of the literature. This paper contributes to the literature on monetary policy shocks and real activity by providing evidence from China, where identifying policy innovations is more challenging than in advanced economies. In the United States, monetary policy shocks are commonly identified using VAR-based approaches (Christiano et al., 2005), narrative measures (Romer and Romer, 1989, 2004), or high-frequency surprises around FOMC announcements (Gürkaynak et al., 2005; Gertler and Karadi, 2015). The direct application of these methods to China is less straightforward, given the PBoC’s multi-instrument framework, the coexistence of quantity- and price-based tools, and the opacity of the ongoing transition toward an interest-rate corridor system.

A growing body of work has developed alternative identification strategies tailored to China. For example, Chen et al. (2018) explore the transmission of China’s quantity-based monetary policy on shadow banking loans and total bank credit from 2009 to 2015, a period in which the PBoC used M2 growth as its principal tool, adjusting it in response to inflation and deviations in GDP growth from the set targets. They estimate this policy rule using the maximum likelihood estimation (MLE) method and derive an exogenous series of M2 growth. Several studies adopt alternative approaches to measure monetary policy shocks in China. Fernald et al. (2014) estimate a factor-augmented VAR to assess the macroeconomic effects of policy, while Sun (2020) constructs narrative indicators and examines high-frequency market responses using an event-study design. Others exploit financial-market movements around major policy announcements to identify unexpected policy components (Kamber and Mohanty, 2018; Lu et al., 2023), or use derivatives-based price changes to extract policy factors and study their effects on financial markets and real activity (Shieh, 2024). Building on this literature, we construct a composite monetary policy (CMP) measure that summarizes both quantity- and price-based instruments into a single index. We

then extract the unexpected component of this index through an estimated policy rule, following the spirit of [Chen et al. \(2018\)](#). This innovation series provides a tractable measure of monetary policy shocks suitable for studying firm-level investment responses over longer horizons using local projections.

Second, we contribute to the literature on the investment channel of monetary policy, specifically regarding the significance of firm heterogeneity in the transmission. Prior studies find that the firm-level response to monetary policy depends on size ([Gertler and Gilchrist, 1994](#); [Lu et al., 2023](#)), age ([Cloyne et al., 2023](#); [Durante et al., 2022](#)), default risk ([Ottonello and Winberry, 2020](#)), debt maturity ([Deng and Fang, 2022](#)), asset pledgeability ([Silva, 2019](#)) and various other firm characteristics. Within this literature, the most relevant paper to ours is [Döttling and Ratnovski \(2023\)](#), which demonstrates that firms with a greater proportion of intangible assets exhibit diminished sensitivity to monetary policy shocks in their stock prices and investment reactions in the United States, emphasizing the credit channel of monetary policy. Our research focuses on examining the role of intangible assets within the dual-track monetary policy framework, evaluating the credit channels, depreciation channels, and adjustment cost channels in China. The country is rapidly advancing in accumulating intangible capital, fostering innovation, and enhancing its economic competencies, with evolving financial institutions. Specifically, we find that the ownership structure of firms and industrial policy significantly influence monetary transmission.

Lastly, this paper also contributes to the growing literature on intangible assets and their impact on firms' decisions and the aggregate economy. [Corrado et al. \(2022\)](#) document the recent rise in the share of intangible assets in the United States and European countries, examining how accounting for intangible capital changes the aggregate measurement of investment, rates of return, and GDP. [Crouzet et al. \(2022\)](#) emphasize the important role of intangible capital to explain the current trends in productivity, factor shares, investment, rents, market power, and firm financing. [Peters and Taylor \(2017\)](#) develop a method for measuring off-balance sheet firm-level intangible assets and show that incorporating intangible capital in measuring total capital stock helps improve the performance of the standard Q theory of investment. It has been widely acknowledged in the literature that firms with a greater proportion of intangible assets typically use less debt and rely more on internal funding, as intangible assets often have lower collateral value in comparison to tangible assets ([Bates et al., 2009](#); [Falato et al., 2022](#)). [Sun and Xiaolan \(2019\)](#) discover that firms tend to finance intangible investment via

employee compensation contracts. The study by [Lim et al. \(2020\)](#) examines the distinction between internally-generated intangible assets and identifiable intangible assets, suggesting that the former ones may discourage debt financing while the latter can support it. [Li \(2025\)](#) utilizes a macroeconomic model to demonstrate that when firms augment savings for liquidity purposes and support investment in intangible assets, it leads to reduced interest rates and increased financial instability. Based on these established findings, we anticipate that the investment channel of China’s monetary policy transmission will be influenced by the interactions between firm investment and financing decisions, and also the existence of financial frictions and adjustment costs. We document the rising trend of intangible capital in China and show that a larger share of intangible assets reduces the stimulative effects of expansionary monetary policy. Our results offer a unique perspective on the efficacy of monetary policy during a period of economic transition characterized by a shift in capital composition and the evolution of the monetary policy framework, highlighting the need to address the mitigation effects of intangible capital when implementing monetary policy.

The remainder of the paper is organized as follows. Section 2 details the construction of the Composite Monetary Policy index, extracts unexpected components from the index, and presents the innovation series. Section 3 describes the data and analyzes firm-level investment responses to the monetary policy innovations. Section 4 develops a dynamic firm investment model for illustrating the mitigation role of intangible assets. Section 5 explores financing, depreciation, and adjustment costs channels through empirical analysis. Section 6 concludes, discusses limitations, and outlines directions for future research.

## 2 Measuring China’s Monetary Policy Stance

### 2.1 Overview of China’s Monetary Policy

China’s monetary policy operates within a multi-instrument framework that has evolved substantially over recent decades. While earlier work often emphasized M2 growth as the primary intermediate target, [Sun \(2018\)](#) shows that quantitative indicators such as M2 do not always align closely with broader measures of monetary conditions, highlighting the difficulty of characterizing policy stance using any single variable. Moreover, as interest rate liberalization has progressed, the PBoC has increasingly relied on market-based tools alongside traditional quantity-based

instruments. Given that the central bank pursues multiple objectives and does not follow an explicit policy rule, recent practice has increasingly adopted a combination of both quantity- and price-based indicators to capture overall monetary conditions.

## 2.2 Construction of the Composite Monetary Policy Index

Specifically, the PBoC governs monetary policy for a set of intermediate targets, including market interest rates, M2, and bank credit. The M2 growth rate remains a widely recognized quantity-based target in China. Nevertheless, price-based targets, such as the Repo 7-Day rate (R007) and the Depository Institutions Repo 7-Day Rate (DR007), have become increasingly important. To facilitate our empirical analysis, we construct a composite monetary policy (CMP) measure that aggregates several commonly used instruments and targets into a single summary index<sup>2</sup>.

The quantity-based instruments include the required reserve ratio (RRR) and the volume of open market operations (OMO). The Required Reserve Ratio and Open Market Operations are widely recognized instruments that the PBoC applies to influence the overall liquidity of the economy. Price-based instruments include the interest rates associated with overnight standing lending facilities (SLF) and medium-term lending facilities (MLF). The SLF rate serves as a benchmark for borrowing costs for policy and commercial banks, particularly in the context of meeting regular and large-scale liquidity requirements (People’s Bank of China, 2013). The MLF rate functions as a medium-term policy rate that affects the costs of medium-term financing and market expectations for financial institutions (People’s Bank of China, 2014)<sup>3</sup>. We exclude the benchmark lending rate from our index construction, as it exhibits negligible variation during the study period. We also omit the loan prime rate, as it began to fluctuate more frequently only after 2019.

Furthermore, we incorporate the intermediate targets, specifically the 7-day inter-bank repo rate and the year-on-year growth rate of M2, into the construction of the Composite Monetary Policy index. Chen et al. (2018) illustrates that not all changes in monetary instruments are immediately transformed into growth in

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<sup>2</sup>We present the time series plots of the instruments over the sample period in the Appendix A.1. The variables present different behaviors over time.

<sup>3</sup>Since 2025, the PBoC employs a multiple-price auction for MLF operations and has ceased to disclose a specific unified MLF rate. It no longer serves as a policy indicator.

M2. Commercial banks and financial institutions may decide to retain the funds instead of issuing new loans. We use the M2 growth rate not only because it is a broad indicator of the money supply in the economy, but it also accounts for the lagged effects of monetary policy instruments, hence offering a comprehensive measure of monetary policy stance over time. Likewise, the 7-day repo rate is the price-based intermediate target that has been shown to significantly impact the real economy (Lu et al., 2023).

We retrieve a series for each variable from the CEIC database at a monthly frequency, contingent upon data availability. Our sample period spans from January 2016 to March 2024, during which we studied the dual-track monetary system and the significance of increasing intangible capital for the investment channel of monetary transmission. The composite index will yield an integrated representation of the underlying monetary policy stance. Table 1 contains the descriptive data for the four instruments and two intermediate targets we include in this study<sup>4</sup>.

**<Insert Table 1 Here>**

Considering these direct instruments and intermediate variables, together with a complicated policy framework and multiple objects that the PBoC needs to attain, we seek to reduce dimensionality and quantitatively assess the underlying shifts in the monetary policy stance. To address this issue, we employ Principal Component Analysis, presuming that the PBoC and the central government adjust the instruments and influence the intermediate targets, guided by their objectives regarding economic movements. With the sophisticated economic structures and evolving institutions, this must be accomplished by simultaneously modifying the tools. We seek to examine the real impact of monetary policy on the economy, intentionally omitting the intricate interactions between these instruments and their intermediate targets, and concentrating on the final medium-term to long-term consequences for investment.

**<Insert Figure 1 Here>**

Based on the estimated weights for each variable, we compute the CMP index over time, as illustrated in Figure 1. A positive index indicates a contractionary monetary policy stance, while a negative index implies an expansionary policy stance. The Composite Monetary Policy (CMP) index turned positive in 2017.

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<sup>4</sup>The positive value for open market operations represents net injection into money circulation.

This pattern is consistent with Governor Zhou Xiaochuan’s speech at the 32nd G30 Annual International Banking Seminar, during which he emphasized the necessity for a more contractionary policy to limit excessive credit expansion (Zhou, 2017). Notably, the CMP index significantly declined in early 2020, shifting from a positive value to negative 1.5 in April. This sharp decline corresponds to the urgent need to stimulate the economy because of the adverse impact of the Covid-19 pandemic, as noted in the Q4 2020 Monetary Policy Report (People’s Bank of China, 2021). Subsequent to the significant decline, the index fluctuates yet mainly remains in the negative range, indicating that the PBoC has continued to employ relatively loose monetary policies to facilitate economic recovery. The trend of the CMP index aligns with prevailing market expectations and the stated intentions of central bankers.

### 2.3 Construction of Monetary Policy Innovations

The People’s Bank of China (PBoC) has the authority to implement monetary policy, under the guidance of the State Council, to achieve its objectives of ensuring currency stability and promoting economic growth. China’s monetary policy variations typically correspond to the central government’s and the PBoC’s apprehensions about the macroeconomy. A portion of the change in the CMP index reflects an endogenous response to the economy and contains information from previous periods. To examine the investment transmission channel of monetary policy using firm-level data, we need to isolate the unanticipated changes in monetary policy to construct an innovation series for establishing causality and identification purposes.

In this paper, we use our CMP index as an indicator for the integrated monetary policy stance. The endogenous change comprises the anticipated adjustments based on observable economic indicators known by the PBoC and other economic agents. The exogenous adaptation of monetary policy in our model refers to unexpected changes or innovations that are not explained by the endogenous variables incorporated in the model describing the policy rule, and is measured by the residual term. To distinguish between endogenous and exogenous impacts, we need to specify the factors taken into account when setting monetary policy. Chen et al. (2018) assert that the People’s Bank of China considers the inflation rate and the disparity between actual GDP growth and the growth target as primary objectives of the Monetary Policy Committee in determining M2 growth from 2009 to 2015.

Recently, the targets have shifted, prioritizing GDP growth rate and exchange rate stability, while the emphasis on inflation has diminished. According to the objectives of the monetary policy outlined by the People’s Bank of China, maintaining the stability of the CNY currency’s value and promoting economic growth are primary goals. [People’s Bank of China \(2024\)](#) summarized its monetary policy in its monetary policy reports, focusing on bolstering the economy, stimulating effective demand, and stabilizing the exchange rate. In comparison, the reports did not specify any instruments to control inflation, and the PBoC asserted that there was no evidence suggesting that China would experience long-term deflation or inflation. During our sample period, the PBoC also introduced several targeted credit and lending programs aimed at specific sectors (e.g., agriculture, small businesses, or carbon reduction facilities; [People’s Bank of China, 2024](#)). We exclude these sector-specific instruments from the CMP index, as our objective is to capture broad economy-wide monetary policy stance rather than industry-directed interventions.

### 2.3.1 Data and Model Specification

In our baseline model, we incorporate two macroeconomic factors to model the endogenous response in monetary policy: the difference between the actual GDP growth rate and the PBoC’s growth target, and the measurement of exchange rate stability with the RMB Index. We construct the series at a quarterly frequency to align with the firm-level data sample. The CEIC database contains quarterly GDP growth rate data. China sets its GDP growth targets annually, and we assume them to be constant across each quarter within the year. Hence, we can obtain the GDP growth gap by subtracting the growth target from the actual growth rate in each quarter. Additionally, we employ the Bank for International Settlements (BIS) RMB Index to measure the effective exchange rate of the Chinese renminbi. The RMB Index uses a currency basket determined by the Bank for International Settlements and the currency weights assigned by the BIS standard. The index value is calculated based on the daily CNY central parity rate and cross-currency foreign exchange rates against the USD. We also use the China Foreign Exchange Trade System (CFETS) RMB index as a robustness check to ensure that the selection of the sample currency and the relative weights do not dominate the result. These index values are available at a weekly frequency, and we calculate the within-quarter average to obtain a quarterly frequency. The model for the policy rule is constructed as follows, in a method similar to that employed in

Chen et al. (2018):

$$CMP_t = \beta_0 + \beta_1 \cdot CMP_{t-1} + \beta_2 \cdot GDPgap_{t-1} + \beta_3 \cdot RMB_{t-1} + \epsilon_t \quad (1)$$

where  $CMP_t$  is the value of the Composite Monetary Policy index,  $RMB_{t-1}$  represents the lagged value of RMB Index, and  $GDPgap_{t-1}$  is the lagged value of the GDP gap, and  $\epsilon_t$  represents the residuals or unexpected innovations to the monetary policy stance. The lagged value of the CMP index is included to account for the persistence in the monetary policy. We take a one-period lag in the independent variables to indicate that the PBoC sets policy based on the conditions in the previous period. In an alternative specification, we estimate a model that includes inflation and unemployment rates as additional endogenous macroeconomic variables, as in [Romer and Romer \(2004\)](#). These alternative specifications capture different assumptions about the set of macroeconomic conditions considered by the PBoC and the State Council when adjusting monetary policy.

Our identification strategy is closely related to a broader literature that interprets monetary policy shocks as the residuals from policy reaction functions. For example, [Iacoviello and Navarro \(2019\)](#) identify U.S. monetary policy shocks using the residuals from regressions of the federal funds rate on domestic macroeconomic conditions, global factors, credit spreads, and policy trend components. In this spirit, we interpret the residuals from our policy equations as exogenous monetary policy innovations.

### 2.3.2 Estimating Monetary Policy Innovation

Table A.3 in Appendix A.3 presents the estimated results for the monetary policy rule. The signs of the coefficients align with economic intuitions. The lagged GDP gap exerts a positive impact on the CMP index across all specifications, suggesting that the PBoC implements contractionary policies when the economy is overheating. The lagged value of the RMB index exhibits a negative effect on the CMP index. This result suggests that the PBoC tends to implement expansionary policies (such as lowering interest rates and expanding the money supply) when the Chinese renminbi appreciates in value. All estimates are significant at the 1% level when employing the BIS RMB Index as a proxy for measuring exchange rate stability. From the regressions, we extract the residuals  $\epsilon_t$  representing the unexpected monetary policy innovations. Figure 2 demonstrates that the residuals from all specifications fluctuate around zero. The patterns of the

residuals from these different specifications closely coincide with each other. The innovations derived from incorporating additional endogenous variables (CPI and Unemployment Rate) closely track the ones obtained from the baseline model, which supports our previous assertions that the inflation rate is not a major concern for the PBoC during our sample period. The exogenous innovations series allows for the analysis of firm-level investment responses to monetary policy and the role of the intangible-to-total capital ratio in mitigating its effects through OLS regressions.

<Insert Figure 2 Here>

### 2.3.3 Validity Check Using Market Interest Rates

We examine the impact of our innovation series on the 90-day Shanghai Interbank Offered Rate (Shibor) as a validity check. The Shibor rate is a daily reference rate that represents the average wholesale, unsecured interest rate at which highly rated banks in China lend money to one another<sup>5</sup>. The 90-day Shibor reflects borrowing costs in China’s money market, derived from quotes from 18 key commercial banks engaged in open market and foreign exchange operations ([National Interbank Funding Center, 2024](#)). Therefore, Shibor is an important indicator of liquidity conditions in China’s banking system and is closely monitored by market participants, including financial institutions, policymakers, and investors.

To evaluate the effectiveness of the constructed innovations in affecting aggregate variables, we conduct two regressions. In the first regression, the dependent variable is the current 90-day Shibor rate, and the independent variables are the constructed innovation series under different specifications. The goal is to determine whether the innovations effectively predict the change in the Shibor rate, thereby influencing overall financial conditions. In the second regression, the dependent variable is the lagged 90-day Shibor rate, with the same constructed innovation series as independent variables. This regression tests whether the innovations have any significant correlation with the Shibor rate of the previous period. The absence of correlation with the lagged Shibor rate indicates that the innovations are specific to the current period and are not influenced by past conditions.

Table A.4 in Appendix A.4 shows the results of this validity check. The results

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<sup>5</sup>Please note that Shibor rate is a market-determined benchmark rate utilized for pricing loans, bonds, and derivatives, distinct from the policy rates set by the PBoC.

from the first regression suggest that our constructed innovation series has a statistically significant impact on the current 90-day Shibor rate at the 1% level. In contrast, the second regression reveals that the constructed innovation series is not significantly correlated with the lagged 90-day Shibor rate. These results indicate that the innovations have predictive power. They do not represent the continuation of past trends in the market, but rather exert their influence specifically in the current period.

