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A Tale of Two Margins: Monetary Policy and Capital Misallocation

Silvia Albrizio, Beatriz González, and Dmitry Khametshin

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WORKING PAPER

A Tale of Two Margins: Monetary Policy and Capital Misallocation*

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Abstract

This paper investigates the impact of monetary policy on capital misallocation, focusing on its heterogeneous effects on firms. Using Spanish firm-level data spanning 1999 to 2019, we demonstrate that expansionary monetary policy leads to a reduction in capital misallocation, measured by the within-industry dispersion of firms' marginal revenue product of capital (MRPK). To analyze the underlying mechanism, we first examine the intensive margin and find that high-MRPK firms exhibit a greater increase in investment and debt financing relative to low-MRPK firms following a monetary policy easing surprise. We also find that a firm's MRPK serves as a stronger determinant of its investment sensitivity to monetary policy than factors such as age, leverage, or cash, suggesting that MRPK is a reliable proxy for financial frictions. Next, we explore the extensive margin and demonstrate that monetary policy easing stimulates entry and discourages exit, although the quantitative impact is small. Moreover, we find no significant changes in the composition of high- and low-MRPK entrants or exiters. Overall, our findings suggest that expansionary monetary policy primarily reduces capital misallocation by alleviating financial frictions among incumbent productive and constrained firms.

Keywords: monetary policy; financial frictions; investment; misallocation; productivity

JEL classification: D22, D24, E22, E32, E52, O11, O47

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I. INTRODUCTION

Monetary policy is often questioned for its unintended supply-side consequences. Policy-makers and academics investigate the potential undesired outcomes of the central banks' decisions, be it the side effects of the ultra-loose monetary policy deployed in the aftermath of the Global Financial Crisis, or the byproduct of the more recent hastened monetary tightening. Indeed, evidence from aggregate data suggests that money is non-neutral for total factor productivity even in the longer run (Jordà, Singh, and Taylor, 2020). Arguably, monetary policy and productivity are linked through financial frictions and capital allocation, although the direction of this effect is unclear a priori.¹ On the one hand, monetary policy easing may foster the entry and growth of productive firms by increasing access to finance thus improving capital allocation. On the other hand, lax credit standards may channel funding to the less productive enterprises, inefficiently maintaining them afloat. In short, the direction and the magnitude of the effect on capital misallocation is ultimately an empirical question.

In this paper, we take advantage of a comprehensive database of the quasi-universe of firms in Spain and analyse the impact of monetary policy on capital allocation in terms of the intensive and extensive margin of firm dynamics, namely how monetary policy affects the investment and entry-exit decisions of firms, respectively.² We follow the theoretical framework of Hsieh and Klenow (2009) and consider the dispersion of the marginal revenue product of capital (MRPK) across firms by sector as a measure of within-sector misallocation. To estimate the effect of monetary policy on misallocation, we rely on monetary policy surprises identified by Jarościński and Karadi (2020) from high-frequency changes in interest rates around the announcements of monetary policy decisions by the ECB. Although throughout the paper we frame the discussion in terms of monetary policy easing,

¹There are other potential channels through which monetary policy can alter TFP, for instance, heterogeneity in markups (Meier and Reinelt, 2022) or the impact on R&D investment (Moran and Queralto, 2018).

²Spain is no exception to the productivity slowdown observed in the developed economies. According to de la Escosura and Rosés (2009) the stagnation started in 1985 with the TFP growth rate turning negative at the beginning of the 90s, followed by a mild revival only in the recent years pre-COVID (Moral-Benito and Fu, 2018). Allocative inefficiency across firms is found to be the main driving force of this trend. Hence, previous contributions have shown that multiple factors may be responsible for resources misallocation, ranging from inefficient management practices (Schivardi and Schmitz, 2020) crony capitalism (García-Santana and others, 2020), to regulation and public policies (Gamberoni, Giordano, and Lopez-Garcia, 2016, McGowan, Andrews, and Millot, 2017, Sanguinetti and Fuentes, 2012). While these papers concentrate on structural factors determining the overall level of capital misallocation in Spain, we focus on its cyclical component and its relation to monetary policy.

the results also speak for the current environment of monetary policy tightening, with the effect being symmetric but with the opposite sign.

Using local projects framework (Jordà, 2005), we show that monetary policy easing *decreases* misallocation of capital. To analyse the mechanism behind this finding, first we explore the impact of monetary policy on the investment behaviour of incumbent firms (intensive margin). We show that after a standard monetary policy easing shock, firms' average capital stock increases on impact by 0.2%, and by about 1.2% in about two years. We confirm the crucial result that it is high-MRPK firms that respond stronger to monetary policy easing by increasing their investment relatively more. Hence, firms that are one standard deviation above their industry-average MRPK increase their capital by additional 0.8 percentage points two years into the shock. We discard alternative explanations, such as the changes in the within-sector variance of MRPK coming from changes in firms' value added rather than changes in the capital stock.

Our working hypothesis is that this finding is consistent with the hypothesis that high-MRPK firms are financially constrained, and that monetary policy easing relaxes financial frictions. To explore the plausibility of this mechanism, we perform several tests. First, we show that after an expansionary monetary policy shock, the average firm increases its debt by 2%, while firms that are one standard deviation above the industry's average MRPK increase their debt by 2.5%. Furthermore, we show that the stronger effect of monetary policy on high-MRPK firms' debt is also present on the extensive margin of credit, i.e., among firms that had no debt prior the shock. Hence, high-MRPK firms are more likely to enter the credit market and keep borrowing after monetary easing.

We then posit the hypothesis that a firm having MRPK higher than the sector's average is a good proxy for a firm being financially constrained. We test for this by analysing whether MRPK is more relevant for determining investment sensitivity to monetary policy than other standard measures of financial constraints, such as age, leverage or cash holdings. We show that it is indeed the case, and that when it comes to explaining investment sensitivity to monetary policy, heterogeneity in leverage, cash holdings, and age is largely irrelevant or matters only as long as the firm has high levels of MRPK. For example, investment of firms with high leverage respond more to a monetary policy expansion in our sample, but those high-leverage high-MRPK firms react nearly four times more than high-leverage low-MRPK firms.

Finally, we also explore the extensive margin, that is, whether monetary policy affects the entry and exit decision of firms, as well as the compositions of these entrants and exiters. We find that monetary policy easing increases entry and decreases exit rates, although both changes are small quantitatively and do not appear to last long. When looking at the composition of entrants and exiters in terms of MRPK, we find no stark differences in entry nor exit: the share of high-MRPK and low-MRPK in entry and exit triggered by monetary policy remains relatively constant at impact, with some exceptions that are not significant in the medium run. Hence, we conclude that monetary policy does not affect significantly the entry and exit choice, nor the allocation of resources through the extensive margin. These findings also rule out the hypothesis that monetary policy easing creates “zombie firms” by helping less productive firms (proxied by low-MRPK firms) to stay afloat relatively more.