### 3 Firm-Level Investment Responses to Monetary Policy Innovations

One essential aspect to assess the effect of monetary policy is through the analysis of the investment channel. Investment is comparatively more volatile and has substantially contributed to China's economic growth over the past several decades. Traditionally, most investments are primarily allocated to physical capital and the accumulation of tangible assets. China's recent economic structural changes underscore the need for intellectual property, R&D, digitized information, and organizational capital to support innovation and growth. According to [Corrado et al. \(2022\)](#), these factors are categorized as intangible assets. They are becoming increasingly vital to China's economy. To accumulate intangible assets, firms must incur expenses, reallocate a portion of their expenditures from investments in tangible assets, and rely on internal or external finance. China has not yet made as much investment in these intangible assets relative to major advanced countries such as the United States. For example, in industries like wholesale and retail, China's investment in intangible assets is merely 1.21% of value-added, whereas this percentage is 5.7% in the United States ([Wu and Hao, 2022](#)). Nevertheless, Figure 3 shows the average intangible assets of firms over time, revealing a steady increase in total intangible assets until 2019, followed by a modest decline post-2019, potentially due to the impact of the COVID-19 pandemic. This overall trend indicates that intangible assets are becoming increasingly important and relevant for China's economy. However, they remain inadequately studied, especially regarding monetary transmission.

<Insert Figure 3 Here>

The difference in the intangible assets ratio between China and other devel-

oped countries implies substantial potential and opportunities. As the importance of intangible capital rises, these assets may have distinct implications on economic fluctuations. Figure 4 illustrates the year-over-year investment growth rates in China from 2016 to 2024. We categorized firms into two groups according to the intangible-to-total capital ratio. Tangible and intangible firms exhibit different variations during the COVID-19 pandemic. Intangible firms, defined as those in the top 30% based on intangible-to-total capital ratio, displayed smoother and more stable investment behaviors, while tangible firms experienced more pronounced fluctuations. [Peters and Taylor \(2017\)](#) and [Falato et al. \(2022\)](#) suggest that intangible assets are more difficult to adjust, depreciate more rapidly, and have less re-deployability and lower collateralized values. The increase of intangible assets may reduce the effectiveness of monetary policy through the investment channel. [Döttling and Ratnovski \(2023\)](#) find that firms with a higher share of intangible assets exhibit mitigated sensitivity to monetary policy innovations in their stock prices and investment in the United States.

This section analyzes the impact of monetary policy innovations on investment in China. It also examines the influence of asset tangibility or the intangible capital ratio on firms' investment behavior in response to monetary policy innovations. Due to adjustment costs and financial frictions associated with intangible assets, firms with higher intangible ratios may exhibit diminished responsiveness to expansionary monetary policy during economic turbulence, undermining the effectiveness of policy implementation, whereas firms with substantial tangible assets may react more. However, it is possible that a higher intangible ratio may amplify the response. For example, if intangible capital is represented as a measurement of firms' human capital or management practices, an increase in intangible assets may alleviate the limitations in managing multiple profitable investment projects, and facilitate the investment channel of monetary policy. By assessing this differential response, we gain insight into how different firms make investment decisions, and how intangible assets play a significant role when firms face expansionary monetary policy changes. This result has profound implications for the design of economic policies intended to promote sustainable growth. It also highlights the importance of firm heterogeneity, particularly with the rising share of intangible capital in the economy. Furthermore, the actual policy effects may depend on the ownership structure of firms. The distribution of firms across the economy could also matter. The findings will help policymakers in reevaluating and redesigning monetary policy.

<Insert Figure 4 Here>

### 3.1 Data

In our baseline analysis, we draw quarterly firm-level data spanning between 2016 Q1 and 2024 Q1 from the China Stock Market & Accounting Research Database (CSMAR), which is analogous to CRSP/Compustat for studying Chinese capital markets. It includes publicly listed A shares to provide a comprehensive overview of Chinese firms. We expand the data sample to examine whether the ratio of intangible assets matters for monetary policy transmission during different periods in our robustness checks. The key variable of interest is the change in the total investment rate. We follow [Jiang et al. \(2021\)](#) by using the cash paid for the acquisition of assets minus net cash received from the disposal of assets as the proxy for total investment. Additionally, we construct total intangible assets by combining net intangible assets and net goodwill<sup>6</sup>. Following the standard practice in corporate finance and firm-level empirical research, we construct variables for cash holdings, age, size, debt and equity growth, asset loss rate, and Tobin's Q as control variables for regression analysis, as these variables have shown significance for firms' investment decisions in the literature. Table 2 provides detailed descriptions of the key variables employed in our analysis.

<Insert Table 2 Here>

Examining the role of intangible assets through data from Chinese listed firms is worth investigating because of the availability of such information on their balance sheets. In the United States, only traded intangible assets are recorded on the balance sheet. Recent studies employ perpetual inventory methods to assess off-balance sheet intangible capital ([Ewens et al., 2025](#); [Peters and Taylor, 2017](#)). The firms in our sample provide a direct measurement of intangible capital in alignment with Chinese accounting principles, enabling us to conduct baseline exercises directly<sup>7</sup>. Otherwise, all previous investments must be recognized as expenses for

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<sup>6</sup>After 2007, net intangible assets and goodwill are reported separately in CSMAR.

<sup>7</sup>Chinese firms classify the investments in innovative projects as intangible assets in their financial statements based on the following criteria: 1) The production process or product has achieved satisfactory technical demonstration, 2) The management team has approved the budget for developing the process or product, 3) Preliminary market research indicates that the process or product possesses market potential, 4) The company has sufficient technological and financial resources to support continued large-scale production, 5) The costs related to the development of the process or product can be reliably measured.

the current period. The features of China’s intangible asset measurement make its listed A-share firms ideal examples for studying how intangible assets impact the transmission of monetary policy innovations at the micro level.

Table 3 presents the descriptive statistics for the variables included in the analysis. All variables are adjusted to their real values using the 1978-base Consumer Price Index (CPI) and are winsorized at the 1% level to mitigate the influence of outliers. The statistics show that there is considerable variability among the firms in the sample.

<Insert Table 3 Here>

### 3.2 Empirical Specification

In our baseline analysis, we estimate how firm investment responds to monetary policy innovations and how this response varies with intangible asset intensity. The regression model aims to estimate the change in the growth rate of a firm’s investment over subsequent periods. The empirical specification models changes in a firm’s investment rate over future horizons, focusing on outcomes 6 and 10 quarters ahead in line with the literature on medium to long run firm-level responses to monetary policy. It provides insight into the medium to long-term effects of monetary policy on corporate investment behavior. We estimate the following empirical specification of the model:

$$\begin{aligned} \Delta \text{invrate}_{i,t+h} = & \alpha_1 \cdot \text{inratio}_{i,t-1} + \alpha_2 \cdot \text{innovation}_t + \beta_1 \cdot \text{inratio}_{i,t-1} \cdot \text{innovation}_t \\ & + \alpha'_3 \cdot X_{i,t-1} + \alpha'_4 \cdot M_{t-1} + \beta'_2 \cdot X_{i,t-1} \cdot \text{innovation}_t \\ & + \mu_i + \eta_y + \psi_q + \epsilon_{i,t+h} \end{aligned} \quad (2)$$

where  $t$  represents the time period at a quarterly frequency and  $i$  indexes each firm. In this model,  $\Delta \text{invrate}_{i,t+h}$  denotes the change in the investment rate of firm  $i$  between time  $t+h$  and  $t-1$ .  $\text{inratio}$  denotes the intangible ratio, and  $\text{innovation}_t$  is the innovation series representing the unexpected change in monetary policy derived from our CMP index in Section 2. The model incorporates firm fixed effects  $\mu_i$  to account for firm-specific unobserved variables using the *stkcd* firm code from the CSMAR database.  $\eta_y$  represents the year-fixed effects used to control for aggregate economic trends and business cycles. We also include seasonality effects  $\psi_q$  to capture seasonal variations in reporting that may influence firms’ decisions. The model controls for a set of firm-specific financial factors and macroeconomic

variables as denoted by  $X_{i,t-1}$  and  $M_{t-1}$ . All the control variables are lagged to reduce simultaneity bias that may cause endogeneity problems. The firm-level controls include cash holdings, debt and equity growth rates, Tobin's Q, firm size, and firm age, which are commonly used in analyses of firm investment behaviors, as in previous research (Deng and Fang, 2022; Döttling and Ratnovski, 2023; Lu et al., 2023; Ottonello and Winberry, 2020). We also include the asset impairment loss rate to account for managers' incentives to manipulate future performance by substantial write-offs. We include the real GDP growth rate and unemployment rate as control variables to account for macroeconomic factors that may affect firms' investment behaviors. The coefficient of interest,  $\beta_1$ , measures the interaction between monetary innovations and the lagged intangible asset ratio on investment growth. This model further accounts for the possibility that the effect of monetary innovations could be amplified or mitigated by other financial factors, as represented by the interaction term  $\beta_2' \cdot X_{i,t-1} \cdot \text{innovation}_t$ , where  $\beta_2$  is a vector of the coefficients. It aims to control the influence of other firm characteristics to ensure the significance of the firm heterogeneity effect related to the ratio of intangible assets.

### 3.3 Baseline Results

This section presents the baseline results that show the stimulating effects of expansionary monetary policy. We examine the investment response to innovations using three series of monetary policy innovations derived from Section 2: innovations based on the BIS RMB index, the CFETS RMB index, and the comprehensive model with five aggregate variables, including inflation and unemployment rates.

**<Insert Table 4 Here>**

Table 4 summarizes the key empirical results. All coefficients for the innovation variables are negative, varying from -0.0164 to -0.0181 for  $h=6$  and from -0.0216 to -0.0258 for  $h=10$ , respectively. The coefficient is statistically significant at the 5% level for the innovation derived from the comprehensive model in the third column and at the 1% level for all the other innovation series. These results reveal that firms tend to increase investment rates following an expansionary monetary innovation. The estimated coefficients for the interaction term between innovation and intangible ratio are positive and statistically significant

at the 1% level. These results suggest that a one standard deviation increase in the intangible-to-total capital ratio reduces a firm’s overall investment response to a one standard deviation increase in the monetary policy innovation by 23 to 39 basis points<sup>8</sup>. Figure 5 illustrates the dynamic response across different time horizons to provide a thorough overview. Panel (a) shows that the average effects of monetary policy innovations on firm-level investment are negative across different periods, suggesting an immediate and persistent stimulating effect of an expansionary monetary policy innovation. Panel (b) shows that the coefficients of the interaction term between the intangible ratio and monetary policy innovations are positive across all horizons and statistically significant in most scenarios, implying that the mitigation effects of the intangible ratio are persistent.

<Insert Figure 5 Here>

### 3.3.1 Micro-Level Validity Check

We perform two sets of regressions to assess the effects of our constructed monetary policy innovations on the micro-level changes in the investment rate. The control variables are consistent with those employed in the previous subsection. In the first set of regressions, the dependent variable is the change in the investment rate from the previous quarter (the difference between periods  $h=-1$  and  $h=-2$ ). This regression aims to determine whether the innovations correlate with the investment rate in an earlier period. In the second set of regressions, the dependent variable is the change in the investment rate for the current period (with  $h=1$ ).

The results of the first set of regressions in Table A.5 in Appendix A.5 indicate that the coefficients of the innovations are positive but not statistically significant. This fact shows that the innovations exert no discernible impact on the investment rate in the previous quarter. It suggests that the innovations are primarily pertinent to the current period. They do not retain effects from previous periods, supporting the idea that they are specific to the current economic conditions they aim to capture. In comparison, the findings from the immediate period after the innovation demonstrate that contractionary innovations have a statistically significant negative impact on the change in the investment rate. All three innovation series have statistically significant negative coefficients, varying from -0.0157 to

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<sup>8</sup>The standard deviations of our innovation series range from 0.468 to 0.507. The standardized coefficient is obtained by multiplying the baseline coefficient by the standard deviations of the innovations and the intangible ratio.

-0.0173. These findings support the validity of the innovation series by demonstrating that the innovations' influence is confined to subsequent periods, free of residual effects from the past.

### 3.4 IV Results Using the Global Uncertainty Index

Despite our efforts to isolate the unexpected changes in the monetary policy from the CMP index by specifying the policy rule of the PBoC, and incorporating firm-level and aggregate control variables in our regression models with multiple fixed effects, one possible concern persists that the expectations are inadequately addressed when decomposing the CMP index into the unexpected and expected components.

To further assess the robustness of our baseline results, we supplement our analysis with an instrumental-variable (IV) specification that uses the Global Economic Policy Uncertainty (GEPU) index<sup>9</sup> as an exogenous instrument for our innovation series. The GEPU index is constructed as a GDP-weighted average of national Economic Policy Uncertainty (EPU) indices from 21 major economies. Our motivation is that episodes of heightened global policy uncertainty may shape the macroeconomic environment faced by Chinese policymakers and thereby influence monetary policy adjustments, while being less directly tied to the investment decisions of individual Chinese firms. This IV strategy serves as a useful robustness check that exploits external uncertainty-driven variation in monetary policy innovations, providing additional support for our main results.

<Insert Table 5 Here>

The IV results in Table 5 reinforce our baseline findings. The IV estimates for the policy innovation are larger in magnitude than OLS. At horizons  $h = 6$  and  $h = 10$ , the IV coefficients on innovation are  $-0.0656$  and  $-0.1001$ , respectively. The interaction term  $\text{innovation} \times \text{intangible}$  is  $0.1229$  at  $h = 6$  and  $0.1114$  at  $h = 10$ , also exceeding the OLS counterparts. Thus, IV indicates stronger real effects of monetary tightening on investment and a stronger mitigating role of intangible intensity than OLS, consistent with attenuation from measurement error and residual endogeneity in OLS. The coefficient for the interaction between the GEPU-instrumented monetary policy innovation and the intangible ratio remains

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<sup>9</sup>Data retrieved from: [https://www.policyuncertainty.com/global\\_monthly.html](https://www.policyuncertainty.com/global_monthly.html)

positive and statistically significant, suggesting that firms with a high ratio of intangible assets are consistently less responsive to monetary innovations.

## **3.5 Robustness**

### **3.5.1 Alternative Monetary Policy Measurements**

To evaluate the robustness of our baseline findings regarding the mitigation effects of intangible assets on monetary transmission, we examine this relationship with the exogenous component of M2 growth, as estimated by [Chen et al. \(2018\)](#) over the period from 2000 to 2016. Throughout this period, M2 growth served as the primary intermediate target of China’s monetary policy. The exogenous M2 series isolates monetary innovations from systematic responses to inflation and the GDP growth gap. This approach ensures that observed effects reflect the response to monetary policy innovations rather than predetermined endogenous adjustments. Using this exogenous measure, we estimate firm investment responses to monetary policy innovations and find consistent results indicating that firms with higher intangible asset intensity exhibit considerably mitigated investment responses. When the constructed exogenous component of M2 growth increases, it indicates that the PBoC conducts expansionary monetary policy unexpectedly. The positive and statistically significant coefficients for the innovation variable in all specifications in Table 6 suggest that firms increase their investment in response to expansionary monetary policy. The negative coefficients for the interaction term between innovation and intangible ratio suggest that firms possessing more intangible assets are less responsive to expansionary policy changes. This pattern is consistent with our results regarding the unexpected innovations derived from the CMP index for the years 2016 to 2024. It reinforces the argument that intangible assets reduce the efficacy of the investment channel in monetary policy transmission.

**<Insert Table 6 Here>**

### **3.5.2 Alternative IV Samples**

As a robustness check, we exclude firms identified as foreign-invested enterprises by dropping ownership codes P0302, P0303, and P0304. These firms include wholly foreign-owned enterprises, Sino-foreign joint ventures, and cooperative firms that

receive capital or managerial input from abroad. In our IV setup, the Global Economic Policy Uncertainty (GEPU) index is used as an external instrument for China’s domestic monetary policy innovations. The validity of this instrument relies on the exclusion restriction that global policy uncertainty affects firm investment only through its influence on China’s monetary policy. However, foreign-invested firms may be directly exposed to global financial conditions, which are themselves correlated with global policy uncertainty. Hence, we mitigate this potential bias and ensure that the IV estimates capture the causal effect of domestic monetary policy innovations on investment decisions made within China’s own institutional environment.

Table 7 shows that the IV results remain robust when the sample excludes foreign-invested enterprises. The coefficients on innovation are -0.0734 at  $h = 6$  and -0.1274 at  $h = 10$ , slightly larger in magnitude than in Table 5, confirming that monetary tightening continues to exert a negative and persistent effect on investment. The interaction term innovation  $\times$  intangible remains positive and statistically significant across both horizons (0.1191 and 0.1052), again indicating that firms with higher intangible intensity are less sensitive to policy shocks. These estimates are consistent with the baseline IV results and stronger than the OLS coefficients, reinforcing that the moderating role of intangible assets is not sample-specific and that OLS understates the true effects due to attenuation bias and residual endogeneity.

<Insert Table 7 Here>

## 4 Theoretical Framework

Motivated by our empirical findings, we develop a simple theoretical framework to clarify the mechanisms through which intangible assets shape firms’ investment responses to monetary policy. Rather than providing a fully fledged quantitative model, our goal is to isolate the key economic forces highlighted in the data and to illustrate how asset tangibility, financial frictions, and ownership structure interact in shaping investment decisions. The model generates testable implications regarding heterogeneous firm responses, which we examine empirically in the subsequent sections.

## 4.1 A Two-Period Firm Investment Model

We consider a two-period firm investment model that incorporates financial frictions and capital adjustment costs. This dynamic structure allows us to study the role of depreciation and capital reallocation, which would be absent in a static setting, while remaining sufficiently tractable for analytical characterization. The key features are as follows: The firm makes investment decisions for capital accumulation. Capital comprises both tangible and intangible assets, with a stable proportion of each. The firm can borrow money for investment purposes, but constrained by collateral requirements. We assume that intangible capital have no collateral value. Investment incurs costs related to capital adjustments. The depreciation rates for tangible and intangible assets are different. Together, these features capture the key channels through which asset tangibility affects firms' investment responses to monetary policy innovations.