Literature review. This paper contributes to several strands of literature. First, it is tightly linked to the literature studying the impact of monetary policy on incumbent firms’ behaviour. This strand of literature pins down the financial friction channel of monetary policy, uncovering various proxies for financially constrained firms. [Cloyne and others \(2022\)](#) find that, in response to a monetary policy shock, younger firms that do not pay dividends adjust their capital expenditure and borrow more than older firms with payouts. [Ottonello and Winberry \(2020\)](#) find that the investment of low-risk firms is more responsive to monetary policy shocks as they face a flatter marginal cost curve for financing investment. [Jeenas \(2019\)](#) find that in response to a contractionary monetary policy shock, firms with higher leverage or less liquid assets reduce investment relatively more. [Jungherr and others \(2022\)](#) and [Deng and Fang \(2022\)](#) find that firms’ investment is more responsive to monetary policy when a higher fraction of their debt matures. [Caglio, Darst, and Kalemli-Özcan \(2021\)](#) find that monetary policy easing increases highly levered SMEs’ demand for credit and their borrowing capacity because their continuation values rises and their ability to repay debt improves. From a theoretical perspective, [González and others \(2022\)](#) find that introducing capital misallocation in a New Keynesian model with heterogeneous firms and financial frictions has important implications for the optimal conduct of monetary policy, since monetary policy also affects misallocation and endogenous TFP. The contribution of our paper to this literature is twofold. First, we study the heterogeneous impact of monetary policy on investment conditional on MRPK, which allows us to focus on the implications for capital misallocation. This contribution complements the paper of [González and others \(2022\)](#) by providing empirical evidence on their theoretical mechanism. Second, we show

that firms' MRPK outperforms the standard measures of financial constraints in explaining investment sensitivity to monetary policy shocks, and that firms with relatively higher MRPK borrow more following a monetary policy easing shock.

This paper also contributes to the literature studying the impact of monetary policy on the extensive margin of firm dynamics, that is, on entry and exit of firms. Using U.S. establishment-level data, [Hartwig and Lieberknecht \(2022\)](#) study the effects of monetary policy on both firm entry and exit and show that monetary policy easing decreases exit and increases entry in the short run. [Zanetti and Hamano \(2022\)](#) confirm these findings using business incorporations and business failures in the U.S.³ Our paper contributes to this literature by confirming some of its findings on the impact of monetary policy on both entry and exit using data from Spain. Notably and novel in the literature, we provide further disaggregated evidence and study the effects of monetary policy on the composition of entering and exiting firms in terms of their MRPK. We show that monetary policy easing increases entry and decreases exit, although its quantitative relevance is low, and it brings no significant changes in the MRPK distribution of entrants and exiters. Along these lines, our paper is also related to the strand of literature studying the impact of the entry-exit channel on aggregate productivity and business cycle fluctuations. The entry channel is crucial for business dynamism since start-ups and young businesses play a key role in job creation ([Haltiwanger, Jarmin, and Miranda, 2013](#)). Furthermore, the “lack” of entry might create a “missing generation” of firms, which may have scarring effects on long-run employment ([Sedláček, 2020](#)). In this context, the literature is quite flamboyant in studying the role played by lax credit conditions on “zombie firms”, i.e., unproductive firms that manage to stay afloat due to subsidized credit ([Caballero, Hoshi, and Kashyap, 2008](#), [McGowan, Andrews, and Millot, 2018](#), [Schivardi, Sette, and Tabellini, 2020](#) or [Acharya and others, 2019](#), among many others). Our paper contributes to this discussion by showing that even though an identified monetary policy easing can result in a lower exit rate of less productive firms in the medium run, overall, it positively affects capital allocation.

More broadly, our paper is related to the literature studying the impact of lower interest rates on allocative efficiency and productivity.⁴ [Gopinath and others \(2017\)](#) show that financial frictions amplify MRPK dispersion in the environment of declining interest rates

³On the theoretical side, [Bilbiie, Fujiwara, and Ghironi \(2014\)](#) show that the optimal conduct of monetary policy changes in the presence of endogenous entry.

⁴Other papers use different proxies for credit shocks, and analyze their impact on TFP—see, for instance, [Zeev \(2021\)](#).

and study Spain as an example of this mechanism. In their setup, size-dependent financial frictions impede productive firms with low net worth from taking advantage of the credit easing, delaying their capital adjustments. In this paper, we focus on the empirical identification of the link between monetary policy and capital misallocation. Differently from [Gopinath and others \(2017\)](#), we take advantage of the administrative data and analyse the quasi-universe of Spanish firms in a sample extended both in time and scope in terms of sector coverage. We confirm the increasing trend of MRPK dispersion in Spain found by [Gopinath and others \(2017\)](#). However, we also find that this trend was interrupted by a noticeable decline in MRPK dispersion in 2007–2008, and, consistently with the TFP rebound documented by [Moral-Benito and Fu \(2018\)](#), reversed in 2015. We also focus on the effects of monetary policy surprises rather than of the structural component of the level of interest rates and, hence, diverge from [Gopinath and others \(2017\)](#) in terms of the identification of the effects of monetary policy. We use high-frequency identification of monetary policy surprises by [Jarociński and Karadi \(2020\)](#) that allows separating the effects of central bank communication shocks and mitigates the concerns about reverse causality or simultaneity bias that may arise when using the level of interest rates as a measure of the monetary policy stance.⁵

In the remainder of the paper we discuss data sources (Section II), document the evolution of the MRPK in Spain and quantify the effect of monetary policy on capital misallocation in a reduced-form framework (Section III). In Section IV we present the analysis on the intensive margin, estimating the heterogeneous effect of monetary policy on firms investment. Section V presents the analysis on the extensive margin, and Section VI concludes.

II. DATA

Firm-level data. We match two main sources of firm-level data: CBI (Integrated Central Balance Sheet Database, *Central de Balances Integrada*) and DIRCE (Central Statistical Database, *Directorio Central de Estadística*). We collect firm financial reports from the CBI, an administrative database of detailed financial reports of firms in Spain available at

⁵In that sense, we also differ from [Jiménez and others \(2012\)](#) who find that in 2002–2008 Spanish banks took on more risk when faced with low interest rates. Unlike [Jiménez and others \(2012\)](#), we analyze a longer sample and use unexpected changes in the interest rates to identify the effects of monetary policy on capital misallocation.

the Bank of Spain. The database contains obligatory filings of annual accounts obtained from mercantile registries and covers the quasi-universe of Spanish firms. We consider the whole economy excluding mining, financial and insurance sectors as well as public administration. When analysing investment, we focus on the change in tangible capital.⁶ We use CBI to obtain other firm-level variables (total assets and debt, employment, value added, cash holdings, age). Appendix A describes in detail the variables used in the analysis and the data cleaning process. Our main firm-level panel dataset includes 9 million observations on more than 1.3 million firms active at some point from 1999 until 2019.

To construct the series of entry and exit rates, we source microdata from DIRCE, a registry of Spanish firms maintained by the Spanish Statistical Office (*Instituto Nacional de Estadística*). DIRCE database contains firm-level entry and exit indicators that combine different data sources (tax, administrative and social security records). The Statistical Office employs this file when constructing aggregate series of firms demographics. We match the firm-level records with the main dataset obtained from CBI on firm tax identifiers. The match allows us to decompose the series of entries and exits by firm characteristics, particularly their MRPK. We describe the data merge process in Appendix A. As a baseline definition of entry year, we take the minimum of the first entry year recorded in DIRCE and the first year of activity self-reported by firms to CBI. We define the exit year as the last year of exit recorded in DIRCE.⁷ If the firm enters the bankruptcy procedure, we take the first year of the bankruptcy process as its exit year.

Monetary policy shocks. We measure changes in monetary policy stance using monetary policy shocks from [Jarociński and Karadi \(2020\)](#). The authors employ high-frequency identification of monetary policy shocks in which monetary policy surprises are inferred from movements of interest rates and equity prices in a narrow window around monetary policy decisions announcements by the ECB. Since asset prices react to news almost immediately, one can isolate the monetary policy shocks from other developments happening in the economy on the same day by tracing changes in asset prices in a narrow intraday window

⁶CBI contains records of intangible capital. However, since most firms are privately held and the value of intangible capital is self-reported, it is likely measured with error. Therefore we exclude intangible capital from our analysis.