We adopt a Cobb-Douglas production function with only capital input for the sake of simplicity and tractability.

$$Y_t = A_t K_t^\alpha, \quad t = 1, 2 \quad (3)$$

where  $A_t$  reflects the profitability and  $\alpha$  denotes the elasticity of profits with respect to capital<sup>10</sup>. The total capital stock comprises tangible and intangible capital, with  $\theta$  representing the asset tangibility or one minus intangible capital ratio. We assume perfect substitutability between tangible and intangible capital in production, to focus on the short-term effects of monetary transmission on the capital market. Parameter  $\theta$  is considered fixed. We treat this as a firm-specific attribute that is time-invariant.

$$K_t = K_{T,t} + K_{N,t}, \quad K_{T,t} = \theta K_t \quad (4)$$

The firm owns the capital instead of renting it. The law of motion for capital follows the standard time-to-build capital accumulation process:

$$K_2 = I_1 + (1 - \delta)K_1 = I_1 + (1 - \delta_T)K_{T,1} + (1 - \delta_N)K_{N,1} \quad (5)$$

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<sup>10</sup>The labor decision and wage rate are ignored in this context. They can be integrated and solved within an intratemporal labor market optimization framework with a Cobb-Douglas production function with two types of inputs, given that there is no labor adjustment costs.  $A_t$  can be derived as effective productivity, and  $\alpha$  is the output elasticity of capital once labor demand is substituted out.

As a result,

$$\delta = \theta\delta_T + (1 - \theta)\delta_N \quad (6)$$

where  $\delta_T$  represents the depreciation rate for tangible assets,  $\delta_N$  denotes the depreciation rate for intangible assets, and the two may differ.

Installing new capital may disrupt a firm's operations or incur additional costs. Prior research usually represents these adjustment costs via a quadratic capital adjustment cost function or a fixed capital adjustment cost whenever investment is non-zero. According to the literature, fixed capital adjustment costs are generally considered more appropriate for analyses at the plant level, while quadratic adjustment cost assumptions are more suitable at the firm level, especially for publicly listed firms. Here we aim to illustrate the impact of asset tangibility qualitatively instead of conducting quantitative estimation, while preserving the feature that a larger change in capital stock results in higher adjustment costs. We assume a linear functional form for the costs of capital adjustment, where  $\phi_T$  is the adjustment cost parameter for tangible assets and  $\phi_N$  the parameter for intangible assets:

$$\begin{aligned} AC &= P_{K_1}(\phi_T I_{T,1} + \phi_N I_{N,1}) \\ &= P_{K_1} \left[ \phi_T \theta [K_2 - (1 - \delta_T)K_1] + \phi_N (1 - \theta) [K_2 - (1 - \delta_N)K_1] \right] \end{aligned} \quad (7)$$

Firms can borrow money at the risk-free interest rate  $r$ , and the debt issued is  $B_1$ . However, there exist financial frictions in the market. The lenders are concerned about the ability of a firm to repay the debt. This concern prevent the firm from borrowing large amounts of money. The firm needs to use its capital as collateral to facilitate its financing. Only tangible assets may serve as collateral, and  $\psi$  measure the pledgeability of the tangible assets. We assume the collateral value of intangible assets to be zero, as in [Falato et al. \(2022\)](#). Furthermore, we assume that a firm cannot distribute negative dividends. This restriction indicates that the firm can not obtain additional financial support through equity financing from shareholders, so that the collateral constraints may bind in certain situations. If the firm can issue equity for external financing, it will never be constrained by the collateral requirements. Consequently, the firm faced two financing constraints:

$$B_1 \leq \bar{B} = \psi P_{K_2} (1 - \delta_T) \theta K_2, \quad (8)$$

$$D_1 \geq 0 \quad (9)$$

The dividends are the variables that the firm values in its objective function. We have

$$D_1 = A_1 K_1^\alpha - P_{K_1} I_1 - AC + B_1 \quad (10)$$

$$D_2 = A_2 K_2^\alpha + P_{K_2}(1 - \delta)K_2 - (1 + r)B_1 \quad (11)$$

Suppose a firm will only survive for two periods, it wants to maximize the present discounted value of dividends given an interest rate  $1 + r$ :

$$D_1 + \frac{1}{1 + r}D_2 \quad (12)$$

### The Firm's Profit Maximization Problem

The firm takes the starting capital stock  $K_1$  as given when determining its investment choice. The price of investment, or equivalently the resale price of capital, is given as  $P_{K_t}$  for periods  $t = 1, 2$ . The key dynamic tradeoff here is the cost of investment today versus the future profits and resale value provided by additional capital tomorrow. In each period, dividends equal variable profits subtracted by the cost of investment. During period 2, the firm disinvests and sells all of its capital assets <sup>11</sup>.

By substituting  $I_1$  with the law of motion of capital involving  $K_2$  into the model, we have the following firm maximization problem:

$$\begin{aligned} \max_{K_2, B_1} & A_1 K_1^\alpha - P_{K_1} [(1 + \phi_T)\theta[K_2 - (1 - \delta_T)K_1] + (1 + \phi_N)(1 - \theta)[K_2 - (1 - \delta_N)K_1]] + \\ & B_1 + \frac{1}{1 + r} [A_2 K_2^\alpha + P_{K_2}(1 - (\theta\delta_T + (1 - \theta)\delta_N))K_2 - (1 + r)B_1] \end{aligned} \quad (13)$$

subject to:

$$B_1 \leq \bar{B} = \psi P_{K_2}(1 - \delta_T)\theta K_2, \quad (14)$$

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<sup>11</sup>The basic setups can be found in Appendix B.1.1

$$A_1 K_1^\alpha - P_{K_1} [(1 + \phi_T)\theta[K_2 - (1 - \delta_T)K_1] + (1 + \phi_N)(1 - \theta)[K_2 - (1 - \delta_N)K_1]] + B_1 \geq 0 \quad (15)$$

When solving this problem, there are two cases to consider in this maximization problem: unconstrained versus constrained cases.

## 4.2 The Unconstrained Case

In this situation, both financial constraints slack, the FOC w.r.t.  $K_2$  gives the optimal condition:

$$(1 + r)P_{K_1} [((1 + \phi_T)\theta) + (1 + \phi_N)(1 - \theta)] = A_2 \alpha K_2^{\alpha-1} + P_{K_2} (1 - (\theta\delta_T + (1 - \theta)\delta_N)) \quad (16)$$

Thus, the unconstrained optimal capital in period 2 is:

$$K_2^{U*} = \left( \frac{A_2 \alpha}{(1 + r)P_{K_1} [((1 + \phi_T)\theta) + (1 + \phi_N)(1 - \theta)] - P_{K_2} (1 - (\theta\delta_T + (1 - \theta)\delta_N))} \right)^{\frac{1}{1-\alpha}} \quad (17)$$

This solution also requires that  $(1 + r)P_{K_1} [((1 + \phi_T)\theta) + (1 + \phi_N)(1 - \theta)] > P_{K_2} (1 - (\theta\delta_T + (1 - \theta)\delta_N))$ , which is valid as long as  $P_{K_2}$  does not exceed  $P_{K_1}$  by a substantial amount.

The debt required to satisfy  $D_1 \geq 0$  is:

$$B_1^{U*} = \max\{0, P_{K_1} ((1 + \phi_T)\theta) + P_{K_1} (1 + \phi_N)(1 - \theta)K_2^{U*} - [A_1 K_1^\alpha + P_{K_1} K_1 [((1 + \phi_T)\theta(1 - \delta_T)) + (1 + \phi_N)(1 - \theta)(1 - \delta_N)]]\} \quad (18)$$

If the internal fund is sufficient to attain the optimal capital level in period 2, the firm will exclusively depend on its internal funds, so that  $B_1 = 0$ . If its internal funds are insufficient, it will borrow until its dividend in the first period is non-negative, complying with the borrowing constraints.

The optimal investment in this scenario is

$$I_1^{U*} = K_2^{U*} - (1 - \theta\delta_T - (1 - \theta)\delta_N)K_1 \quad (19)$$

### 4.3 The Constrained Case

In this situation, the firm will rely on external financing, reaching the borrowing limits  $B_1^{C*} = \psi P_{K_2}(1 - \delta_T)\theta K_2^{C*}$ , and its dividend in the first period is  $D_1 = 0$ . These two binding constraints yield the optimal capital stock in period 2:

$$\begin{aligned} A_1 K_1^\alpha - P_{K_1} [(1 + \phi_T)\theta [K_2 - (1 - \delta_T)K_1] + (1 + \phi_N)(1 - \theta)[K_2 - (1 - \delta_N)K_1]] \\ + \psi P_{K_2}(1 - \delta_T)\theta K_2 = 0 \end{aligned} \quad (20)$$

$$K_2^{C*} = \frac{[A_1 K_1^\alpha + P_{K_1} K_1 [(1 + \phi_T)\theta(1 - \delta_T) + (1 + \phi_N)(1 - \theta)(1 - \delta_N)]]}{P_{K_1} [(1 + \phi_T)\theta + (1 + \phi_N)(1 - \theta)] - \psi P_{K_2}(1 - \delta_T)\theta} \quad (21)$$

The optimal investment in this case is:

$$I_1^{C*} = K_2^{C*} - (1 - \theta\delta_T - (1 - \theta)\delta_N)K_1 \quad (22)$$

### 4.4 Effects of Asset Tangibility on Monetary Policy Transmission

To formalize the monetary transmission mechanisms, we consider three channels through which expansionary monetary policy affects firm behavior. A monetary easing reduces the user cost of capital, enhances collateral value and borrowing capacity, and increases demand and profitability through the cash-flow channel. These mechanisms together determine how asset tangibility influences firms' investment responses<sup>12</sup>.

**Proposition 1** *Unconstrained firms and the user cost channel: 1. An increase in the user cost of capital  $D_U$  reduces optimal investment.*

$$\frac{\partial I_1^{U*}}{\partial D_U} < 0 \quad (23)$$

2. Under assumptions  $\phi_N > \phi_T$  and  $\delta_N > \delta_T$ , a higher intangible capital share  $(1 - \theta)$  attenuates the negative response of investment to user costs.

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<sup>12</sup>We introduce compact notation in Appendix B.1.2 to keep the following proofs concise.

$$\frac{\partial^2 I_1^{U*}}{\partial D_U \partial (1-\theta)} > 0. \quad (24)$$

The result follows from two properties of the unconstrained problem. First, optimal capital satisfies  $A_2 \alpha K_2^{\alpha-1} = D_U(\theta)$ , so investment is decreasing in the user cost. Second, as suggested in the literature (Döttling and Ratnovski, 2023; Falato et al., 2022), intangible capital tends to carry both higher adjustment costs and higher depreciation ( $\phi_N > \phi_T$  and  $\delta_N > \delta_T$ ), then the user cost  $D_U(\theta)$  is increasing in the intangible share. A larger  $(1-\theta)$  therefore raises the level of the user cost, and since the investment schedule  $I_1^{U*}(D_U)$  becomes flatter as  $D_U$  increases, the negative effect of further increases in the user cost is dampened. This yields the positive cross partial derivative.

**Proposition 2** *Collateral Channel and Intangible Assets: For constrained firms, optimal investment is given by:*

$$I_1^{C*} = \frac{N(\theta)}{D(\theta)} - (1 - \delta(\theta))K_1,$$

1.  $\frac{\partial I_1^{C*}}{\partial \psi} > 0$ . Higher pledgeability ( $\psi$ ) increases the collateral value of tangible assets, relaxing financing constraints and boosting investment.
2.  $\frac{\partial I_1^{C*}}{\partial P_{K2}} > 0$ . Higher expected future capital prices ( $P_{K2}$ ) also raise collateral value and stimulate investment.
3. Assuming that intangible assets have little to no collateral value,  $\frac{\partial^2 I_1^{C*}}{\partial \psi \partial (1-\theta)} < 0$ ,  $\frac{\partial^2 I_1^{C*}}{\partial P_{K2} \partial (1-\theta)} < 0$ . A higher intangible share  $(1-\theta)$  weakens the positive effects of increase in pledgeability and asset prices on investment, since intangible assets cannot be easily pledged as collateral.

**Proposition 3** *Cash Flow Channel and Intangible Assets: For unconstrained firms with costless access to external financing, current internal cash flows are irrelevant. Hence, changes in current profitability  $A_1$  have no effect on their investment as*

$$\frac{\partial I_1^{U*}}{\partial A_1} = 0 \quad (25)$$

For constrained firms, optimal capital depends directly on  $A_1$ :

$$\frac{\partial I_1^{C*}}{\partial A_1} = \frac{\partial K_2^{C*}}{\partial A_1} > 0 \quad (26)$$

An expansionary monetary policy that raises current profitability  $A_1$  stimulates investment for constrained firms by increasing internal funds and relaxing borrowing constraints. Under assumptions  $\phi_N > \phi_T$ ,  $\delta_N > \delta_T$ , and  $\psi > 0$ :

$$\frac{\partial^2 I_1^{C*}}{\partial A_1 \partial (1 - \theta)} = \frac{\partial^2 K_2^{C*}}{\partial A_1 \partial (1 - \theta)} < 0 \quad (27)$$

The positive effect of increase in profitability is weaker for firms with a higher share of intangible assets  $1 - \theta$ , given their lower collateral value, faster depreciation, and higher adjustment costs. Unconstrained firms remain unaffected because they can finance investment independently of current cash flows.

## 4.5 Testable Predictions

**Financing/Collateral Channel:** The collateral and cash-based constraints in the model imply that monetary policy affects investment based on firms' financing conditions. This mechanism relies on three assumptions embedded in the model setups. First, some firms operate under a binding borrowing constraint. In the model, external financing is limited by the collateral constraint, so investment is determined by available internal resources whenever this constraint binds. Second, only tangible assets can be pledged as collateral. The parameter  $\psi$  applies exclusively to the tangible assets  $\theta K_2$ , while intangible assets have zero collateral value. As a result, firms with a larger intangible share have weaker borrowing capacity and are more likely to be financially constrained. Third, when the borrowing constraint binds, higher current resources loosen the constraint. Internal funds enter the dividend non-negativity condition,

$$D_1 = A_1 K_1^\alpha - P_{K_1} I_1 - AC + B_1 \geq 0, \quad (28)$$

and therefore directly expand the set of feasible investment choices when external financing is limited.

Empirically, firms with low cash holdings or high leverage are natural proxies for tighter financing conditions. Therefore, the model predicts that the interaction between monetary policy innovations and intangible intensity will be statistically significant for such firms, while the interaction should be weak or absent among firms with ample liquidity or low leverage that are unlikely to be financially constrained.

**Depreciation Gap Channel:** In our model, we assume that intangible assets depreciate faster than tangible assets,  $\delta_N > \delta_T$ . This implies that the effective depreciation rate

$$\delta(\theta) = \theta\delta_T + (1 - \theta)\delta_N \quad (29)$$

is increasing in the intangible share  $(1 - \theta)$ . Hence, a higher intangible share raises the effective depreciation rate embedded in the user cost of capital. As a result, the marginal value of additional future capital is lower, and investment becomes less sensitive to changes in monetary policy.

If this depreciation mechanism is important in the data, then firms or sectors in which the depreciation gap between intangible and tangible assets is larger should exhibit a stronger dampening effect of intangible intensity on the response of investment to monetary policy innovations. In other words, the interaction between monetary policy and  $(1 - \theta)$  should be more pronounced when  $\delta_N - \delta_T$  is larger.

**Adjustment Cost Channel:** The model predicts that higher adjustment costs for intangible capital dampen the investment response to monetary policy shocks. In the model, this corresponds to a higher  $\phi_N$ , which raises the user cost  $D_U(\theta)$  and flattens the investment schedule. Motivated by this mechanism, we conduct a supplementary heterogeneity exercise examining whether the mitigating role of intangible intensity varies with proxies for adjustment frictions. We use the presence of local patent exchanges, as well as firm-level measures such as executive compensation share and research personnel share, to capture differences in intangible adjustment costs.

**Firm Ownership:** Differential Investment Sensitivity by Ownership Type: Consider two types of firms: State-Owned Enterprises (SOEs) and private firms (Non-SOEs).

- (a) SOEs exhibit lower sensitivity of investment to expansionary monetary policy than Non-SOEs.
- (b) The dampening effect of a high intangible asset share  $(1 - \theta)$  on these sensitivities is more pronounced for Non-SOEs than for SOEs.

SOEs benefit from preferential access to credit and implicit government guarantees, implying a higher inherent pledgeability  $\psi$  and a lower likelihood of binding borrowing constraints. As a result, SOEs are more likely to behave as unconstrained firms, while Non-SOEs are more likely to face tight borrowing limits. For

unconstrained firms, investment depends only on the user cost of capital:

$$K_2^{U*} = \left( \frac{A_2 \alpha}{D_U} \right)^{\frac{1}{1-\alpha}}, \quad \frac{\partial K_2^{U*}}{\partial A_1} = 0, \quad (30)$$

whereas for constrained firms, investment depends on internal funds  $N(\theta)$  and net financing costs  $D(\theta)$ :

$$K_2^{C*} = \frac{N(\theta)}{D(\theta)}, \quad \frac{\partial K_2^{C*}}{\partial A_1} = \frac{K_1^\alpha}{D(\theta)} > 0, \quad \frac{\partial K_2^{C*}}{\partial \psi} > 0, \quad \frac{\partial K_2^{C*}}{\partial P_{K2}} > 0. \quad (31)$$

Since SOEs are closer to the unconstrained regime, their investment reacts less to changes in  $A_1$ ,  $\psi$ , and  $P_{K2}$ . Non-SOEs, operating under binding constraints, display stronger sensitivities to these variables. The role of intangible assets follows from the negative cross-partials:

$$\frac{\partial^2 K_2^{C*}}{\partial A_1 \partial (1-\theta)} < 0, \quad \frac{\partial^2 K_2^{C*}}{\partial \psi \partial (1-\theta)} < 0, \quad \frac{\partial^2 K_2^{C*}}{\partial P_{K2} \partial (1-\theta)} < 0, \quad (32)$$

indicating that a higher intangible share dampens the positive effects of profitability and collateral values on investment. Because Non-SOEs are more likely to be constrained, this dampening effect is economically more relevant for them than for SOEs. Intuitively, non-SOEs rely on internal cash flows and pledgeable collateral to finance investment. Innovations to  $A_1$  directly affect internal liquidity, while innovations to  $\psi$  and  $P_{K2}$  influence borrowing capacity. Intangible assets weaken both channels by reducing liquid funds and providing poor collateral, making investment highly sensitive yet fragile. SOEs, by contrast, have access to policy-directed credit independent of collateral quality. Their investment is thus less responsive to changes in  $A_1$ ,  $\psi$ , or  $P_{K2}$ , and the composition of assets plays only a minor role.