⁷In cases when firms file for bankruptcy, we adjust the exit year as the earliest year corresponding to the start of the bankruptcy procedure. We collect the information on the starting year of bankruptcy procedure from CBI, as well as from the Registry of Bankruptcy Procedures, *Registro Público Concursal*, and country's credit registry (Central Credit Registry, *Central de Información de Riesgos*)

around central bank announcements. The use of a stock market index, in turn, is motivated by the idea that central bank announcements may contain new information about monetary policy stance *and* updates about the assessment of the economic outlook (“information shock”). Therefore, their identification of monetary policy stance relies on sign restrictions, in which an unexpected monetary policy tightening raises interest rates and reduces stock prices, while an unanticipated positive information shock tends to increase both. We use monthly shocks to monetary policy stance from [Jarociński and Karadi \(2020\)](#) aggregated to the annual frequency as a measure of monetary policy surprises.⁸

To construct the annual shock, we extend the time aggregation scheme of [Ottonello and Winberry \(2020\)](#) to the yearly frequency. In this approach, a monthly shock enters both the current year and the following year’s annual surprises, with the split between the current and the next year depending on the timing of the monthly shock within the current year. Hence, a high-frequency surprise happening in January is entirely attributed to the current year, while the one occurring in December mainly contributes to the following year’s annual shock. More specifically, we construct annual monetary policy shocks as

$$\varepsilon_t = \sum_m \omega_{\text{past}}(m) \varepsilon_{m,t-1} + \sum_m \omega_{\text{current}}(m) \varepsilon_{m,t} \quad \omega_{\text{past}}(m) = \frac{m}{12}, \quad \omega_{\text{current}}(m) = \frac{12-m}{12}, \quad (1)$$

where ε_t is the aggregated annual monetary policy shock in year t , and $\varepsilon_{m,t}$ is high-frequency shock in month $m = 0 \dots 11$ of year t . We discuss the time aggregation and quantification of the effects in more detail in [Appendix A.B](#). For comparison purposes, we plot the time series of original monthly shocks and the resulting annual time series in [Figure B.1](#) in the [Appendix A.B](#). We test alternative weighting schemes and discuss the robustness of the above time aggregation in [Section V](#).

III. THE IMPACT OF MONETARY POLICY ON CAPITAL MISALLOCATION

Following the theoretical framework of [Hsieh and Klenow \(2009\)](#), in the absence of any frictions profit maximization leads to equalized marginal revenue product of capital (MRPK)

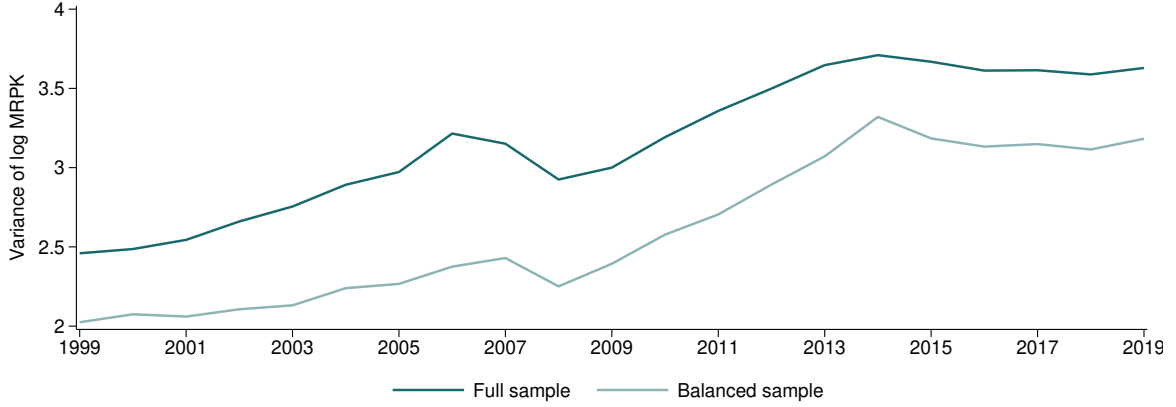
⁸We use the series of shocks from [Jarociński and Karadi \(2020\)](#) updated until 2020. In this version, the authors use the first principle component of the changes in the short-term risk-free interest rates in Europe (derived from OIS swaps) to measure interest rate changes. We are grateful to the authors for maintaining the dataset publicly available.

across firms within the same industry. It then immediately follows that any observed dispersion in MRPK indicates the existence of frictions, creating “wedges” between MRPK and the marginal cost of funds. These frictions can be of technological or institutional nature. Alternatively, they can stem from financial imperfections that push financing costs beyond the levels justified by firm’s riskiness. Therefore, following the existing literature, we treat MRPK dispersion within the sector as a measure of capital misallocation. If a monetary policy shock *decreases* the within-industry dispersion of MRPK, this would be indicative of this shock alleviating the underlying frictions causing misallocation and hence improving the allocation of resources.⁹

In Figure 1, we document the evolution of the variance of MRPK across firms within the same sector in Spain from 1999 to 2019. As it is standard in the literature, we proxy the MRPK by the average return of capital, and use this variable in logs.¹⁰ The solid dark line shows the evolution of the dispersion of MRPK for the full sample, including firms that enter or exit during the sample period. The light grey line represents the evolution of the dispersion of MRPK considering the firms in the balanced sample that are observed every year from the beginning to the end of the sample period. The two-digit within-sector variance of MRPK is aggregated using as weights the value-added shares averaged over all years. Sector weights are held constant across years to keep the composition of the aggregate variance of MRPK fixed as in [Gopinath and others \(2017\)](#). In the case of the full sample, the MRPK dispersion was increasing until 2014, albeit with noticeable exclusions in 2007–2008, but started to decrease in 2015, pointing to a changing capital misallocation throughout the sample period, consistent with [Moral-Benito and Fu \(2018\)](#). Similar dynamics in the balanced sample indicates that the above finding is not driven exclusively by the entry and exit decisions of firms. In fact, almost a parallel shift in the variance of MRPK measured in the two samples points to a limited relevance of the extensive margin for the cyclical fluctuations of misallocation.

⁹This interpretation is valid under assumptions employed by [Hsieh and Klenow \(2009\)](#). In Online Appendix, we discuss their framework and the implications of relaxing these assumptions for the interpretation of our findings. Also, although throughout the paper we follow [Hsieh and Klenow \(2009\)](#) and use variance of MRPK as a measure of misallocation, most of the results remain unchanged when considering TPF_R as dependent variable.

¹⁰That is, throughout the paper, “MRPK” is to be understood as the average return of capital, computed as the log of the ratio of value added to physical capital, taken to be a proxy of the marginal product of capital. According to the [Hsieh and Klenow \(2009\)](#), MRPK is proportional but not equal to the average return to capital. However, as long as factor intensities are considered constant and common within industries, a change in the average product of capital is a good proxy for the marginal one.

Figure 1: Dispersion of marginal revenue product of capital in Spain, 1999-2019.

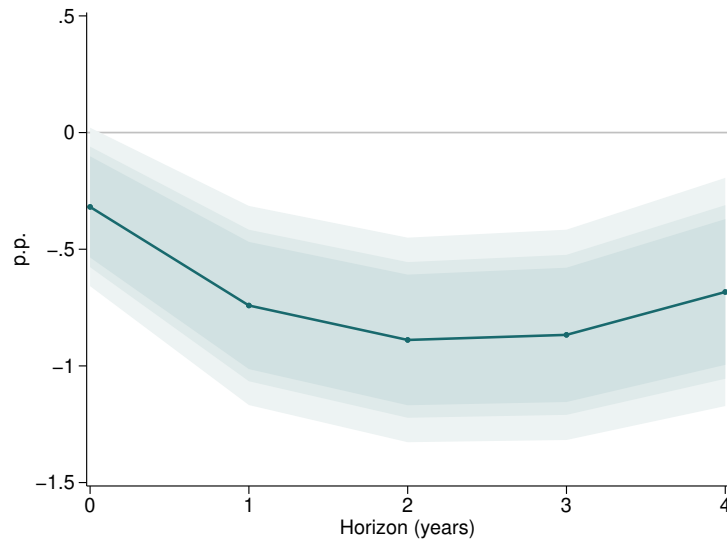
The chart shows the evolution of the dispersion of MRPK defined as the average variance of the log MRPK at sector level, aggregated using sector-level value-added shares. Sector-level shares are averaged over years as in [Gopinath and others \(2017\)](#). Full sample includes all firms, while balanced sub-sample includes only those firms that are observed throughout the whole sample period.

We assess the dynamic impact of monetary policy on the dispersion of MRPK using local projection framework ([Jordà, 2005](#)), where changes in the sector MRPK dispersion are regressed on the contemporaneous policy shock according to the following specification:

$$\Delta \log \text{Var}(MRPK)_{j,t-1,t+h} = \beta_1^h \varepsilon_t + \beta_2^h \vartheta_t + \beta_3^h S_{j,t} + \mu_j^h + u_{j,t+h}. \quad (2)$$

The dependent variable, $\Delta \log \text{Var}(MRPK)_{j,t-1,t+h}$, is the change of the variance of log MRPK from time $t - 1$ to $t + h$ in the sector j at a horizon $h = 0, \dots, 4$; ε_t is the monetary policy shock; ϑ_t is a vector of aggregate controls that includes contemporaneous inflation and unemployment rate, and $S_{j,t}$ is contemporaneous sector-level output growth. We control for time-invariant unobservables at the sector level by including sector fixed effects, μ_j^h . We include time trend in all regressions, and use heteroscedasticity-robust standard errors.¹¹ Unless mentioned otherwise, here and everywhere below in the paper, we report the effect of monetary policy easing by one standard deviation of high-frequency monetary policy shocks.

¹¹Results are qualitatively similar if we include lags or leads of the shocks to further control for autocorrelation ([Alloza, Gonzalo, and Sanz, 2019](#)).

Figure 2: Effect of monetary policy easing on MRPK dispersion

The figure shows the dynamic effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on the within-sector dispersion of MRPK (the estimated β_1^h from the equation (2)). The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using robust standard errors.

Figure 2 shows the estimated β_1^h for different horizons h (x-axis). Following an unexpected one standard deviation monetary policy easing shock, the variance of MRPK decreases at impact, and this decrease persists in time at around a 0.8% decrease. The negative effect of monetary policy easing on the variance of MRPK is indicative of *decreasing* misallocation.¹² This is the net aggregate effect of monetary policy on capital misallocation. It may result from adjustments in the intensive margin, i.e., high-MRPK firms investing more than low-MRPK firms, or from changes in the extensive margin, i.e., exit and entrance of new high-MRPK competitors. In the following two sections, we provide evidence on the two margins of adjustment.

¹²When estimating equation ((2)) with the EONIA rate as the explanatory variable, in a manner consistent with the GKKV model, we find that an increase in the EONIA rate leads to a decrease in misallocation. This observation aligns with the findings of GKKV.

IV. INTENSIVE MARGIN

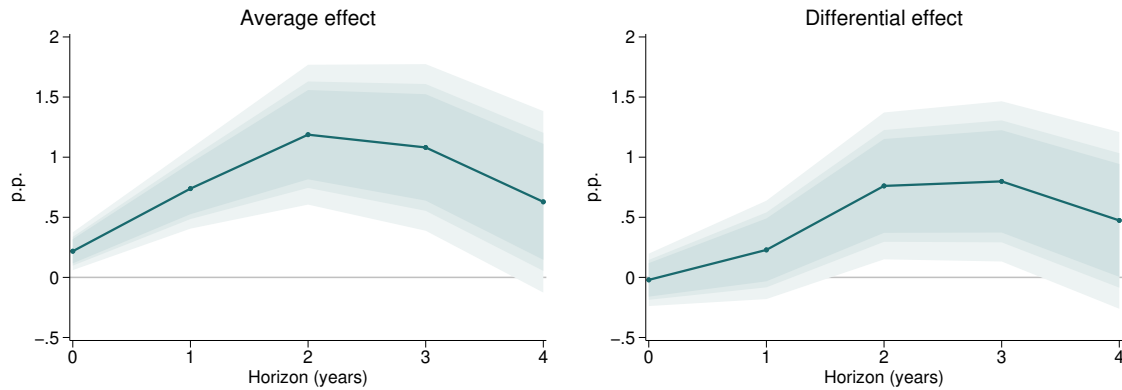
A. Monetary policy, firm investment and MRPK

The improvement in capital allocation discussed in the previous section can happen via intensive margin if, when faced with monetary policy easing, high-MRPK firms invest relatively more than low-MRPK ones. This would imply that the capital of ex-ante high-MRPK firms increases relatively more, decreasing their MRPK and hence reducing the dispersion of MRPK. To test this hypothesis, we estimate the dynamic effect of monetary policy on the *average* investment, as well as the *differential* effect of monetary policy on investment of high-MRPK firms. Namely, we use firm-level local projections, and estimate the two effects of monetary policy according to the following specification:

$$k_{i,t+h} - k_{i,t-1} = \beta_1^h \varepsilon_t + \beta_2^h \varepsilon_t \times MRPK_{i,t-1} + \beta_3^h MRPK_{i,t-1} + \beta_4^h Z_{i,t-1} + \beta_5^h \vartheta_t + \beta_6^h S_{j,t} + \mu_j^h + u_{i,t+h}, \quad (3)$$

where $k_{i,t+h} - k_{i,t-1}$ is the log difference of tangible capital stock of firm i at different horizons h , and $MRPK_{i,t}$ is the level of MRPK of firm i in period t . We express MRPK in deviation from the industry's mean, since our focus is on within-industry deviations, and we standardize the demeaned MRPK over the entire sample to facilitate the interpretation.¹³ In this specification, β_1^h captures the average effect of MP, while β_2^h captures the differential effect of monetary policy on a firm whose MRPK is one standard deviation above its industry mean. The vector of lagged firm characteristics, $Z_{i,t-1}$, includes log number of employees to account for firm size, leverage, age, and liquidity proxied by ratio of the stock of cash over total assets. ϑ_t and $S_{j,t}$ are the same vectors of macroeconomic controls and sector-level output growth that we used in the MRPK dispersion exercise in Section III. We control for time invariant sector-level unobservables by including sector fixed effects, μ_j^h . We use two-way clustering by firm and sector-year. The first dimension accounts for potential heteroscedasticity and serial correlation of firm's errors. The second dimension makes

¹³Note our specification differs from [Ottonello and Winberry \(2020\)](#): we demean MRPK using industry's average instead of the firm average since we are interested in within industry misallocation, i.e., dispersion of MRPK across firms within industry. Nevertheless, our main results in this Section IV are robust to a) using simple levels of MRPK (as [Jeenas, 2019](#)); and b) demeaning MRPK at the firm level (as [Ottonello and Winberry, 2020](#)). We report the corresponding results in the Appendix C.B.