## 5 Transmission Channels

In this section, we aim to investigate the specific mechanisms through which intangible assets influence firms' responses to monetary policy, based on the testable predictions derived in Section 4.

## 5.1 Financing Channel

Section 4 implies that constrained firms with a higher intangible-to-total capital ratio exhibit less sensitivity to monetary policy innovations because of tight borrowing constraints. Intangible assets typically possess little collateral value, which makes it hard for firms to secure debt at favorable terms with these assets (Bates et al., 2009; Falato et al., 2022). As a result, firms with a high share of intangible assets are less dependent on external funds and are not able to respond effectively to fluctuations in monetary policy. We first empirically show that this financing channel affects the monetary transmission on investment.

### 5.1.1 Tests with Financial Variables as Proxies

To test the financing channel, we examine whether firms with weaker internal liquidity or tighter external financing conditions display stronger heterogeneity in their response to monetary policy. Our model implies that the interaction between monetary policy and intangible intensity should be most pronounced when borrowing constraints are more likely to bind. We proxy financing frictions using cash holdings and leverage.

First, among firms with low cash reserves, investment relies more heavily on external funds. In this group, the dampening effect of intangible intensity is expected to be larger because intangible assets provide limited collateral value and do not relax borrowing constraints when policy eases. Firms with high cash reserves, by contrast, depend less on external finance, so differences in asset tangibility should matter less.

Second, leverage provides a complementary proxy for dependence on external borrowing. Highly leveraged firms are more exposed to shifts in credit conditions. In this group, we again expect a stronger moderating effect of intangible intensity: firms with more tangible assets benefit more from the loosening of collateral constraints during expansionary innovations, whereas intangible-heavy firms do not. For low leverage firms, financing constraints are less binding, and the difference between intangible and tangible intensive firms should be smaller.

<Insert Table 8 Here>

Panel A of Table 8 shows that firms with lower cash reserves exhibit larger interaction coefficients (0.0437 at  $h=6$  and 0.0251 at  $h=10$ ) compared to those

with higher cash reserves. For firms with higher cash reserves, the behavior between tangible and intangible firms is less differentiated, as both can rely on cash holdings to finance investments internally. In Panel B, the results indicate that high-leverage firms exhibit larger interaction coefficients for the innovation and intangible ratio, 0.0420 at  $h=6$  and 0.0378 at  $h=10$ , both statistically significant at the 1% level. This aligns with the financing-constraint channel: highly leveraged firms are more exposed to changes in credit conditions, making differences in collateral capacity more salient. Intangible-intensive firms respond less to monetary easing because their limited pledgeable assets provide little scope for borrowing constraints to relax.

Consequently, the gap in investment decisions between intangible and tangible firms widens as financial constraints intensify. Intangible firms are not responsive in their investments, while tangible firms benefit from increased borrowing capacity. This interpretation aligns with the Credit Channel theory developed by [Kiyotaki and Moore \(1997\)](#), which illustrates that firms relying on collateralized borrowing are more affected by business cycles through their limited ability to get financing.

### 5.1.2 Empirical Results by Ownership Type

In this subsection, we study the response of firm investment based on the ownership type to understand the heterogeneity in responses among different types of firms. China's economy consists of various ownership structures. Recent literature studying China suggests that state-owned enterprises (SOEs) barely face credit constraints because governmental endorsement allows them to secure funding under various circumstances ([Cao et al., 2023](#); [Gao et al., 2019](#); [Li et al., 2021](#)). Therefore, we hypothesize that their investment behaviors are unlikely to be significantly influenced by monetary policy innovations. In contrast, monetary policy innovations can affect the behaviors of non-state-owned enterprises (non-SOEs). To examine this phenomenon, we categorize the whole sample into state-owned and non-state-owned firms according to the ownership classifications provided in the CSMAR database. Non-state-owned firms include Sino-foreign joint ventures, wholly foreign-owned firms, and private firms. State-owned firms include state-owned or state-holding enterprises, government agencies, and public institutions. All control variables and fixed effects remain unchanged. We analyze the investment response when  $h=6$  and  $h=10$ , as in our baseline exercises.

<Insert Table 9 Here>

The regression results are presented in Table 9. The coefficients of the monetary policy innovation for SOEs are statistically insignificant, both at the 6-quarter and 10-quarter horizons. This result suggests that SOEs do not significantly adjust their investment decisions in response to monetary contraction or expansion. It is consistent with the general idea that SOEs are less financially constrained, and they enjoy favorable access to government-backed credit or other financial assistance not available to Non-SOEs. Their investment decisions are not sensitive to variations in external financing conditions during periods of monetary policy changes.

In contrast, Non-SOEs exhibit a statistically significant positive response to expansionary monetary policy innovations, with coefficients ranging from -0.0195 to -0.0284 across different measures of monetary policy innovations. These coefficients indicate the extent to which Non-SOEs increase their investment in response to expansionary monetary policy. The negative values suggest that Non-SOEs, which lack direct government support or access to favorable credit supply, exhibit greater sensitivity to reductions in borrowing rates or increases in credit availability.

For Non-SOEs, the positive interaction terms show that firms with more intangible assets are less responsive when facing monetary expansion. A one-unit increase in the intangible asset ratio reduces the investment growth by approximately 3% at  $h=6$  and 2.3% at  $h=10$ . This result suggests that Non-SOEs, who have greater challenges in financing due to a lack of government support, may suffer because of their asset composition. These assets force them to reduce reliance on external borrowing and restrict their credits. The coefficients of the interaction terms for SOEs are statistically insignificant. This insignificance implies that intangible assets do not matter, given that SOEs already have easier access to government-backed financing. Therefore, monetary expansion has minimal impact on their investment decisions, regardless of asset tangibility.

### **5.1.3 Empirical Analysis by Strategic Emerging Firm Classification**

We also explore sectoral-level differences in alignment with the country's strategic emerging industry priorities. China officially initiated its policy focus on Strategic Emerging Industries (SEIs) in 2010, which are the industries of national strategic

importance<sup>13</sup>. It has established itself as a leading force in various advanced technologies, including green energy, artificial intelligence, and biotechnology over the past decade (Wang et al., 2022). The policy emphasis on SEIs reflects their critical role in promoting productivity growth. Government policies, including R&D subsidies and public procurement programs, have been crucial in fostering innovation, ensuring that SEIs remain competitive on the global stage (Howell, 2017; Kalouptsi, 2018).

We hypothesize that SEIs will experience a sharper increase in investment given an expansionary monetary policy innovation. First, SEIs often require substantial capital investments for research and development (R&D), production scaling, and market expansion. They typically rely more on external financing, such as venture capital, private equity, and debt financing. When monetary policy expands, resulting in lower interest rates, the cost of borrowing decreases, making it easier for firms in these industries to receive the necessary funds for growth and innovation.

Moreover, these industries often receive substantial government support and subsidies due to their strategic importance for national economic and technological development. They may benefit from favorable policies, grants, and tax incentives. However, when monetary policy tightens, governments may also reduce the level of support and subsidies allocated to these industries. This reduction in support can further hinder their ability to invest in new projects and sustain growth, making them more vulnerable to monetary policy innovations. Firms not in the strategic emerging industries face tighter borrowing constraints and are less dependent on external financing for capital investment. The banks may also be reluctant to lend money to firms in these industries, as they are not considered good lending targets and doing so could contradict the missions specified by the government. With insignificant average effects of monetary policy innovations, the intangible ratio will not matter for the monetary transmission on firm investment.

To test this hypothesis, we divide our firms into two categories, namely SEIs and non-SEIs, according to their industries. We use the 2012 CSRC Industry code from the CSMAR dataset for classification. There are 81 industries in total, and we manually categorize them based on the definition<sup>14</sup> of strategic-emerging industries

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<sup>13</sup>We also present a set of results based on the SDRI (Specialized, Refined, Differentiated and Innovative) strategic orientation in China, which can be found in Appendix A.7. SRDI firms are often small- and medium-sized enterprises.

<sup>14</sup>These industries are crucial for economic transformation and technological advancement. They include sectors with high growth potential, major technological innovation, and the ability to drive overall economic development.

provided by [National Bureau of Statistics of China \(2018\)](#). We determine that 38<sup>15</sup> out of the 81 industries qualified as strategic-emerging industries.

<Insert Table 10 Here>

The results in Table 10 show that strategic-emerging firms experience a statistically significant positive response to expansionary monetary policy innovations, with coefficients ranging from -0.0288 to -0.0362. The values indicate that these strategic-emerging firms, which depend more on external funding for R&D and growth, are particularly sensitive to the borrowing conditions. Their investment needs and increased government support during monetary expansion lead to a statistically significant increase in investment relative to non-strategic firms. In contrast, non-strategic firms show much weaker and statistically insignificant responses, indicative of their lower reliance on external capital and more stable investment patterns. These firms, operating in traditional sectors, are less affected by monetary innovations because they tend to finance investments internally and have limited access to external funds. For strategic-emerging firms, the positive and statistically significant coefficients for the interaction terms between 0.0317 and 0.05158 suggest that the firms with higher intangible-to-total capital ratios respond less. It indicates that intangible assets constrain strategic-emerging firms from increasing investment when decreasing borrowing costs enable the firms to expand their investment levels as credit conditions improve.

#### 5.1.4 Empirical Results by Geographic Location

Intangible capital, such as patents, trademarks, and proprietary technologies, has considerable value. However, its liquidity and market tradability depend significantly on the development of the local trading market and the quality of institutions. In well-developed and established markets, intangible assets can be more easily traded and used as collateral, reducing the frictions typically associated with their utilization. Therefore, firms with a high ratio of intangible assets in these mature markets may behave similarly to firms with a lower proportion of intangible assets, as the challenges and frictions posed by intangible capital are diminished. To understand the significance of location within our theoretical framework, it may be attributed to the lower capital value  $P_k$  in developed markets, or the fact

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<sup>15</sup>A detailed division can be found in Appendix A.7.

that intangible assets have collateral value in these places, which relaxes the borrowing constraints. Overall, this hypothesis posits that the market environment plays a crucial role in determining the effective use of intangible assets. To analyze this effect, we divide the firms into two groups: those with headquarters in the top 20 cities (Top 20), as identified by the city index from [State Council Information Office \(2023\)](#), and those headquartered elsewhere (Other Cities).

**<Insert Table 11 Here>**

The results in Table 11 reveal that firms registered in cities outside the top 20 exhibit a statistically significant and positive coefficient for the interaction term between monetary innovations and intangible ratio. Specifically, the coefficients for these firms are 0.0525 ( $h = 6$ ) and 0.0460 ( $h = 10$ ), both statistically significant at the 1% level. Firms in these regions experience a more pronounced mitigation effect from intangible assets, indicating that the environment or institution does not facilitate the effective utilization of intangible assets, making them less responsive to monetary innovations.

In contrast, firms registered in the top 20 cities, characterized by more developed trading markets and higher-quality institutions, do not exhibit a statistically significant interaction term between monetary innovations and intangible ratio. The coefficients for these firms are 0.0222 ( $h = 6$ ) and 0.0121 ( $h = 10$ ), neither of which is statistically significant. It suggests that in these top-tier cities, the advanced market infrastructure and high institutional quality reduce the frictions associated with intangible assets, leading to behavior that is less distinguishable from firms with lower intangible ratios.

Overall, the analysis indicates that the market environment significantly influences the impact of intangible assets on firm behavior in response to monetary policy innovations. This discovery highlights the importance of institutional quality in the efficient utilization of intangible capital. The dampening effects of intangible assets may diminish as the market develops, making monetary policy innovations more effective.

## 5.2 Depreciation Channel

Previous research examining the effect of intangible assets by [Döttling and Ratnovski \(2023\)](#) suggests that higher depreciation rates reduce the sensitivity of in-

tangible investment to interest rate changes. The basic theory of user cost of capital suggests that higher depreciation rates make firms to be more cautious when making investment decisions. Our two-period dynamic firm investment model in Section 4 illustrate the effects of the depreciation rate on monetary transmission on investment, and we empirically test the model implications in this subsection. The model indicates that asset tangibility  $\theta$  affects monetary transmission via the depreciation channel if there is a significant difference between the depreciation rates of tangible and intangible assets  $\delta_T$  and  $\delta_N$ .

To examine the influence of depreciation rates on the sensitivity of investment to monetary policy innovations, we divide the sample into two groups according to the differences in depreciation rates between intangible and tangible assets within the firms. Precisely measuring the firm-level depreciation rates for intangible and tangible assets is challenging, and we roughly approximate these values with our data. Specifically, we compute the amortization rate for intangible assets and the depreciation rate for tangible assets, both winsorized at the 1% level to reduce the effects of outliers. The depreciation gap is defined as the difference between the amortization rate and the depreciation rate. We calculate the average depreciation gap for each firm across all available time periods and use it to classify firms into high depreciation gap and low depreciation gap groups. Based on this classification, we perform an empirical analysis to investigate how the depreciation gap influences the heterogeneous effects of monetary policy innovations on firm investment by the intangible ratio.

**<Insert Table 12 Here>**

As shown in Table 12, the interaction coefficients are 0.0372 and 0.0349 at  $h=6$  and  $h=10$ , for firms with a high depreciation gap between tangible and intangible assets. These coefficients are statistically significant at the 1% level, indicating that a one standard deviation increase in the intangible ratio will mitigate the investment increase in response to a one standard deviation monetary policy expansion by approximately 40 basis points. Conversely, the coefficients are smaller and statistically insignificant for firms with a low depreciation gap. These results imply that the mitigating effect of intangible assets diminishes when the difference in depreciation rates between intangible and tangible assets is less pronounced. The findings support the hypothesis that the effectiveness of intangible assets in reducing the sensitivity of investment to monetary policy innovations is contingent upon the depreciation gap of intangible and tangible assets.

### 5.3 Adjustment Cost Channel

Lastly, we examine whether differences in firms' adjustment costs can explain heterogeneity in the investment response to monetary policy innovations. To assess this mechanism empirically, we split the sample based on whether the firm is located in a city with a patent exchange, which is the market for technology. Cities with patent exchanges provide a more flexible environment for investment and disinvestment in knowledge capital and are therefore interpreted as regions in which firms face lower effective adjustment costs. We also proxy intangible capital adjustment costs using executive compensation share, and the share of R&D personnel. Each of these proxies is divided into top- and bottom-50% groups based on the variable's sample median.

<Insert Table 13 Here>

Panel A of Table 13 reports the estimates for firms in cities without a patent exchange versus those with one. Across both horizons, the interaction between monetary policy innovations and the intangible asset ratio is positive and statistically significant in both subsamples. In other words, firms' intangible intensity appears to shape their response to monetary policy to a comparable degree regardless of whether they operate in a high or low adjustment cost environment. Likewise, Panels B and C indicate no material differences when splitting firms by executive compensation share and research personnel ratio. In both cases, the coefficients for the top and bottom groups are similar in magnitude and statistically significant, indicating a stable relationship between intangible asset intensity and firms' investment responses that is largely independent of adjustment costs.

These results indicate that variation in adjustment costs does not materially alter the relationship between intangible intensity and the investment response to monetary policy. This finding is consistent with [Döttling and Ratnovski \(2023\)](#), who also report no evidence supporting the adjustment-cost channel in U.S. data.

## 6 Conclusion

This study provides firm-level evidence on how monetary policy innovations affect investment in China and highlights the moderating role of intangible assets in monetary transmission. We show that expansionary monetary policy increases

firm investment on average, but this effect is statistically significantly weaker for firms with higher intangible asset intensity. The results underscore the importance of firm heterogeneity in shaping the investment channel of monetary policy.

Our analysis reveals that the mitigating effect of intangible assets operates primarily through financing and depreciation channels. Intangible-intensive firms rely more on internal liquidity, face weaker collateral effects, and exhibit higher depreciation rates, all of which reduce their sensitivity to monetary easing. These effects vary systematically by ownership structure, strategic emerging industry status, and regional financial development, reflecting differences in firms' access to external finance.

We construct a Composite Monetary Policy index that integrates China's major quantity- and price-based policy instruments, along with two intermediate targets. This index offers a unified measure of China's monetary stance and a tractable framework for analyzing complex policy environments. The approach may be applicable to other economies that rely on multiple evolving instruments.

From a policy perspective, our findings suggest that the effectiveness of monetary policy is not uniform across firms but depends critically on their intangible capital intensity. As intangible assets become increasingly important in modern economies, monetary policy may have more limited influence on firm investment through traditional credit channels, highlighting the need for complementary policies that address financing frictions faced by intangible-intensive firms.

Several limitations point to avenues for future research. First, our analysis does not distinguish between asymmetric responses to contractionary versus expansionary monetary policy; whether intangible assets mitigate tightening shocks to the same extent remains an open question. Second, our analysis focuses on listed firms, for which reliable balance-sheet measures of intangible assets are available. Investment responses among non-listed firms, particularly those relying more heavily on informal finance, remain an important topic for future research. As data availability and reporting standards improve, future research could extend the analysis to broader firm populations and explore alternative measures of intangible capital.