Figure 3: The effects of monetary policy easing on firm investment

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

inference robust to contemporaneously correlated errors of firms that belong to the same industry.¹⁴

Results are reported in Figure 3. Following a standard monetary policy easing shock, the capital stock of a firm with the average level of MRPK increases on impact by 0.2%, and by about 1.2% in about two years. The figure also shows that firms with high MRPK are more sensitive to monetary policy: firms that are one standard deviation above their industry-average MRPK increase their capital by additional 0.8 percentage points two years into the shock. These results show that expansionary monetary policy leads high-MRPK firms to invest relatively more, reducing misallocation of capital and therefore contributing to increasing aggregate TFP.¹⁵

¹⁴The two-way clustering employed in this paper is conceptually similar, although not identical, to that used by [Ottonello and Winberry \(2020\)](#), who clusters errors by firm and by quarter. Due to the lower frequency of observations in our dataset and, consequently, a smaller number of time periods available for analysis, clustering the second dimension by year is not feasible. To account for some contemporaneous correlation of errors, we instead cluster the second dimension by industry-year.

¹⁵The variance of MRPK could also decrease if the value added of high-MRPK firms exhibited a stronger reaction to monetary policy shocks than the one of low-MRPK firms. To test this hypothesis, we have performed a similar analysis using firm's value added instead of capital stock as the dependent variable. We

To confirm the above findings, we implement a series of robustness checks. First, as mentioned in Section II, we use an alternative aggregating scheme of the high-frequency monetary policy shocks with linearly decaying weights within the year. The results are qualitatively similar to our baseline findings; we report the estimates in the Appendix C.A. Furthermore, we introduce additional controls in the equation 3. First, we interact monetary policy shocks with lagged firm characteristics to ensure that our measure of MRPK does not capture the differential effects of monetary policy associated with these variables. Second, we interact MRPK with aggregate controls to ensure that the differential effect reported in Figure 3 is attributed to monetary policy and not other aggregate shocks. In both exercises, our baseline results stay unaffected (see Appendix C.C). Next, to mitigate the concerns about the potential confounders at the industry-time level, we estimate the differential effect by employing the industry-time fixed effect estimator. With this approach, only the differential effect of monetary policy is identified. The results reported in the Appendix C.D are very similar to the ones obtained in the baseline specification.¹⁶

Furthermore, we reformulate our baseline specification and estimate the effects of interest rate shocks instrumented with the monetary policy shocks from the baseline version. When doing this, we use annual interest rate shocks aggregated from high-frequency interest rate changes around monetary policy announcement similarly to the monetary policy shocks. The resulting response of investment to the interest rate changes are very similar to the baseline findings (the estimates are reported in the Appendix C.G).

Finally, to illustrate the validity of the estimates derived from the annual panel, we use a subsample of firms for which financial data is available at a higher — quarterly — frequency. This subsample includes mainly large firms that report more detailed financial information to the Bank of Spain, and this sample is biased towards the manufacturing sector. When using this quarterly panel, we first aggregate high-frequency monetary policy shocks to the quarterly frequency following the same structure as Ottonello and Winberry (2020) and estimate the baseline regression on this higher frequency dataset. We next verify the validity of the baseline annual aggregation scheme. To do this, we use the end-of-year values of the quarterly panel and monetary policy shocks aggregated as described in Section

found no significant differential effect of monetary policy on value added, which points at the differential effect on investment being the main driver of the intensive margin channel.

¹⁶We also try lagging all control variables, including lagged dependent variable or an indicator of the Global Financial Crisis 2008-2009. The results are reported, respectively, in the Appendix C.E and C.F and show no significant deviations from our baseline specification.

II and re-run the analysis on the annual data of firms from the quarterly panel. We find that the average effect of monetary policy exhibits similar magnitude and dynamics in both frequencies. Moreover, the average effect estimated from the quarterly sample is similar to the one derived from the full yearly panel. These findings allow us to conclude that the baseline results reported above are not due to specificities of the aggregation to annual frequency. We report the results in Appendix C.H.

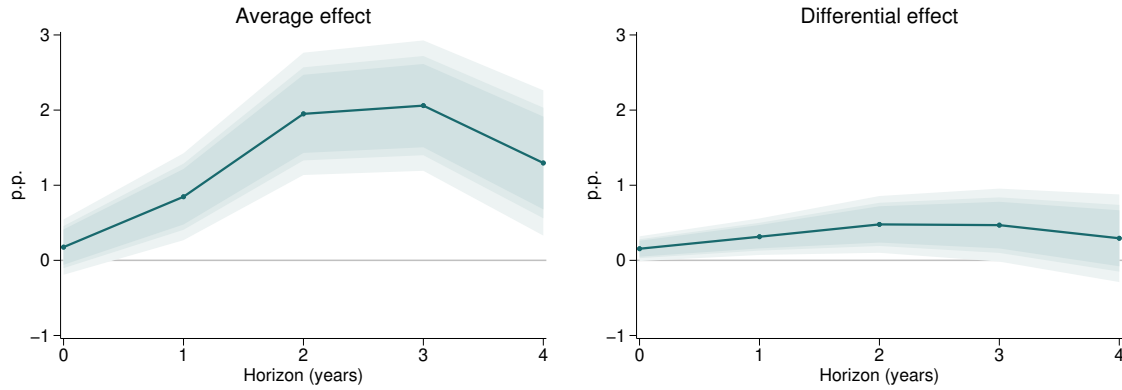
B. Monetary policy, firm's financing and MRPK

Our baseline results demonstrate that high-MRPK firms are more sensitive to changes in monetary policy. We next show that the mechanism behind this effect is likely to be related to firms' financial frictions. First, we analyse whether high-MRPK firms react to monetary policy easing by increasing their leverage relatively more. To do this, we estimate equation (3) considering changes in the log of firm's debt as a dependent variable.¹⁷ To measure firm's indebtedness, we use all interest-bearing sources of debt which in the vast majority of Spanish firms include solely bank financing.

The results are reported in Figure 4. According to these estimates, both the average and the differential effects of monetary policy easing on firm debt are positive, suggesting that, similarly to their investments, the debt of high-MRPK firms is more sensitive to changes in monetary policy stance. Two years after a one standard deviation monetary policy easing, the average firm increases its debt by 2%, while firms that are one standard deviation above the industry's average MRPK increase their debt by 2.5%. This finding is in line with the hypothesis that high-MRPK firms are financially constrained.¹⁸ Interestingly, we find that the average effect on debt is somewhat stronger—while the differential effect is lower—than the corresponding effects on investment. Yet, when comparing the reaction of high-MRPK firms to monetary policy easing, one can see that the overall (i.e., average plus differential) effects on their capital and debt are similar (approximately 2% and 2.3% two

¹⁷ Almost all firms in our data are small and privately held. These firms almost never finance themselves via public equity issuance. Thus, we do not consider equity issuance as an alternative source of financing.

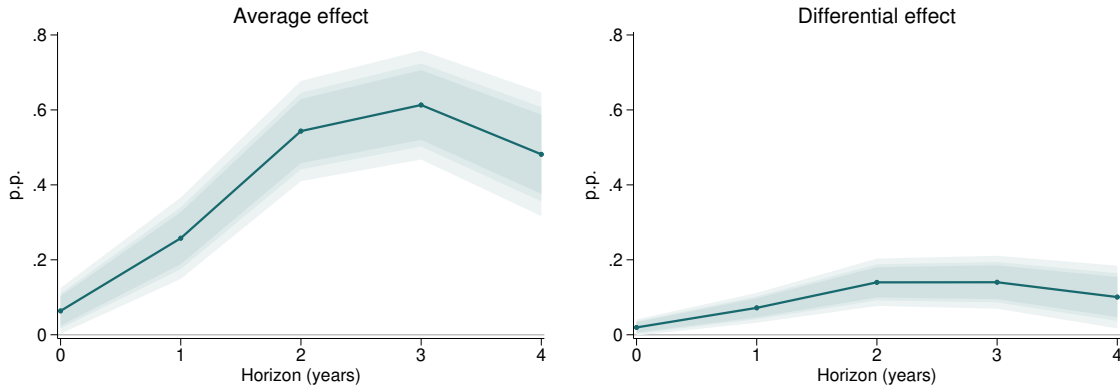
¹⁸ It could also be the case that firms use internal cash buffers rather than debt to finance new investment. In Appendix C.I we run the same specification as the one behind Figure 4 with the only difference that we use net debt on the left-hand side of the regression. Both the average and the differential effect are similar to those reported in Figure 4, which points at cash holdings not changing significantly after an expansionary monetary policy shock.