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# Tables and Figures

## Figures

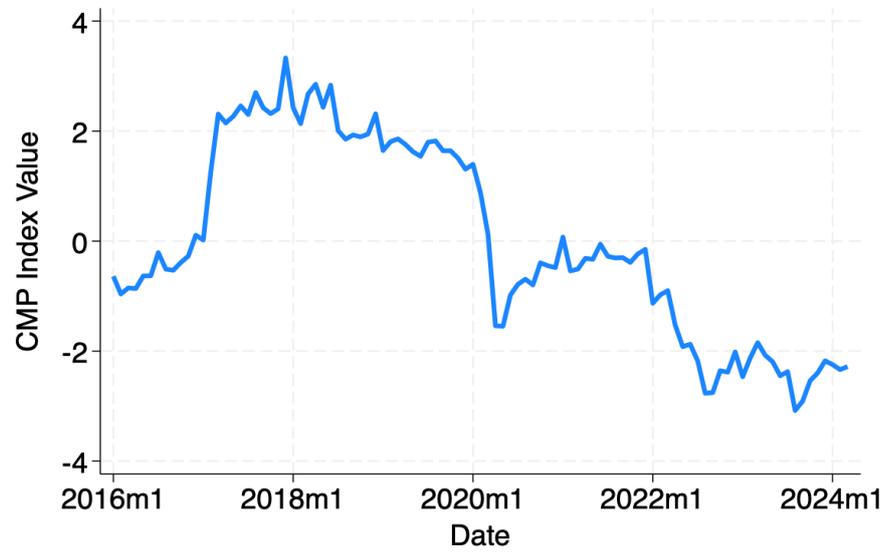


Figure 1: Trend of the CMP Index

**Notes:** This figure plots the monthly values of the CMP Index from January 2016 to March 2024. The index is constructed using the first principal component of standardized monetary policy instruments. Higher values indicate a tighter monetary policy stance, whereas lower values reflect expansionary conditions.

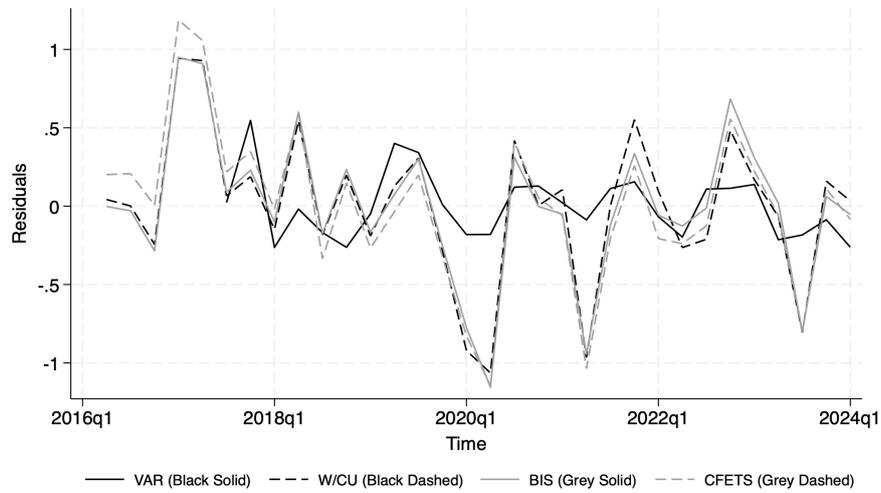


Figure 2: Time Series of China’s Monetary Policy innovations

**Notes:** This figure plots four alternative measures of monetary policy innovations for China from 2016Q1 to 2024Q1. BIS represents the series of residuals derived from the model specification with the BIS RMB Index as a proxy for assessing exchange rate stability; CFETS represents the series of residuals extracted from the specification employing the CFETS RMB Index, and W/CU denotes the series of residuals extracted from the monetary policy rule specification incorporating the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. VAR represents residuals from var estimations.

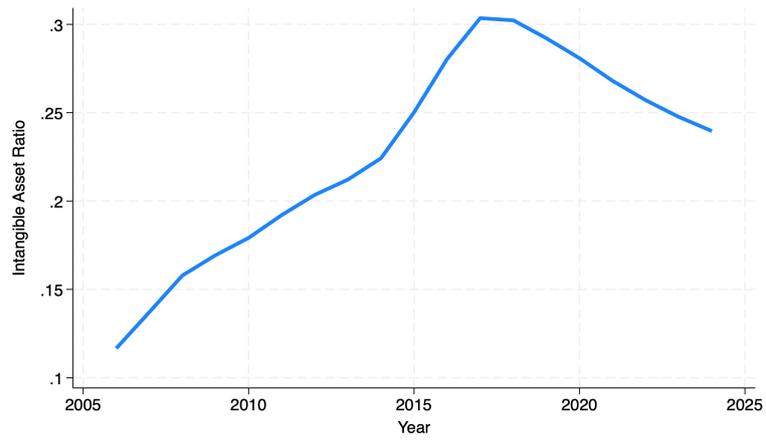


Figure 3: Average Intangible Assets Ratio over Time

**Notes:** The trend of the intangible asset ratio is plotted by calculating the mean of the intangible-to-total capital ratio for each year using the data in our sample. Observations with missing values for intangible ratio are excluded, and data for years after 2005 are included for this plot.

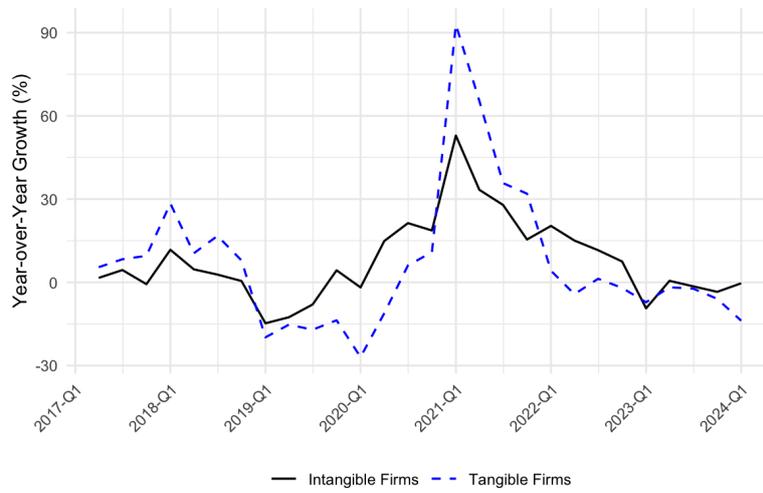
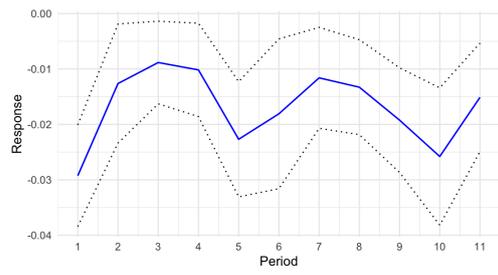
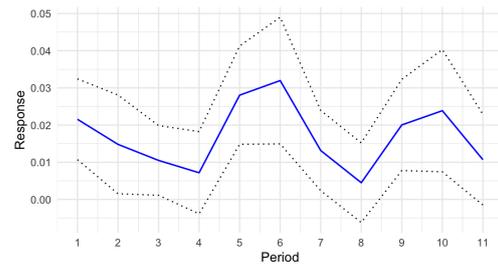


Figure 4: Year-over-Year Growth in Firms' Investment Rates

**Notes:** Year-over-year investment growth rates in China from 2016 to 2024, categorized by firms' intangible-to-total capital ratio. Firms are divided into two groups: intangible firms (top 30% in intangible-to-total capital ratio) and tangible firms (bottom 30%).



(a)



(b)

Figure 5: Dynamic Responses

**Notes:** We plot the dynamic responses to monetary policy innovations. The left panel illustrates the firms' investment rates respond to innovations over time. The right panel presents how the interaction between the intangible ratio and monetary policy innovations influences investment rate dynamics.

## Tables

Table 1: Descriptive Statistics of Monetary Policy Instruments and Targets

Variable	Obs	Mean	Std. Dev.	Min	Max
7 Day Repo Rate	99	2.561	0.492	1.574	3.863
Required Reserve Ratio	99	11.323	3.443	7	17
Open Market Operations	99	12749.49	493940.9	-1133000	1407000
Standing Lending Facility Rate	99	3.063	0.263	2.65	3.4
Medium-term Lending Facility Rate	99	3.007	0.241	2.5	3.3
M2 YoY Growth Rate	99	9.896	1.584	7.97	13.97

**Notes:** This table reports descriptive statistics for the main monetary policy instruments and targets used in the analysis. All variables are monthly and cover the sample period from January 2016 to March 2024, and are retrieved from the CEIC China Economic Database. Rates are in percent. Open market operations are in RMB million. All variables are reported here in their original raw units, while the subsequent analysis uses their standardized values.

Table 2: Variable Descriptions

Variable	Measure	Source
incap	Total Intangible Capital: [Net Intangible] + [Goodwill]	CSMAR-Balance Sheet
tancap	Total Tangible Capital: [Net Fixed Asset] + [Investment Property]	CSMAR-Balance Sheet
totcap	Total Capital: [Total Intangible Capital] + [Total Tangible Capital]	Author's Calculation with CSMAR data
inratio	Intangible Ratio: [Total Intangible Capital]/[Total Capital]	Author's Calculation with CSMAR data
inv	Total Investment: [Cash Paid to Acquire and Construct Fixed Assets, Intangible Assets and Other Long-term Assets] - [Net Cash Received from Disposal]	CSMAR-Cash Flow
invrate	Investment Rate: [Total Investment]/lag([Total Capital])	Author's Calculation with CSMAR data
cash	Cash Rate: [Cash and Equivalents]/[Total Asset]	Author's Calculation with CSMAR data
age	Firm Age: ([Report Date] - [List Date])/365.25	Author's Calculation with CSMAR data
size	Firm Size: [Total Asset]/1000,000,000	CSMAR-Balance Sheet
eq	Equity Growth: [Total Equity]/lag([Total Equity]) - 1	Author's Calculation with CSMAR data
debt	Debt Growth: ([Long-term Loans] + [Bond Payables] + [Short-term Loans])/lag([Long-term Loans] + [Bond Payables] + [Short-term Loans])	CSMAR-Balance Sheet
assetloss	Asset Loss Rate: [Asset Impairment Loss]/[Total Asset]	Author's Calculation with CSMAR data
tobinq	Tobin's Q: [Market Value]/[Total Asset]-[Net Intangible Assets]-[Net Goodwill]	CSMAR-Relative Index

Table 3: Descriptive Statistics

Variable	Obs	Mean	SD	Min	Max
invrate	75,053	0.1210	0.193	-0.0556	1.400
inratio	75,053	0.2940	0.246	0.0008	0.961
tobinq	75,053	2.0800	1.340	0.8560	9.630
cash	75,053	0.1470	0.101	0.0032	0.636
age	75,053	11.6000	8.060	0.0000	31.500
assetloss	75,053	-0.0001	0.0066	-0.0412	0.0214
eq	75,053	0.0314	0.145	-0.3860	0.961
debt	75,053	0.0969	0.623	-1.0000	4.220
size	75,053	27.0000	87.000	0.2200	636.000

**Note:** This table reports the descriptive statistics used in the baseline empirical analysis. The sample covers all A-share listed firms in China from 2016 Q1 to 2024 Q1 at a quarterly frequency, and all series are deflated using the 1978 base-year Consumer Price Index (CPI). To mitigate the influence of outliers, all continuous variables are winsorized at the 1 percent level.

Table 4: Baseline Regression Results

<b>Panel A.</b> Dependent Variable: $\Delta\text{invrate}_{h=6}$						
	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_3$
innovation	-0.0161*** (0.0021)	-0.0181*** (0.0069)	-0.0136*** (0.0020)	-0.0172*** (0.0065)	-0.0162*** (0.0021)	-0.0164** (0.0066)
innovation $\times$ inratio		0.0320*** (0.0087)		0.0272*** (0.0082)		0.0297*** (0.0083)
innovation $\times$ tobinq		-0.0087*** (0.0019)		-0.0070*** (0.0017)		-0.0085*** (0.0018)
innovation $\times$ cash		-0.1318*** (0.0261)		-0.1150*** (0.0245)		-0.1290*** (0.0245)
innovation $\times$ age		0.0028*** (0.0003)		0.0025*** (0.0003)		0.0027*** (0.0003)
innovation $\times$ assetloss		1.3145*** (0.2857)		1.3419*** (0.2734)		0.7552*** (0.2381)
innovation $\times$ eq		-0.0074 (0.0192)		-0.0095 (0.0170)		-0.0110 (0.0183)
innovation $\times$ debt		-0.0098** (0.0038)		-0.0075** (0.0034)		-0.0107*** (0.0037)
innovation $\times$ size		-0.0000 (0.0000)		-0.0000 (0.0000)		-0.0000 (0.0000)
Observations	95,576	75,053	95,576	75,053	95,576	75,053
Adj $R^2$	0.2420	0.2769	0.2419	0.2774	0.2421	0.2778
Firm and Macro controls	No	Yes	No	Yes	No	Yes
Fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
<b>Panel B.</b> Dependent Variable: $\Delta\text{invrate}_{h=10}$						
	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_3$
innovation	-0.0101*** (0.0019)	-0.0258*** (0.0063)	-0.0094*** (0.0018)	-0.0258*** (0.0062)	-0.0091*** (0.0018)	-0.0216*** (0.0060)
innovation $\times$ inratio		0.0239*** (0.0084)		0.0253*** (0.0081)		0.0212*** (0.0081)
innovation $\times$ tobinq		-0.0057*** (0.0016)		-0.0051*** (0.0016)		-0.0058*** (0.0015)
innovation $\times$ cash		-0.0424* (0.0256)		-0.0428* (0.0243)		-0.0439* (0.0240)
innovation $\times$ age		0.0022*** (0.0003)		0.0022*** (0.0003)		0.0021*** (0.0003)
innovation $\times$ assetloss		1.1859*** (0.2868)		1.0166*** (0.2693)		0.6985*** (0.2508)
innovation $\times$ eq		0.0254 (0.0175)		0.0194 (0.0156)		0.0260 (0.0171)
innovation $\times$ debt		-0.0045 (0.0034)		-0.0043 (0.0031)		-0.0039 (0.0034)
innovation $\times$ size		-0.0000** (0.0000)		-0.0000** (0.0000)		-0.0000* (0.0000)
Observations	76,017	59,824	76,017	59,824	76,017	59,824
Adj $R^2$	0.2849	0.3268	0.2849	0.3265	0.2849	0.3263
Firm and Macro controls	No	Yes	No	Yes	No	Yes
Fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes

**Notes:** The dependent variables are the changes in investment rates for  $h = 6$  and  $h = 10$ . The subscripts for  $\Delta\text{invrate}$  indicate the innovation series used in the regression analysis: 1 represents the series of residuals derived from the model specification with the BIS RMB Index as a proxy for assessing exchange rate stability; 2 represents the series of residuals extracted from the specification employing the CFETS RMB Index, and 3 denotes the series of residuals extracted from the specification incorporating the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. The key explanatory variable is the monetary policy innovations, and its interaction with the firm's intangible asset ratio captures the heterogeneity in investment responses. Control variables include Tobin's Q, cash ratio, firm age, asset loss rate, equity growth, debt growth, and firm size. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels. Standard errors are clustered at the firm level and reported in the parentheses below the coefficients.

Table 5: IV Regression Results

<b>Panel A.</b> Dependent Variable: $\Delta\text{invrate}_{h=6}$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_3$
innovation	-0.0240 (0.0304)	-0.0656** (0.0312)	-0.0174 (0.0254)	-0.0468* (0.0267)	-0.0337 (0.0313)	-0.0525* (0.0303)
innovation $\times$ inratio	0.1718* (0.0960)	0.1229*** (0.0328)	0.1437* (0.0804)	0.0983*** (0.0265)	0.1832* (0.1017)	0.1214*** (0.0329)
innovation $\times$ tobinq		-0.0189** (0.0086)		-0.0142** (0.0065)		-0.0177** (0.0083)
innovation $\times$ cash		-0.0827 (0.1060)		-0.0751 (0.0847)		-0.0825 (0.1039)
innovation $\times$ age		0.0061*** (0.0012)		0.0051*** (0.0010)		0.0059*** (0.0011)
innovation $\times$ assetloss		7.2102*** (1.4018)		5.4360*** (0.9528)		6.5823*** (1.4083)
innovation $\times$ eq		0.1304 (0.0818)		0.1060** (0.0534)		0.1450* (0.0859)
innovation $\times$ debt		-0.0278** (0.0121)		-0.0229** (0.0095)		-0.0282** (0.0124)
innovation $\times$ size		-0.0000 (0.0001)		-0.0000 (0.0000)		-0.0000 (0.0000)
Observations	95,573	75,053	95,573	75,053	95,573	75,053
Adj. $R^2$	0.2302	0.2654	0.2314	0.2676	0.2294	0.2622
Firm and Macro controls	No	Yes	No	Yes	No	Yes
Fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F (innovation)	1325.0	299.4	1406.5	241.5	1851.0	322.8
<b>Panel B.</b> Dependent Variable: $\Delta\text{invrate}_{h=10}$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_3$
innovation	-0.0419 (0.0286)	-0.1001*** (0.0330)	-0.0384 (0.0267)	-0.0848*** (0.0299)	-0.0583* (0.0320)	-0.1079*** (0.0380)
innovation $\times$ inratio	0.1998** (0.0872)	0.1114*** (0.0366)	0.1879** (0.0823)	0.0950*** (0.0311)	0.2392** (0.1045)	0.1331*** (0.0425)
innovation $\times$ tobinq		-0.0088 (0.0097)		-0.0079 (0.0080)		-0.0109 (0.0116)
innovation $\times$ cash		-0.0457 (0.1115)		-0.0399 (0.0942)		-0.0608 (0.1306)
innovation $\times$ age		0.0066*** (0.0013)		0.0057*** (0.0011)		0.0078*** (0.0015)
innovation $\times$ assetloss		2.4274 (1.4831)		2.2222** (1.0414)		1.5794 (1.5016)
innovation $\times$ eq		0.2547*** (0.0764)		0.1904*** (0.0538)		0.3028*** (0.0885)
innovation $\times$ debt		-0.0165* (0.0098)		-0.0150* (0.0083)		-0.0193* (0.0114)
innovation $\times$ size		0.0000 (0.0001)		0.0000 (0.0001)		0.0000 (0.0001)
Observations	76,014	59,824	76,014	59,824	76,014	59,824
Adj. $R^2$	0.2704	0.3125	0.2693	0.3161	0.2650	0.3033
Firm and Macro controls	No	Yes	No	Yes	No	Yes
Fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F (innovation)	1244.4	445.4	1197.1	345.8	2392.5	491.4

**Notes:** This table reports IV estimates with firm, quarter, and year fixed effects. “Innovation” denotes the instrumented monetary policy innovation series. Columns (1)–(2) use the residual series obtained from the specification that proxies exchange-rate stability with the BIS RMB Index. Columns (3)–(4) use the residual series from the specification employing the CFETS RMB Index. Columns (5)–(6) use the residual series from the specification that incorporates the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. The interaction term innovation  $\times$  inratio captures heterogeneity by the intangible asset ratio. Standard errors are clustered at the firm level and reported in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

Table 6: M2 innovations on Investment Growth

Dependent Variable	$h = 6$		$h = 10$	
	$\Delta\text{invrate}_1$ (1)	$\Delta\text{invrate}_1$ (2)	$\Delta\text{invrate}_1$ (3)	$\Delta\text{invrate}_1$ (4)
innovation	0.0033*** (0.0013)	0.2450*** (0.0398)	0.0078*** (0.0013)	0.1816*** (0.0484)
innovation $\times$ intangible	-0.0085* (0.0051)	-0.0130** (0.0058)	-0.0140*** (0.0054)	-0.0155*** (0.0059)
innovation $\times$ tobinq		-0.0009 (0.0008)		0.0002 (0.0008)
innovation $\times$ cash		0.0113 (0.0076)		0.0150* (0.0083)
innovation $\times$ age		0.0011*** (0.0002)		0.0014*** (0.0002)
innovation $\times$ assetloss		-0.1836 (0.1264)		-0.1798 (0.1258)
innovation $\times$ equity		-0.0049 (0.0045)		-0.0082* (0.0045)
innovation $\times$ debt		-0.0115** (0.0058)		-0.0193*** (0.0066)
innovation $\times$ size		-0.0012* (0.0007)		-0.0011* (0.0007)
innovation $\times$ GDP		-0.0008* (0.0005)		0.0009** (0.0004)
innovation $\times$ unemployment		-0.0524*** (0.0082)		-0.0412*** (0.0105)
Observations	102,490	94,794	102,228	94,561
Adj. $R^2$	0.1787	0.1997	0.1958	0.2196
Firm and Macro Controls	No	Yes	No	Yes
Fixed Effects	Yes	Yes	Yes	Yes

**Notes:** This table reports the interaction effects of exogenous monetary policy innovations on firm investment growth over 6- and 10-quarter horizons. The dependent variable is the change in the investment rate over the respective horizon. The innovation variable refers to the exogenous component of M2 growth as in [Chen et al. \(2018\)](#). All specifications include firm, year, and quarter fixed effects. Columns (1) and (3) show specifications without firm-level or macroeconomic controls. Columns (2) and (4) include firm-level and macroeconomic control variables and their interactions with the innovation; the levels of these variables are included in the regressions but omitted from the table for brevity. Standard errors are clustered at the firm level and reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table 7: Robustness: IV

Dependent Variable	$h = 6$	$h = 10$
	$\Delta\text{invrate}_6$	$\Delta\text{invrate}_{10}$
	(1)	(2)
innovation	-0.0734** (0.0328)	-0.1274*** (0.0347)
innovation $\times$ intangible	0.1191*** (0.0351)	0.1052*** (0.0382)
innovation $\times$ tobinq	-0.0177* (0.0093)	-0.0036 (0.0105)
innovation $\times$ cash	-0.0528 (0.1102)	0.0106 (0.1184)
innovation $\times$ age	0.0061*** (0.0013)	0.0070*** (0.0013)
innovation $\times$ assetloss	6.7782*** (1.5106)	2.1062 (1.6256)
innovation $\times$ equity	0.0816 (0.0928)	0.2766*** (0.0866)
innovation $\times$ debt	-0.0305** (0.0126)	-0.0226** (0.0102)
innovation $\times$ size	-0.0000 (0.0001)	0.0000 (0.0001)
Observations	67,383	53,919
Adj. $R^2$	0.2591	0.2982
Fixed Effects (firm / quarter / year)	Yes	Yes
First-stage $F$	282.8	352.1

**Notes:** This table reports the IV estimates of instrumented monetary policy innovations and their interaction effects with firm characteristics on investment growth over 6- and 10-quarter horizons excluding foreign-investing enterprises. The innovation variable is instrumented using the Global Economic Policy Uncertainty (GEPU) index and its interactions with firm-level covariates. All regressions include firm, quarter, and year fixed effects; standard errors are clustered at the firm level. First-stage  $F$ -statistics indicate strong instrument relevance. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

Table 8: Financing Channel

	(1)	(2)	(3)	(4)
	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$
	$h = 6$	$h = 10$	$h = 6$	$h = 10$
<b>Panel A: Cash Ratio</b>		<b>Low</b>		<b>High</b>
innovation $\times$ inratio	0.0437***	0.0251**	0.0091	0.0202
	(0.0106)	(0.0111)	(0.0144)	(0.0128)
Observations	42,495	34,297	32,558	25,527
<b>Panel B: Leverage</b>		<b>High</b>		<b>Low</b>
innovation $\times$ inratio	0.0420***	0.0378***	0.0208	0.0033
	(0.0115)	(0.0114)	(0.0130)	(0.0124)
Observations	47,055	38,079	27,998	21,745

**Notes:** This table examines the heterogeneous effects of monetary policy innovations on firms' investment growth through the financing channel. The dependent variable is the change in firms' investment rates at horizons 6 and 10 quarters ahead. The key variable of interest is the interaction between monetary policy innovation and the intangible ratio. Panel A splits firms based on whether their cash ratio is below (Low) or above (High) the median level. Panel B splits firms by leverage ratio. All regressions include firm and time fixed effects, and standard errors (in parentheses) are clustered at the firm level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels.

Table 9: Regression Results Based on Ownership Structure

$h = 6$	Variable	Non-SOE			SOE		
		$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$
	innovation	-0.0195** (0.0087)	-0.0196** (0.0083)	-0.0190** (0.0082)	0.0119 (0.0117)	0.0104 (0.0106)	0.0137 (0.0115)
	innovation $\times$ inratio	0.0331*** (0.0109)	0.0284*** (0.0103)	0.0312*** (0.0103)	0.0044 (0.0136)	0.0027 (0.0124)	0.0005 (0.0130)
	Observation	50,330	50,330	50,330	24,174	24,174	24,174
$h = 10$	Variable	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$
	innovation	-0.0267*** (0.0081)	-0.0284*** (0.0077)	-0.0226*** (0.0077)	-0.0031 (0.0116)	-0.0014 (0.0114)	-0.0009 (0.0110)
	innovation $\times$ inratio	0.0239** (0.0104)	0.0261*** (0.0101)	0.0202** (0.0100)	0.0125 (0.0141)	0.0129 (0.0135)	0.0112 (0.0134)
	Observation	39,370	39,370	39,370	19,992	19,992	19,992

**Notes:** This table analyzes the heterogeneity in the effect of monetary policy innovations on firms' investment growth across ownership types. The dependent variable is the change in firms' investment rates at horizons 6 and 10 quarters ahead. The key variable of interest is the interaction between monetary policy innovation and the intangible ratio. Firms are classified into non-state-owned enterprises (Non-SOEs) if their ownership type codes are P0302, P0303, P0304, P0305, or P0306, and into state-owned enterprises (SOEs) if their codes are P0301, P0307, or P0308. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors are clustered at the firm level and reported in the parentheses below the estimated coefficients.

Table 10: Regression Results based on Strategic Firm Division

$h = 6$	Variable	Strategic Firm			Non-Strategic Firm		
		$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$
	innovation	-0.0288*** (0.0081)	-0.0289*** (0.0077)	-0.0279*** (0.0077)	0.0098 (0.0130)	0.0111 (0.0118)	0.0112 (0.0129)
	innovation $\times$ inratio	0.0516*** (0.0101)	0.0432*** (0.0094)	0.0490*** (0.0096)	-0.0177 (0.0169)	-0.0131 (0.0162)	-0.0198 (0.0162)
	Observation	53,301	53,301	53,301	21,752	21,752	21,752
$h = 10$	Variable	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_2$	$\Delta\text{invrate}_3$
	innovation	-0.0348*** (0.0074)	-0.0362*** (0.0074)	-0.0302*** (0.0071)	0.0084 (0.0122)	0.0092 (0.0119)	0.0094 (0.0114)
	innovation $\times$ inratio	0.0351*** (0.0101)	0.0367*** (0.0098)	0.0317*** (0.0097)	-0.0038 (0.0149)	-0.0029 (0.0147)	-0.0049 (0.0144)
	Observation	42,141	42,141	42,141	17,683	17,683	17,683

**Notes:** This table investigates whether the response of firm investment to monetary policy innovations differs between strategic and non-strategic firms. The dependent variable is the change in firms' investment rates at horizons 6 and 10 quarters ahead. The key variable of interest is the interaction between monetary policy innovation and the intangible ratio. Industry classification follows the 2012 CSRC Industry codes. Detailed division can be found in Appendix A.7. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors are clustered at the firm level and reported in the parentheses below the coefficients.

Table 11: Adjustment Cost Channel

	(1)	(2)	(3)	(4)
	$\Delta \text{inrate}_1$	$\Delta \text{inrate}_1$	$\Delta \text{inrate}_1$	$\Delta \text{inrate}_1$
	$h = 6$	$h = 10$	$h = 6$	$h = 10$
<b>Panel A: Patent Exchange</b>		<b>Yes</b>		<b>No</b>
innovation $\times$ inratio	0.0328***	0.0200*	0.0353***	0.0391***
	(0.0113)	(0.0110)	(0.0137)	(0.0131)
Observations	43,374	34,512	31,679	25,312
<b>Panel B: Executive Pay Share</b>		<b>Bottom</b>		<b>Top</b>
innovation $\times$ inratio	0.0333***	0.0208*	0.0280**	0.0261**
	(0.0107)	(0.0107)	(0.0127)	(0.0123)
Observations	42,096	33,915	32,496	25,706
<b>Panel C: R&amp;D Staff Share</b>		<b>Bottom</b>		<b>Top</b>
innovation $\times$ inratio	0.0557***	0.0408***	0.0489***	0.0300**
	(0.0147)	(0.0125)	(0.0146)	(0.0134)
Observations	27,486	20,731	24,829	18,324

**Notes:** This table examines whether the investment response to monetary policy innovations differs by firms' intangible capital adjustment costs, proxied by the presence of a local patent exchange, executive compensation share, and research person ratio. Firms are classified according to whether the city in which they are registered hosts an officially established patent exchange for the trading center proxy. The remaining proxy variables are each divided into top- and bottom-50% groups based on their respective sample medians. The dependent variable is the change in the firm's investment rate at horizons 6 and 10 quarters ahead. The key coefficient of interest is the interaction between monetary policy innovations and the firm's intangible asset ratio. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors are clustered at the firm level and reported in the parentheses below the coefficients.

Table 12: Depreciation Channel

	(1)	(2)	(3)	(4)
	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$
	$h = 6$	$h = 10$	$h = 6$	$h = 10$
<b>Split by Depreciation Gap</b>	<b>High Depre Gap</b>	<b>Low Depre Gap</b>		
innovation $\times$ inratio	0.0372***	0.0349***	0.0256	-0.0044
	(0.0113)	(0.0128)	(0.0161)	(0.0160)
Observations	19,855	15,657	15,820	12,574

**Notes:** This table analyzes whether firms with different intangible depreciation rates respond differently to monetary policy innovations. The depreciation channel is captured using a depreciation gap, which reflects the difference between the amortization of intangible assets and the depreciation of tangible assets relative to their respective asset bases. The dependent variable is the change in firms' investment rates at horizons 6 and 10 quarters ahead. The key variable of interest is the interaction between monetary policy innovation and the intangible ratio. Firms are divided into high- and low-gap groups based on the median. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors are clustered at the firm level and reported in the parentheses below the coefficients.

Table 13: Location Channel

	(1)	(2)	(3)	(4)
	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$	$\Delta\text{invrate}_1$
	$h = 6$	$h = 10$	$h = 6$	$h = 10$
<b>Panel A: Split by City Index</b>		<b>Other Cities</b>		<b>Top 20</b>
innovation $\times$ inratio	0.0525***	0.0460 ***	0.0222*	0.0121
	(0.0129)	(0.0129)	(0.0118)	(0.0111)
Observations	36,574	29,325	38,479	30,499

**Notes:** This table investigates whether the investment response to monetary policy innovations varies by firms' geographic location. Firms are classified based on the city in which they are registered. "Top 20" refers to firms located in the 20 largest cities by city index from [State Council Information Office \(2023\)](#), while "Other Cities" includes all remaining locations. The dependent variable is the change in firms' investment rates at horizons 6 and 10 quarters ahead. The key variable of interest is the interaction between monetary policy innovation and the intangible ratio. Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Standard errors are clustered at the firm level and reported in the parentheses below the coefficients.

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# A Additional Tables & Figures

## A.1 Trends in Monetary Policy Instruments

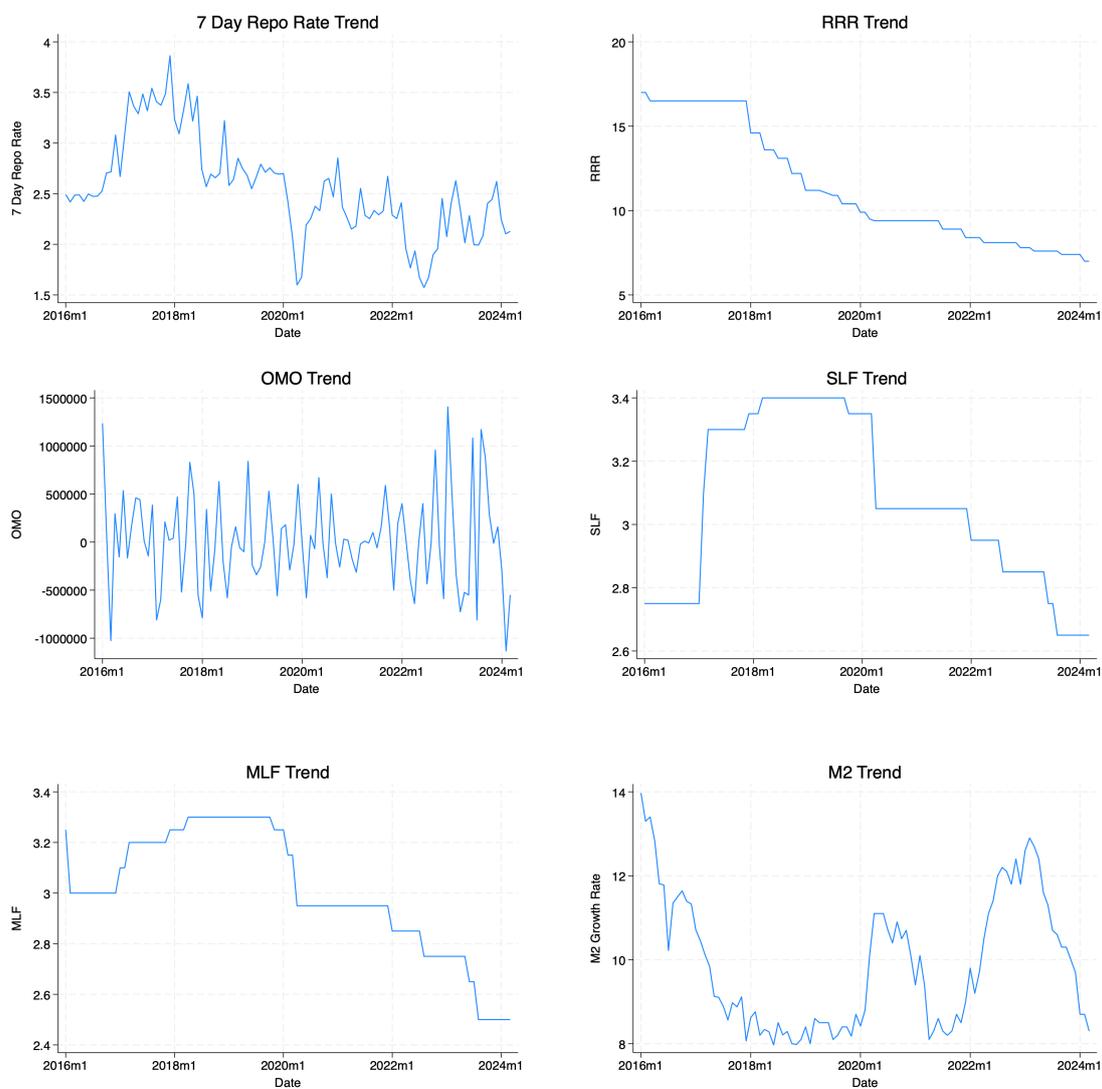


Figure A.1: Trends of Instruments

**Notes:** These graphs present the trends of the instruments over time. The variables display different behaviors. This could also reflect that a single measure, such as the M2 growth rate, could be insufficient to capture all the variations in the PBoC's monetary policy stance.

## A.2 Eigenvalues and Explained Variance of the CMP Index

PCA is appropriate for the context in this study because it reduces data complexity by transforming correlated variables into a set of uncorrelated components. The components are ordered according to their eigenvalues, with the component having the highest eigenvalue accounting for the largest portion of the variance in the data. The CMP index is a linear combination of the standardized variables, calculated by multiplying the variables by their respective eigenvectors. The eigenvectors indicate the direction of these components. PCA assists in filtering out noise (less significant variance) by concentrating on the major sources of variation. This method ensures that the retained components reflect the core dynamics of the monetary policy instruments, while being easy to implement and adaptable to many situations. Considering these benefits, we use PCA to consolidate the multiple monetary policy instruments into a single composite measure - the CMP index, which provides a succinct interpretation of the overall monetary policy stance.