Figure 4: The effects of monetary policy easing on firm debt (intensive margin)

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm debt (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right), conditional on debt being positive. The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

years after the shock, respectively). This suggests that high-MRPK firms expand their capital keeping a more stable leverage ratio. On the contrary, firms with average MRPK issue relatively more debt (approximately 1.25% and 2% for capital and debt two years after the shock, respectively), implying that an expansionary monetary policy shock increases their leverage.

The above mentioned results capture variation in firm debt on the intensive margin, i.e., the effects of monetary policy on firm leverage conditional on firms having a positive amount of outstanding debt. The effects of monetary easing are also noticeable in the extensive margin, i.e., in the firm's decisions to obtain or maintain debt financing. To illustrate this point, we re-estimate the specification above using as the dependent variable in (3) the change in the indicator of positive debt balances. The results are reported in Figure 5. According to these estimates, monetary policy easing makes firms use debt financing more exhaustively, and more so in the case of high-MRPK firms. We further decompose this effect into firm's decision to enter credit market, and to maintain positive debt level. In other words, we test for the effect of monetary easing on firm's debt status for enterprises that,

Figure 5: The effects of monetary policy easing on firm debt (extensive margin)

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on the probability of a firm having positive debt (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

before the monetary policy shock had, zero or positive debt, respectively. We find that, on average, monetary easing matters for both decisions, and the effect is stronger for the decision to enter the credit market. In both cases, the reaction of high-MRPK firms is stronger, suggesting that access to credit is as important as the level of debt financing in explaining the heterogeneous reaction of firm investment to monetary policy.¹⁹

C. MRPK as a proxy for financial frictions

The existing literature has documented that monetary policy transmission is heterogeneous with respect to specific firm characteristics taken as proxies of financial constraints. Thus, [Cloyne and others \(2022\)](#) find that younger firms not paying dividends increase more their investment after an expansionary monetary policy shock. [Jeenas \(2019\)](#) find that highly-leveraged or illiquid firms are more sensitive to monetary policy. Yet, MRPK can be more informative about the investment sensitivity to monetary policy than the traditional mea-

¹⁹We report the results in the Appendix C.J.

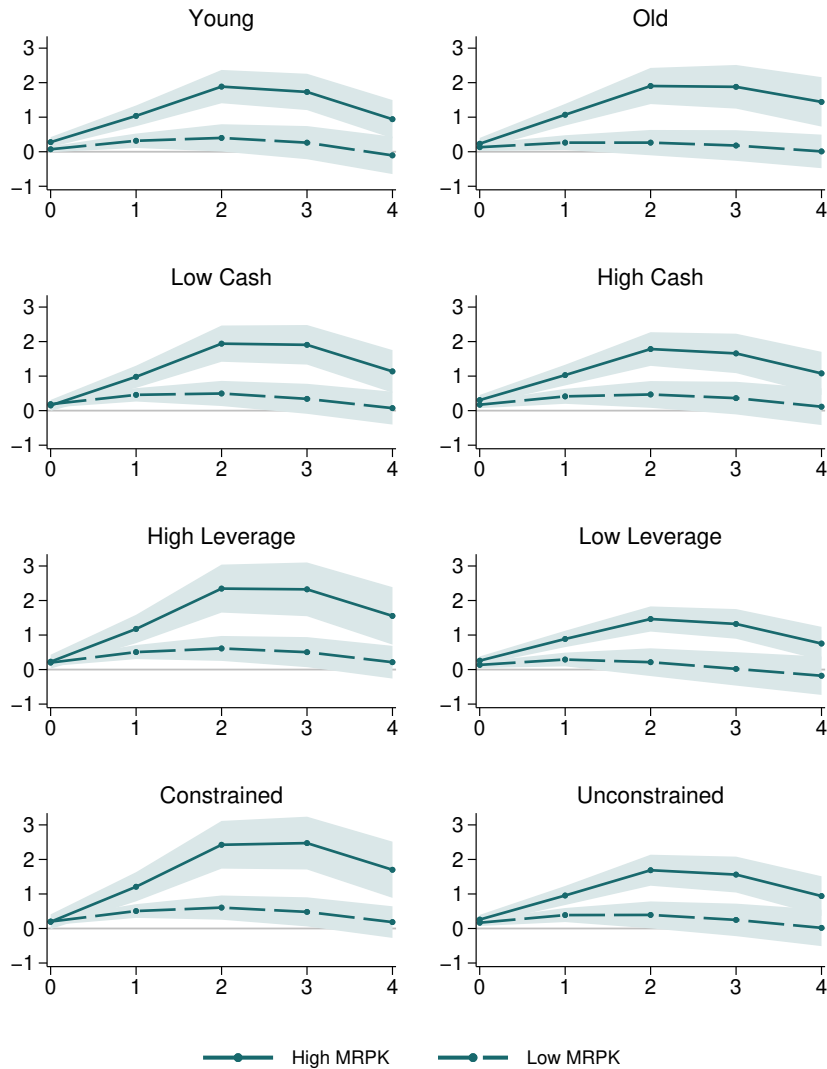
asures of financial constraints. If it is the case, one could argue that firm's deviation of MRPK from a given benchmark is itself a good proxy for financial financial frictions.

To asses whether it is the case, we allow for additional sources of heterogeneous sensitivity of investment to monetary policy shocks by re-specifying the baseline equation (3) as:

$$k_{i,t+h} - k_{i,t-1} = \sum_{g \in G} \beta_{1,g}^h \varepsilon_t \times I\{i \in g\}_{i,t-1} + \beta_2^h Z_{i,t-1} + \beta_3^h \theta_t + \beta_4^h S_{j,t} + \mu_j^h + u_{i,t+h}. \quad (4)$$

Here, G is a Cartesian product of high-MRPK dummy (defined as MRPK being above industry average) with an indicator of financial constraints used in the literature. To measure the latter, we sequentially use firm age, leverage, and liquidity indicators. The age indicator differentiates between young and old firms, i.e., those firms whose age is below or above sample median of the industry (which range between 5 to 16 years old). Similarly, the leverage and cash indicators distinguish firms whose leverage and cash holdings are below or above the corresponding industry sample medians (which range between 0 to 0.5, and 0.02 to 0.2, respectively). Finally, we use the interaction of highly-leveraged and cash-poor firms as an additional indicator of financial constraints. By interacting each of this proxies with the high-MRPK dummy, we can contrast the role of MRPK in investment sensitivity to monetary policy shocks against the traditional measures of financial constraints. We include the non-interacted indicators, $I\{i \in g\}$, in the set of firm-level controls, Z , and estimate equation (4) separately for each proxy of financial constraints.