Given that the variables under consideration are measured on different scales and units, representing either quantities or prices, we standardize each series of instruments prior to performing the Principal Component Analysis. Furthermore, we adjust the year-on-year M2 growth rate and the volume of open market operations so that a positive value indicates a contractionary monetary policy stance, consistent with the other variables. We construct the CMP index as follows:

$$CMP_t = w_1 \cdot MLF_t + w_2 \cdot SLF_t + w_3 \cdot 7DayRepo_t + w_4 \cdot RRR_t + w_5 \cdot OMO_t + w_6 \cdot M2_t \quad (\text{A.1})$$

where  $w_1, w_2, w_3, w_4, w_5$  and  $w_6$  denote the weights assigned to MLF, SLF, the 7 Day Repo Rate, RRR, OMO, and YOY M2 growth rate, respectively, with the values of these variables being standardized.

Figure A.2 shows the scree plot from our PCA exercise and Table A.1 summarizes the loadings for each variable. The scree plot illustrates the eigenvalues, reflecting the proportion of variance explained by each principal component, in descending order. The first component has an eigenvalue of 3.17 and accounts for 52.76%<sup>16</sup> of the variation of the original variables. We proceed with the weights derived from the first component for constructing our CMP index, as it reduces the number of dimensions of our dataset from six to one, and it explains a suffi-

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<sup>16</sup>PCA estimates are available in Appendix A.2.

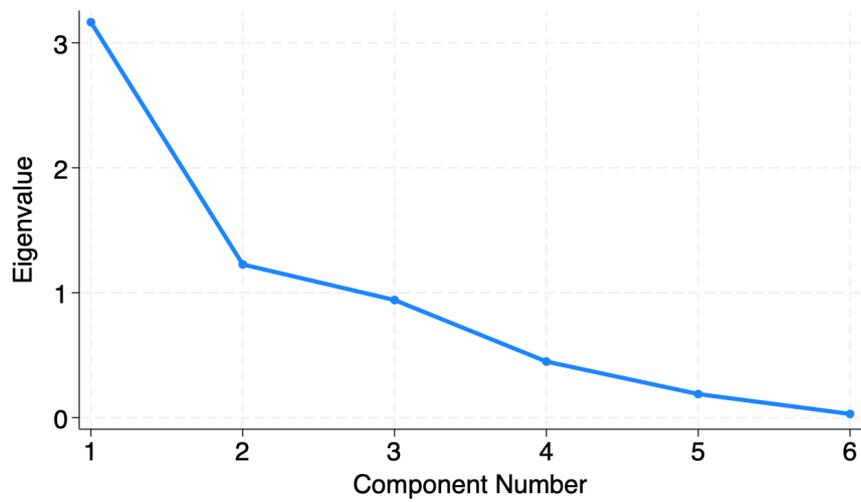


Figure A.2: Scree Plot from the Principal Component Analysis

**Notes:** This figure displays the scree plot of the eigenvalues of the principal components extracted from the six monetary policy instruments. The sharp drop after the first component and the flattening of the curve indicate diminishing explanatory power of subsequent components. PCA loadings and detailed estimates are reported.

cient proportion of variance in the variables. Selecting the first component that

Table A.1: Principal Components (Eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
7 Day Repo	<b>0.4716</b>	-0.2236	0.1403	0.5820	-0.5783	-0.1865
RRR	<b>0.3535</b>	-0.6216	0.2871	0.0309	0.5041	0.3887
OMO	<b>0.0541</b>	0.4424	0.8915	-0.0763	0.0184	-0.0181
SLF	<b>0.4924</b>	0.2899	-0.1866	-0.3779	-0.3357	0.6190
MLF	<b>0.5180</b>	-0.0736	-0.0559	-0.5297	0.1155	-0.6552
M2	<b>0.3727</b>	0.5277	-0.2551	0.4808	0.5339	-0.0374

**Notes:** The values in each column represent the loadings of each monetary policy variable on the corresponding principal component. Larger absolute values suggest that the variable is more important in defining the component. Negative values in PCA component weights indicate that the variables contribute negatively to that principal component.

accounts for around 50% of the variance for our baseline exercise is consistent with the practices used in [Creel et al. \(2015\)](#) and [Tram et al. \(2023\)](#). The changes in these monetary policy-related factors will affect our CMP index. All weights for the first component are positive. We have modified the variables to ensure that an increase in any one of the variables leads to an increase in the CMP index, indicating a contractionary monetary policy stance as expected. For the remaining components, some weights are negative and that is why we exclude them from our baseline.

Table A.2: Eigenvalues and Variance explained from PCA

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.16561	1.93914	0.5276	0.5276
Comp2	1.22647	0.28545	0.2044	0.7320
Comp3	0.941024	0.492277	0.1568	0.8889
Comp4	0.448747	0.260103	0.0748	0.9636
Comp5	0.188644	0.15914	0.0314	0.9951
Comp6	0.0295038	–	0.0049	1.0000

### A.3 CMP Results

Table A.3: Estimated Monetary Policy

Coefficient	$CMP_{BIS}$		$CMP_{CFETS}$		$CMP_{CU}$	
	Estimate	SE	Estimate	SE	Estimate	SE
$CMP_{t-1}$	0.7934***	0.0700	0.8539***	0.0704	0.8295***	0.0836
$GDPgap_{t-1}$	0.0845***	0.0252	0.0874***	0.0274	0.1059***	0.0271
$RMB_{t-1}$	-0.0938***	0.0293	-0.0789**	0.0370	-0.0999***	0.0350
$CPI_{t-1}$					0.0877***	0.0292
$Unemp_{t-1}$					0.2386	0.2544

**Notes:**  $CMP_{BIS}$  denotes the estimated coefficients from regressing the CMP index on the lagged CMP index, GDP growth gap, and BIS RMB Index, while  $CMP_{CFETS}$  represents the estimated coefficients from regressing the CMP index on the lagged CMP index, GDP growth gap, and CFETS RMB Index.  $CMP_{CU}$  summarizes the coefficients obtained by regressing the CMP index on the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. Standard errors are reported in the SE columns. \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

## A.4 Validity Check I: Market Interest Rates

Table A.4: Validity Assessment Using the 90-Day Shibor Rate

<b>Panel A: 90-Day Shibor Rate</b>	<b>Coefficient</b>	<b>SE</b>	<b><i>p</i>-value</b>
innovation 1	0.8157***	0.2856	0.008
innovation 2	0.8957***	0.2482	0.001
innovation 3	0.7907***	0.2841	0.009
<b>Panel B: Lagged 90-Day Shibor Rate</b>	<b>Coefficient</b>	<b>SE</b>	<b><i>p</i>-value</b>
innovation 1	0.2870	0.3150	0.370
innovation 2	0.3504	0.2876	0.233
innovation 3	0.2574	0.3124	0.417

**Notes:** Innovation 1 represents the series of residuals derived from the model specification with the BIS RMB Index as a proxy for assessing exchange rate stability; innovation 2 represents the series of residuals extracted from the specification employing the CFETS RMB Index, and innovation 3 denotes the series of residuals extracted from the monetary policy rule specification incorporating the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. Standard errors are reported in the SE columns. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

## A.5 Validity Check II: Micro Level Evidence

Table A.5: Validity Checks Using Investment Rate

Lagged $\Delta\text{invrate}$	Coefficient	SE	$p$ -value
innovation 1	0.0009	0.0014	0.5088
innovation 2	0.0012	0.00133	0.3702
innovation 3	0.0008	0.0013	0.5176
$\Delta\text{invrate}$ with $h=1$	Coefficient	SE	$p$ -value
innovation 1	-0.0173***	0.0016	0.0000
innovation 2	-0.0157***	0.0015	0.0000
innovation 3	-0.0158***	0.0015	0.0000

**Notes:** Innovation 1 represents the series of residuals derived from the model specification with the BIS RMB Index as a proxy for assessing exchange rate stability; innovation 2 represents the series of residuals extracted from the specification employing the CFETS RMB Index, and innovation 3 denotes the series of residuals extracted from the monetary policy rule specification incorporating the lagged CMP index, GDP growth, the BIS RMB Index, inflation, and the unemployment rate. Lagged  $\Delta\text{invrate}$  represents the change in investment rate in the previous quarter.  $\Delta\text{invrate}$  with  $h = 1$  represents the next period change in investment rate. Standard errors are reported in the Std. Err. columns. \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

## A.6 Stock Return Responses to Monetary Policy Innovations

We also estimate the change in the stock return in response to the monetary policy innovation to further investigate the explanatory power of the innovations we construct and evaluate whether they align with our economic intuitions. We construct the stock return measure by calculating the cumulative annualized return as in [Hassan et al. \(2023\)](#). We use the same set of macroeconomic control variables and firm-level control variables in this specification as in the baseline with investment response. A substantial body of literature has examined the factors influencing stock returns we applied in this model specification. [Fama and French \(1995\)](#) demonstrate the relevance of firm size, suggesting larger firms often exhibit different return characteristics compared to smaller firms. The cash rate is the indicator of a firm's liquidity and financial health which can also impact firms' valuation and investor's perceptions ([Modigliani, 1944](#); [Ozdogli, 2012](#)).

$$\begin{aligned} \Delta \text{return}_{i,t+h} = & \alpha_1 \cdot \text{inratio}_{i,t-1} + \alpha_2 \cdot \text{innovation}_t + \beta_1 \cdot \text{inratio}_{i,t-1} \cdot \text{innovation}_t \\ & + \alpha'_3 \cdot X_{i,t-1} + \alpha'_4 \cdot M_{t-1} + \beta'_2 \cdot X_{i,t-1} \cdot \text{innovation}_t \\ & + \mu_i + \eta_y + \psi_q + \epsilon_{i,t+h} \end{aligned} \quad (\text{A.2})$$

The coefficient  $\alpha_2$  represents the direct response of stock returns to the monetary policy innovation, while the coefficient  $\beta_1$  represents the interaction effect of the monetary policy innovation with the intangible asset ratio on stock returns. Table A.6 provides an overview of the average effect of monetary policy on change in stock return across different horizons.

First, monetary policy innovations have statistically significant negative coefficients on changes in stock returns. These results indicate that firms' stock returns tend to decrease following a contractionary monetary innovation. The effect is immediate (-0.6832) and persists over the longer term (-0.6641) at  $h = 11$ ). Firms with higher intangible assets experience less negative impact from these innovations, as indicated by the positive interaction term coefficients. The coefficients ( $\beta_1$ ) are statistically significant at the 1% level except for  $h = 2$  and  $h = 7$ . This result suggests that a one standard deviation rise in the intangible-to-total capital ratio diminishes a firm's immediate stock return response to a one standard deviation increase in the monetary policy innovation by approximately 3.9%<sup>17</sup>.

<sup>17</sup>The standardized response is derived by multiplying the baseline coefficient at  $h=1$  by the standard deviations of the innovations and the intangible ratio.

Table A.6: Impact of monetary policy innovation on change in stock return.

Horizon	$\alpha_2$	(SE)	$\beta_1$	(SE)	N	$R^2$
$h = 1$	-0.6832***	(0.0409)	0.3324***	(0.0511)	95,882	0.0743
$h = 2$	-0.6161***	(0.0409)	0.0311	(0.0512)	91,464	0.0876
$h = 3$	-0.1490***	(0.0425)	0.2921***	(0.0515)	87,184	0.0639
$h = 4$	-0.5256***	(0.0436)	0.2585***	(0.0515)	82,934	0.0674
$h = 5$	-0.7487***	(0.0456)	0.2759***	(0.0546)	78,806	0.0820
$h = 6$	-1.0217***	(0.0486)	0.1576***	(0.0599)	74,800	0.0941
$h = 7$	-0.6125***	(0.0493)	0.0756	(0.0615)	70,938	0.0675
$h = 8$	-0.6821***	(0.0491)	0.2683***	(0.0575)	67,133	0.0080
$h = 9$	-0.4956***	(0.0478)	0.3927***	(0.0574)	63,411	0.0631
$h = 10$	-0.7700***	(0.0493)	0.3276***	(0.0588)	59,737	0.0767
$h = 11$	-0.6641***	(0.0515)	0.1268**	(0.0626)	56,180	0.0921

**Notes:** This table reports the estimated impact of monetary policy innovations on firms' stock returns across forecast horizons from  $h = 1$  to  $h = 11$  months. The coefficient  $\alpha$  captures the direct effect of monetary policy innovations.  $\beta$  denotes the interaction term response. The regression contains the same set of controlled variables and fixed effects as in baseline regression models. Standard errors are clustered at the firm level and reported in the Std. Err. columns. \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively.

We believe the results can be attributed to the following aspects. First, firms with high levels of intangible assets, such as patents, trademarks, and proprietary technologies, often have higher profit margins and more stable revenue streams due to their innovative capabilities and competitive advantages. These firms can better weather economic fluctuations, including those induced by monetary policy changes. This stability is attractive to investors, which helps sustain their stock prices during periods of monetary tightening. Second, intangible-intensive firms typically rely more on internal funding rather than external borrowing. According to [Bernanke and Gertler \(1995\)](#), during periods of tight monetary policy, the cost of external finance increases due to higher interest rates and worsened informational frictions in credit markets. However, firms with substantial internal funds are less affected by these higher external financing costs. Their reliance on internal cash flows for financing operations mitigates the negative impacts of monetary policy innovations on their financial health and stock returns. Finally, [Corrado et al. \(2009\)](#) suggest that intangible assets, such as software, research and development, and intellectual property, significantly improve labor productivity. Higher labor productivity leads to better growth prospects because it means reduced costs and increased profitability, which can boost investor confidence even in the face of monetary policy innovations. This finding is consistent with the mitigating effects of intangible assets; however, investigating the specific mechanisms behind this is

beyond the scope of this paper.

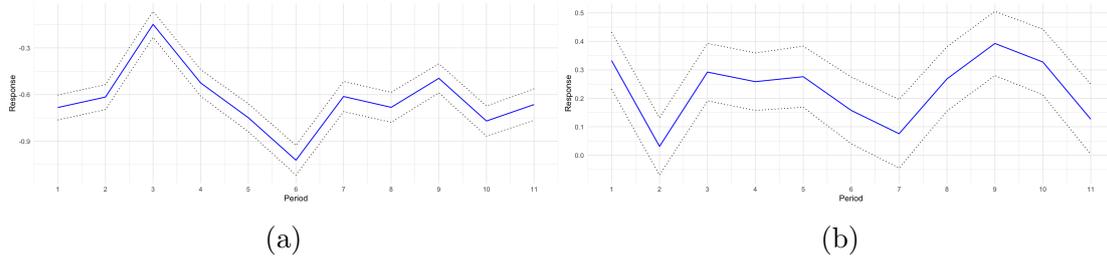


Figure A.3: Stock Return Dynamic Responses

**Note:** These figures present the impulse responses for the 11 periods after the innovation. Panel (a) represents the dynamic response of the coefficient before innovation and (b) represents the dynamic response of the coefficient before the interaction term.

## **A.7 Strategic-Emerging Industry Classification**

### **A.7.1 Strategic Emerging Industries**

Computer, Communication and Other Electronic Device Manufacturing; Internet and Relevant Services; Software and IT Services; Telecommunications, Broadcast, Television, and Satellite Transmission Services; Automobile Manufacturing; Railway, Shipbuilding, Aerospace and Other Transportation Equipment Manufacturing; Special Equipment Manufacturing; General Equipment Manufacturing; Instrument and Meter Manufacturing; Electric Machines and Apparatuses Manufacturing; Chemical Fiber Manufacturing; Rubber and Plastic Product Industry; Paper-making & Paper Products; Raw Chemical Materials and Chemical Products; Non-metallic Mineral Products; Ferrous Metal Smelting and Extruding; Non-ferrous Metals Smelting & Rolling Processing; Metal Products; Medicine Manufacturing; Chemical Products; Fermentation Products Manufacturing; Biological Engineering and Related Services; Production and Supply of Electric Power and Thermal Power; Gas Production & Supply; Water Production & Supply; Automobile Manufacturing (specific to new energy vehicles); Parts and Components Manufacturing for New Energy Vehicles; Ecological Preservation and Environmental Treatment Industry; Comprehensive Utilization Industry of Waste Resources; Culture and Education, Arts and Crafts, Sports and Entertainment Products Manufacturing; Culture & Arts; News and Publishing Industry; Broadcast, Television, Film and Television Recording Industry; Professional Technical Services; Business Services; Education; Health Care; Research and Experimental Development

### **A.7.2 Non-Strategic Emerging Industries**

Accommodation; Agriculture; Air Transport; Ancillary Activities for Mining; Animal Husbandry; Building Construction; Catering Industry; Civil Engineering Construction; Coal Mining and Processing; Conglomerates; Construction Decoration and Other Construction; Construction and Installation; Farm and Sideline Products Processing; Ferrous Metals Mining and Dressing; Fishery; Food Manufacturing; Forestry; Furniture Manufacturing; Insurance; Leasing Industry; Loading, Unloading and Transportation Agency; Monetary Financial Service; Nonferrous Metal Mining; Nonmetallic Mineral Mining and Quarrying; Oil and Gas Extraction; Other Finance; Other Manufacturing; Petroleum Processing, Coking and Nuclear Fuel Processing; Postal Industry; Printing and Reproduction of Recorded Media; Public Utility Management; Railroad Transport; Real Estate Industry; Repair and Maintenance of Motor Vehicles, Electronic Products and Daily Use Products; Retailing; Road Transport; Science and Technology Promotion and Application Services; Sports; Support Services for Farming, Forestry, Animal Husbandry, and Fishery; Textile Industry; Textiles, Garments and Apparel Industry;

Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products; Warehousing; Water Transportation; Wholesale; Wine, Drinks and Refined Tea Manufacturing

## B Model and Analytical Derivations

This appendix develops a simplified dynamic investment framework, together with analytical derivations, to illustrate the mechanisms underlying the empirical results.