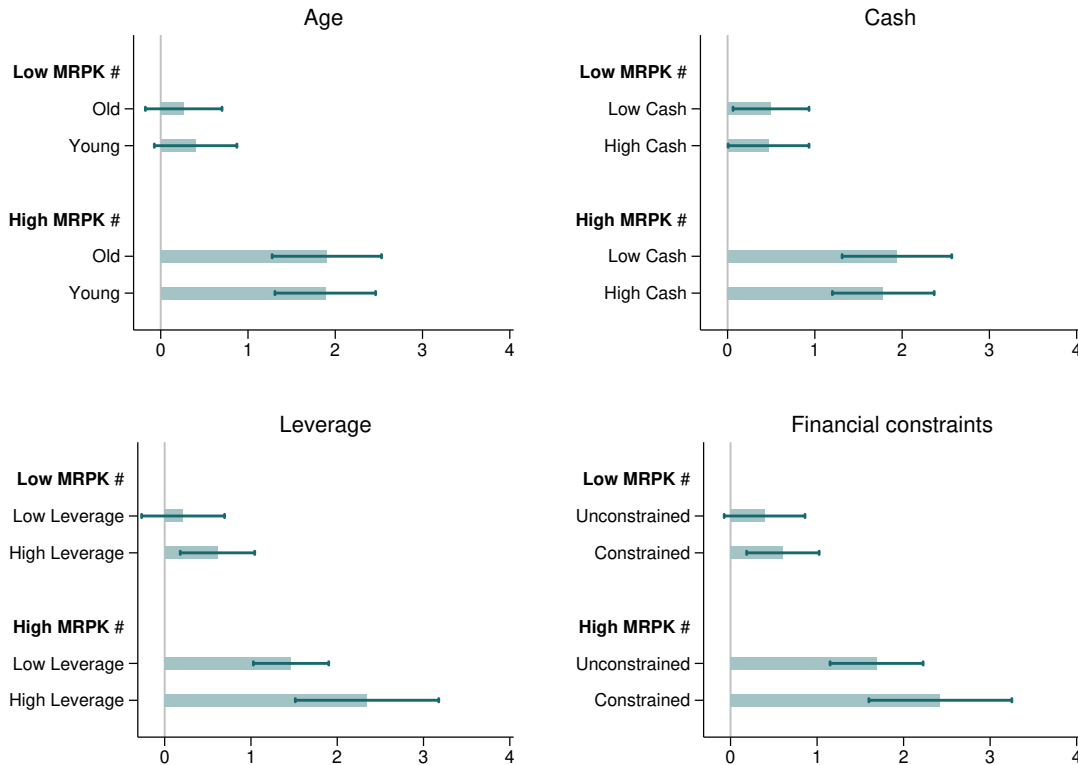
The results are presented in Figure 7 and Figure 6. Figure 6 plots the full dynamic response, while Figure 7 reports the estimated coefficient $\beta_{1,g}^h$ from equation (4) at peak, i.e. for $h = 2$. Both figures illustrate the striking role of MRPK in transmission of monetary policy: independently of the measure of financial constraints considered, only high-MRPK firms show a higher sensitivity to monetary policy. Hence, when compared to high-MRPK firms, low-MRPK firms (1) tend to have lower sensitivity to monetary policy shocks, and (2) do not exhibit strong heterogeneity in investment sensitivity along traditional dimensions of financial constraints. High-MRPK firms, on the contrary, are more sensitive to monetary policy shocks while the standard measures of financial constraints are either irrelevant (age or cash holdings) or tend to amplify the investment sensitivity further (leverage). For instance, the first panel in the bottom row of Figure 7 shows that, 2 years after a one standard deviation monetary policy easing shock, high-MRPK high-leverage firms increase their

Figure 6: The dynamic heterogeneous effects of monetary policy easing on firm investment

The figure shows the effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment for different groups g defined by the interaction of high-MRPK and financial constraints indicators. “Financial constraints” in the lower chart indicates highly-leveraged cash-poor firms, that is, the firm is ‘constrained’ if its leverage is above the industry median *and* its cash ratio is below the industry median; and it is ‘unconstrained’ otherwise. The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Errors are two-way clustered by firm and industry-year. Shaded areas represent 90% confidence intervals.

capital by around 2.25%, while low-MRPK high-leverage firms increase their capital stock only about 0.5%. All in all, traditional measures of financial frictions do not appear to outperform MRPK when explaining firms' sensitivity to monetary policy.

Figure 7: The heterogeneous effects of monetary policy easing on firm investment 2 years after the shock



The figure shows the effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment for different groups g defined by the interaction of high-MRPK and financial constraints indicators. "Financial constraints" in the lower right chart indicates highly-leveraged cash-poor firms, that is, the firm is 'constrained' if its leverage is above the industry median *and* its cash ratio is below the industry median; and it is 'unconstrained' otherwise. The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Errors are two-way clustered by firm and industry-year.

The evidence presented in this section suggests that high-MRPK firms are more sensitive to monetary policy. Furthermore, we find that the common proxies for tighter financial frictions, such as firm age, leverage, or liquidity, matter for investment sensitivity to monetary

policy only as long as firms have a high return on capital (MRPK). All in all, these results stress the importance of heterogeneity in MRPK for the transmission of monetary policy in the short- and long-run and point at high-MRPK firms being more constrained and benefiting relatively more from a relaxation of financial frictions that follows after an expansionary monetary policy shock.

V. EXTENSIVE MARGIN

Firms' entry and exit are essential for the creative destruction process that leads to productivity growth (Haltiwanger, Jarmin, and Miranda, 2013). However, despite the effort of recent papers, the empirical link between monetary policy and firm creation and destruction is not fully documented. One of the main reasons for this is the lack of disaggregated data on firms' entry and exit. Using our micro-level dataset, we can link firms' entry and exit decisions with their ex-post performance and ex-ante characteristics. Hence, as explained in Section II, we construct entry and exit measures that capture the composition of firms in terms of their MRPK levels.

To estimate the effects of monetary policy on entry and exit and on the composition of entering and exiting firms, we use a specification similar to the equation (2) where the dependent variable is the sector-level entry or exit rate:

$$y_{j,t+h} = \beta_1^h \varepsilon_t + \beta_2^h \vartheta_t + \beta_3^h S_{j,t} + \mu_j^h + u_{j,t+h}, \quad y_{j,t+h} = \frac{n_{j,t+h}}{N_{j,t+h-1}} \quad (5)$$

where $y_{j,t+h}$ is either entry or exit rate in industry j during the period $t+h$ calculated as the number of entering or exiting firms in period $t+h$, $n_{j,t+h}$, relative to the number of firms active in the previous period, $N_{j,t+h-1}$.²⁰ As in the analysis of within-industry variance of MRPK, we include linear time trend in all regressions; ϑ_t is the vector of aggregate controls that includes contemporaneous inflation and unemployment rate, and $S_{j,t}$ is contemporaneous sector-level output growth. As before, we also control for time-invariant unobservables at the sector level by including sector fixed effects, μ_j^h .

To analyse the effects of monetary policy on the composition of entering firms, we replace $n_{j,t+h}$ with the number of high- or low-MRPK entrants in each industry-year, $n_{j,t+h}^H$ and

²⁰We plot the aggregate entry and exit rates in Figure A.1 in the Appendix A.A.