### B.1 Model Setup

#### B.1.1 Firm Optimization Problem

The firm chooses  $I_1$  and  $B_1$  to solve:

$$\max_{I_1, B_1} A_1 K_1^\alpha - P_{K_1} I_1 - AC + B_1 + \frac{1}{1+r} [A_2 K_2^\alpha + P_{K_2} (1-\delta) K_2 - (1+r) B_1] \quad (\text{B.1})$$

subject to:

$$B_1 \leq \bar{B} = \psi P_{K_2} (1-\delta_T) \theta K_2, \quad (\text{B.2})$$

$$A_1 K_1^\alpha - P_{K_1} I_1 - AC + B_1 \geq 0 \quad (\text{B.3})$$

with

$$K_t = K_{T,t} + K_{N,t}, \quad K_{T,t} = \theta K_t, \quad t = 1, 2 \quad (\text{B.4})$$

$$K_2 = I_1 + (1-\delta) K_1 = I_1 + (1-\delta_T) K_{T,1} + (1-\delta_N) K_{N,1} \quad (\text{B.5})$$

$$\delta = \theta \delta_T + (1-\theta) \delta_N \quad (\text{B.6})$$

$$AC = P_{K_1} [\phi_T \theta [K_2 - (1-\delta_T) K_1] + \phi_N (1-\theta) [K_2 - (1-\delta_N) K_1]] \quad (\text{B.7})$$

#### B.1.2 Condensed Form of the Investment Decision

To streamline exposition in the main text, several composite terms and notational conventions are introduced below:

- Effective depreciation rate:

$$\delta(\theta) = \theta \delta_T + (1-\theta) \delta_N, \quad \delta_N > \delta_T.$$

- Composite adjustment cost term:

$$M(\theta) = (1 + \phi_T)\theta + (1 + \phi_N)(1 - \theta), \quad \phi_N > \phi_T.$$

- User cost term in the unconstrained regime:

$$D_U = (1 + r)P_{K1}M(\theta) - P_{K2}(1 - \delta(\theta)).$$

- Collateral constraint terms under the constrained regime:

$$N(\theta) = A_1K_1^\alpha + P_{K1}K_1[(1 + \phi_T)\theta(1 - \delta_T) + (1 + \phi_N)(1 - \theta)(1 - \delta_N)],$$

$$D(\theta) = P_{K1}M(\theta) - \psi P_{K2}(1 - \delta_T)\theta.$$

- Optimal capital and investment:

$$K_2^{U*} = \left( \frac{A_2\alpha}{D_U} \right)^{\frac{1}{1-\alpha}}, \quad I_1^{U*} = K_2^{U*} - (1 - \delta(\theta))K_1,$$

$$K_2^{C*} = \frac{N(\theta)}{D(\theta)}, \quad I_1^{C*} = K_2^{C*} - (1 - \delta(\theta))K_1.$$

## B.2 User Cost Channel: Analytical Derivation

In the unconstrained regime of the two-period investment model, the firm's optimal period-2 capital stock is given by:

$$K_2^{U*} = \left( \frac{A_2 \alpha}{D_U} \right)^{\frac{1}{1-\alpha}}, \quad (\text{B.8})$$

where  $A_2$  is productivity in period 2 and  $D_U$  is the user cost of capital. The user cost is defined as:

$$D_U = (1+r)P_{K1}M(\theta) - P_{K2}(1-\delta(\theta)), \quad (\text{B.9})$$

where  $P_{K1}$  and  $P_{K2}$  are the prices of capital in periods 1 and 2,  $r$  is the interest rate, and  $\theta \in [0, 1]$  denotes the share of tangible assets, with  $1-\theta$  representing the intangible share. Adjustment costs and depreciation depend on the asset composition:

$$M(\theta) = (1+\phi_T)\theta + (1+\phi_N)(1-\theta), \quad (\text{B.10})$$

$$\delta(\theta) = \theta\delta_T + (1-\theta)\delta_N, \quad (\text{B.11})$$

where  $\phi_N > \phi_T$  and  $\delta_N > \delta_T$ , implying that intangible assets are costlier to adjust and depreciate faster.

Let  $C = (A_2 \alpha)^{\frac{1}{1-\alpha}} > 0$  and  $\gamma = \frac{1}{1-\alpha} > 0$ . Then Eq. (B.8) can be written more compactly as:

$$K_2^{U*} = CD_U^{-\gamma}. \quad (\text{B.12})$$

Differentiating Eq. (B.12) with respect to  $D_U$ ,

$$\frac{\partial K_2^{U*}}{\partial D_U} = -\gamma CD_U^{-\gamma-1} < 0. \quad (\text{B.13})$$

Hence,

$$\frac{\partial I_1^{U*}}{\partial D_U} = \frac{\partial K_2^{U*}}{\partial D_U} < 0 \quad (\text{B.14})$$

*Interpretation:* Firms invest until the marginal return on capital equals the marginal cost of capital. A higher user cost of capital makes each unit of investment more expensive relative to its future return, leading firms to cut back on investment.

Next, consider how the intangible share  $(1-\theta)$  affects this sensitivity. Differentiating  $D_U$  in Eq. (B.9) with respect to  $\theta$  yields:

$$\frac{\partial M(\theta)}{\partial \theta} = \phi_T - \phi_N < 0, \quad (\text{B.15})$$

$$\frac{\partial \delta(\theta)}{\partial \theta} = \delta_T - \delta_N < 0, \quad (\text{B.16})$$

so that

$$\frac{\partial D_U}{\partial \theta} = (1+r)P_{K1}(\phi_T - \phi_N) + P_{K2}(\delta_T - \delta_N) < 0. \quad (\text{B.17})$$

Since  $1 - \theta$  is the intangible share,

$$\frac{\partial D_U}{\partial(1-\theta)} = -\frac{\partial D_U}{\partial \theta} > 0,$$

implying that a higher intangible share increases the user cost of capital.

Substituting this result into the mixed derivative of Eq. (B.13), we obtain:

$$\frac{\partial^2 K_2^{U*}}{\partial D_U \partial(1-\theta)} = \gamma C \beta D_U^{-\beta-1} \frac{\partial D_U}{\partial(1-\theta)}, \quad \beta = \gamma + 1 > 0. \quad (\text{B.18})$$

Because each term is strictly positive,

$$\frac{\partial^2 K_2^{U*}}{\partial D_U \partial(1-\theta)} > 0. \quad (\text{B.19})$$

Additionally,

$$\frac{\partial I_1^*}{\partial D_u \partial(1-\theta)} = \frac{\partial K_2^*}{\partial D_u \partial(1-\theta)} > 0$$

### B.3 Collateral Channel: Analytical Derivation

For constrained firms, the optimal capital stock  $K_2^{C*}$  is given by:

$$K_2^{C*} = \frac{N(\theta)}{D(\theta)} \quad (\text{B.20})$$

where:

$$N(\theta) = A_1 K_1^\alpha + P_{K1} K_1 [(1 + \phi_T)\theta(1 - \delta_T) + (1 + \phi_N)(1 - \theta)(1 - \delta_N)] \quad (\text{B.21})$$

$$D(\theta) = P_{K1} M(\theta) - \psi P_{K2}(1 - \delta_T)\theta \quad (\text{B.22})$$

and  $M(\theta) = (1 + \phi_T)\theta + (1 + \phi_N)(1 - \theta)$ .

We examine how the investment response to changes in collateral channel variables ( $\psi$  and  $P_{K2}$ ) varies with the intangible share  $(1 - \theta)$ . To examine the response to pledgeability  $\psi$ , we first find the first derivative with respect to  $\psi$ :

$$\frac{\partial I_1^{C*}}{\partial \psi} = \frac{\partial K_2^{C*}}{\partial \psi} = \frac{\frac{\partial N}{\partial \psi} \cdot D(\theta) - N(\theta) \cdot \frac{\partial D}{\partial \psi}}{[D(\theta)]^2} \quad (\text{B.23})$$

Since  $N(\theta)$  does not depend on  $\psi$  ( $\frac{\partial N}{\partial \psi} = 0$ ), and from Equation (B.22):

$$\frac{\partial D}{\partial \psi} = -P_{K2}(1 - \delta_T)\theta$$

Substitute into Equation (B.23):

$$\frac{\partial K_2^{C*}}{\partial \psi} = \frac{0 \cdot D(\theta) - N(\theta) \cdot (-P_{K2}(1 - \delta_T)\theta)}{[D(\theta)]^2} = \frac{N(\theta)P_{K2}(1 - \delta_T)\theta}{[D(\theta)]^2} > 0 \quad (\text{B.24})$$

The derivative is positive because all terms are positive:  $N(\theta) > 0$ ,  $P_{K2} > 0$ ,  $(1 - \delta_T) > 0$ ,  $\theta > 0$ , and  $[D(\theta)]^2 > 0$ . Hence, optimal investment increases when pledgeability increases. We then derive the partial derivative with respect to  $\psi$  and  $(1 - \theta)$  to examine the impact of intangible assets on the investment response.

$$\frac{\partial^2 K_2^{C*}}{\partial \psi \partial (1 - \theta)} = \frac{\partial}{\partial (1 - \theta)} \left( \frac{N(\theta)P_{K2}(1 - \delta_T)\theta}{[D(\theta)]^2} \right) \quad (\text{B.25})$$

Treat the numerator and denominator separately. Let:

$$\text{Numerator} = N(\theta)P_{K2}(1 - \delta_T)\theta$$

$$\text{Denominator} = [D(\theta)]^2$$

Apply the quotient rule:

$$\begin{aligned}\frac{\partial^2 K_2^{C*}}{\partial \psi \partial (1-\theta)} &= P_{K2}(1-\delta_T) \cdot \frac{\frac{\partial}{\partial (1-\theta)} (N(\theta)\theta) \cdot [D(\theta)]^2 - N(\theta)\theta \cdot 2D(\theta) \frac{\partial D}{\partial (1-\theta)}}{[D(\theta)]^4} \\ &= \frac{P_{K2}(1-\delta_T)}{[D(\theta)]^3} \left[ \frac{\partial}{\partial (1-\theta)} (N(\theta)\theta) \cdot D(\theta) - 2N(\theta)\theta \frac{\partial D}{\partial (1-\theta)} \right]\end{aligned}\quad (\text{B.26})$$

Now compute the key partial derivatives:

1. Compute  $\frac{\partial D}{\partial (1-\theta)}$  from Equation (B.22):

$$\frac{\partial D}{\partial (1-\theta)} = P_{K1} \frac{\partial M(\theta)}{\partial (1-\theta)} - \psi P_{K2}(1-\delta_T) \frac{\partial \theta}{\partial (1-\theta)}$$

Since  $\frac{\partial M(\theta)}{\partial (1-\theta)} = \phi_N - \phi_T > 0$  and  $\frac{\partial \theta}{\partial (1-\theta)} = -1$ , we get:

$$\frac{\partial D}{\partial (1-\theta)} = P_{K1}(\phi_N - \phi_T) + \psi P_{K2}(1-\delta_T) > 0 \quad (\text{B.27})$$

This is positive because  $\phi_N > \phi_T$  implies  $\phi_N - \phi_T > 0$ , and all other terms are positive.

2. Compute  $\frac{\partial}{\partial (1-\theta)}(N(\theta)\theta)$ :

$$\frac{\partial}{\partial (1-\theta)}(N(\theta)\theta) = -\theta \frac{\partial N}{\partial \theta} - N(\theta) < 0 \quad (\text{B.28})$$

This is negative because  $\frac{\partial N}{\partial \theta} > 0$  under the assumptions (as shown below), and  $N(\theta) > 0$ .

$$\frac{\partial N}{\partial \theta} = P_{K1}K_1 [(1+\phi_T)(1-\delta_T) - (1+\phi_N)(1-\delta_N)] \quad (\text{B.29})$$

Given  $\phi_N > \phi_T$  and  $\delta_N > \delta_T$ , we assume:  $(1+\phi_T)(1-\delta_T) > (1+\phi_N)(1-\delta_N)$  as in a standard model assumption, implying that tangible assets contribute more to internal funds than intangible assets. Thus,  $\frac{\partial N}{\partial \theta} > 0$ .

Hence, we find that the term  $\frac{\partial}{\partial (1-\theta)}(N(\theta)\theta) \cdot D(\theta)$  is negative because both factors are negative ( $\frac{\partial}{\partial (1-\theta)}(N(\theta)\theta) < 0$  and  $D(\theta) > 0$  for the solution to exist). The term  $-2N(\theta)\theta \frac{\partial D}{\partial (1-\theta)}$  is negative because  $N(\theta)\theta > 0$  and  $\frac{\partial D}{\partial (1-\theta)} > 0$ . Thus, the entire expression inside the brackets is negative. Since the prefactor  $\frac{P_{K2}(1-\delta_T)}{[D(\theta)]^3} > 0$ , the mixed derivative is negative:

$$\frac{\partial^2 I_1^{C*}}{\partial \psi \partial (1-\theta)} = \frac{\partial^2 K_2^{C*}}{\partial \psi \partial (1-\theta)} < 0 \quad (\text{B.30})$$

In summary:

$$\frac{\partial I_1^{C*}}{\partial \psi} > 0$$

Higher pledgeability increases collateral value, which boosts investment.

$$\frac{\partial^2 I_1^{C*}}{\partial \psi \partial (1 - \theta)} < 0$$

The positive effect of pledgeability is dampened by a higher intangible share because intangibles cannot be easily used as collateral. Similarly, we measure the response to Asset Price  $P_{K2}$  by finding the first derivative with respect to  $P_{K2}$ :

$$\frac{\partial K_2^{C*}}{\partial P_{K2}} = \frac{\frac{\partial N}{\partial P_{K2}} \cdot D(\theta) - N(\theta) \cdot \frac{\partial D}{\partial P_{K2}}}{[D(\theta)]^2} \quad (\text{B.31})$$

Since  $N(\theta)$  does not depend on  $P_{K2}$  ( $\frac{\partial N}{\partial P_{K2}} = 0$ ), and from Equation (B.22):

$$\frac{\partial D}{\partial P_{K2}} = -\psi(1 - \delta_T)\theta$$

Substitute into Equation (B.31):

$$\frac{\partial I_1^{C*}}{\partial P_{K2}} = \frac{\partial K_2^{C*}}{\partial P_{K2}} = \frac{0 \cdot D(\theta) - N(\theta) \cdot (-\psi(1 - \delta_T)\theta)}{[D(\theta)]^2} = \frac{N(\theta)\psi(1 - \delta_T)\theta}{[D(\theta)]^2} > 0 \quad (\text{B.32})$$

Similarly, we measure the mixed partial derivative with respect to  $P_{K2}$  and  $(1 - \theta)$  to investigate the role of intangible assets:

$$\frac{\partial^2 K_2^{C*}}{\partial P_{K2} \partial (1 - \theta)} = \frac{\partial}{\partial (1 - \theta)} \left( \frac{N(\theta)\psi(1 - \delta_T)\theta}{[D(\theta)]^2} \right) \quad (\text{B.33})$$

Following the same procedure as in Section 2.2, we get:

$$\begin{aligned} \frac{\partial^2 I_1^{C*}}{\partial P_{K2} \partial (1 - \theta)} &= \frac{\partial^2 K_2^{C*}}{\partial P_{K2} \partial (1 - \theta)} \\ &= \frac{\psi(1 - \delta_T)}{[D(\theta)]^3} \left[ \frac{\partial}{\partial (1 - \theta)} (N(\theta)\theta) \cdot D(\theta) - 2N(\theta)\theta \frac{\partial D}{\partial (1 - \theta)} \right] < 0 \end{aligned} \quad (\text{B.34})$$

These results confirm that intangible assets weaken the collateral channel of monetary policy transmission. Firms with higher intangible shares  $(1 - \theta)$  benefit less from improvements in pledgeability ( $\psi$ ) or asset prices ( $P_{K2}$ ) because their assets provide less collateral value.

## B.4 Cash Flow Channel: Analytical Derivation

The effect of a change in current profitability  $A_1$  on investment depends on the firm's financial status. For unconstrained firms, the optimal capital  $K_2^{U*}$  and thus optimal investment is independent of  $A_1$ :

$$\frac{\partial I_1^{U*}}{\partial A_1} = \frac{\partial K_2^{U*}}{\partial A_1} = 0 \quad (\text{B.35})$$

Intuitively, unconstrained firms finance investment based on future returns ( $A_2$ ) and the cost of capital ( $D_U$ ), not current earnings. They can costlessly access external markets, making current cash flows irrelevant for investment decisions.

For constrained firms, optimal capital depends directly on  $A_1$ :

$$\frac{\partial I_1^{C*}}{\partial A_1} = \frac{\partial K_2^{C*}}{\partial A_1} = \frac{1}{D(\theta)} \cdot \frac{\partial N(\theta)}{\partial A_1} = \frac{K_1^\alpha}{D(\theta)} > 0 \quad (\text{B.36})$$

Intuitively, constrained firms rely on internal funds. An increase in  $A_1$  boosts operating cash flows ( $N(\theta) \uparrow$ ), relaxing the financing constraint and enabling more investment. We investigate how the intangible share ( $1 - \theta$ ) moderates the sensitivity of constrained investment to  $A_1$ . We compute the mixed partial derivative:

$$\begin{aligned} \frac{\partial^2 I_1^{C*}}{\partial A_1 \partial (1 - \theta)} &= \frac{\partial^2 K_2^{C*}}{\partial A_1 \partial (1 - \theta)} = \frac{\partial}{\partial (1 - \theta)} \left( \frac{K_1^\alpha}{D(\theta)} \right) = K_1^\alpha \cdot \frac{\partial}{\partial (1 - \theta)} \left( \frac{1}{D(\theta)} \right) \\ &= -K_1^\alpha \cdot \frac{1}{[D(\theta)]^2} \cdot \frac{\partial D}{\partial (1 - \theta)} \end{aligned} \quad (\text{B.37})$$

From the model, the net financing cost increases with the intangible share:

$$\frac{\partial D}{\partial (1 - \theta)} = P_{K1}(\phi_N - \phi_T) + \psi P_{K2}(1 - \delta_T) > 0 \quad (\text{B.38})$$

This is positive because intangibles have higher adjustment costs ( $\phi_N > \phi_T$ ) and provide less collateral ( $\psi$  term is multiplicative in  $\theta$ ). Substituting Equation (B.38) into (B.37) yields the final result:

$$\frac{\partial^2 I_1^{C*}}{\partial A_1 \partial (1 - \theta)} = \frac{\partial^2 K_2^{C*}}{\partial A_1 \partial (1 - \theta)} < 0 \quad (\text{B.39})$$