$n_{j,t+h}^L$, where a firm is considered to be a high-MRPK firm if its MRPK is above the industry mean. Namely, we define $n_{j,t+h}^H$ and $n_{j,t+h}^L$ as

$$n_{j,t+h}^H = \sum_{i \in I_{j,t+h}} 1[\text{MRPK}_{i,t+h} > \overline{\text{MRPK}}_j], \quad n_{j,t+h}^L = \sum_{i \in I_{j,t+h}} (1 - 1[\text{MRPK}_{i,t+h} > \overline{\text{MRPK}}_j]), \quad (6)$$

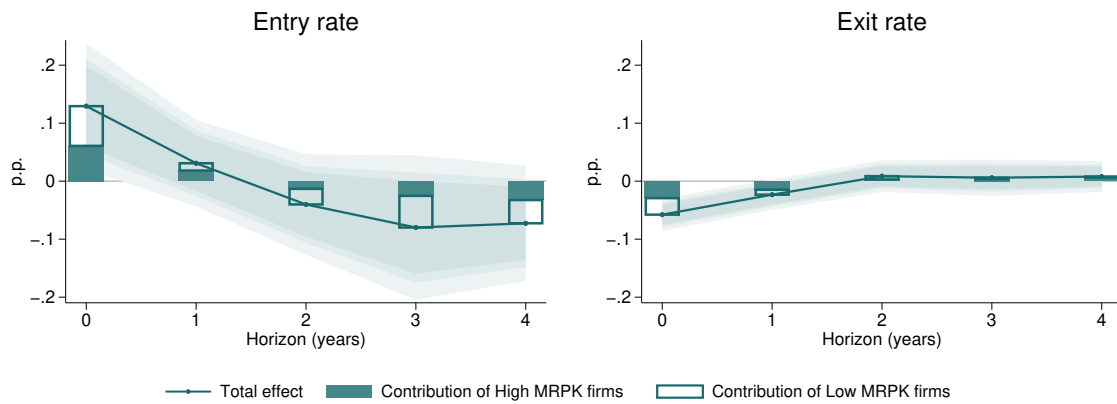
where $I_{j,t+h}$ is the set of firms in industry j in period $t+h$, $\overline{\text{MRPK}}_j$ is the industry mean of MRPK, and $1[\cdot]$ is an indicator variable equal to one if the expression in square brackets holds and zero otherwise. In cases when $\text{MRPK}_{i,t}$ is missing, we impute the corresponding values of the indicator variable as its firm-average value, $T_i^{-1} \sum_t 1[\text{MRPK}_{i,t} > \overline{\text{MRPK}}_j]$, where T_i is the number of non-missing observations of MRPK of firm i .²¹ Similarly, when calculating the contribution of high- and low-MRPK firms to exit rates, we replace $n_{j,t+h}$ with the number of high- or low-MRPK firms exiting in industry j in the period $t+h$ where firms' MRPK status is captured at the moment of the shock, t , rather than at the moment of exit, $t+h$. Note that with these definitions, the contributions of high- and low-MRPK firms add up to the industry-level entry or exit rate.

A. Monetary policy and firm entry

The results for firm entry rate are reported in Figure 8 in the left chart. The green line shows the estimated effect of monetary policy on the entry rate (in percentage points), while the stacked bars show the contribution of high- and low-MRPK entrants to the main effect. The average entry rate in our sector-year sample is 5.6%, and approximately half of entrants are considered as high-MRPK firms.

Our estimates suggest that, following a standard monetary policy easing shock, the entry rate increases by approximately 0.12 p.p. at impact. The initial increase in firms' entry is also found in the U.S. data by [Hartwig and Lieberknecht \(2022\)](#) or [Zanetti and Hamano \(2022\)](#), and it is consistent with an easing of financial conditions. In contrast to these papers, however, we find that, on aggregate, this increase in entry rates is less persistent, and it turns slightly negative (albeit not statistically significant) after three years. In any case,

²¹See Appendix C.K for results obtained under alternative imputation schemes.

Figure 8: The effects of monetary policy easing on entry and exit rates

The solid line in the figure shows the effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm entry rate (on the left) and on the exit rate (on the right), i.e., the estimated β_1^h from the equation (5). The stacked bars show the β_1^h from running the same specification, but having one of the two sub-group of firms entering (on the left) or exiting (on the right) over the total number of firms as the dependent variable: the contribution of the low-MRPK firms to the total effect of monetary policy easing is plotted in light green bars, while the one of the high-MRPK firms is plotted in dark green bars—see equation (6). Shaded areas represent 90%, 95%, and 99% confidence intervals of the total effect calculated using robust standard errors. The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend.

even the statistically significant on-impact effect is relatively small economically when measured against either the average entry rate or its standard deviation.

The aggregate effects can potentially mask differences in the effect of monetary policy on the composition of firm entry. To assess these changes in composition of entry, we plot in stacked green bars in Figure 8 the contributions of high- and low-MRPK firms to the main effect obtained from estimating the equation (6). We find that high- and low-MRPK firms contribute similarly to the positive on-impact effect of monetary policy easing. We also find that the contribution of high-MRPK firms is marginally more persistent, and it turns less negative in longer horizons. Nevertheless, the difference in the contributions is not statistically significant at conventional levels. These findings point at the monetary policy having a muted effect on misallocation via entry margin at impact, and a positive but quantitatively small effect on misallocation in the medium run.

B. Monetary policy and firm exit

We next present the results for exit rates. The results for firm exit rate are presented in the right chart of Figure 8. A standard monetary policy easing shock decreases firm exit rate at impact about 0.6 p.p. This decrease persists one year after the shock shrinking by a factor of three, and turns zero from horizon two onward. Taking into account the differences in the standard deviations of the entry and exit rates in our sample, one can conclude that the effects of monetary policy on exit and entry rates are of similar magnitudes.²² Yet, as discussed in the previous section, these effects are economically small.

In terms of the changes in the composition of exiters, the stacked bars of Figure 8 show that at impact, the decrease in exit is homogeneous among high- and low-MRPK. That is, similarly to the entry rate, we find that monetary policy has no effect on misallocation at impact via the exit channel. One year after the shock, around 2/3 of the decrease in exit comes from high-MRPK firms not exiting in that period. The results from Section IV suggest that after monetary policy easing these incumbent firms invest relatively more than low-MRPK ones. Hence, coupled with this observation, one can conclude that monetary policy easing

²²The average exit rate and its standard deviation in our sample are, respectively, 3.5% and 1.9% with approximately half of exiting firms being high-MRPK firms. We report the industry-level summary statistics in Table 2.

leads to an improvement in the allocation of resources through the exit margin one year after the shock, although arguably very mild.

Summing up, as other papers in the literature, we find that expansionary monetary policy increases entry and decreases exit in the short run, although quantitatively these effects in our sample are rather small. We further contribute to this discussion by documenting that there is no strong adverse change in the composition of entrants and exiters in response to an expansionary monetary policy shock. If anything, there is a mild improvement in the allocation of resources through the extensive margin. Namely, we find that there are relatively less high-MRPK firms exiting and more high-MRPK firms entering one year after the shock, although these effects are small economically. While these findings are consistent with the idea that monetary policy easing relaxes the financial constraints of high-MRPK firms, they also point out that its main effect acts through the intensive rather than the extensive margin. More generally, our results do not support the hypothesis that monetary policy easing leads to a “zombification” of the economy in which low-MRPK firms are more likely to enter or stay alive for longer period after monetary expansions.

C. Robustness

As in the case of intensive margin analysis, we perform a series of robustness checks that are reported in Appendix C.K. First, we try different imputation methods for the missing values we assign. Instead of the average value of the high-MRPK indicator to replace missing values, $T_i^{-1} \sum_t 1[MRPK_{i,t} > \overline{MRPK}_j]$, we use its value rounded to 0 or 1. Alternatively, we use the value of 0.5 instead of the average value of the high-MRPK indicator. In both cases, the results are very similar to the ones obtained with the baseline definition. See Appendix C.K for further details.

Additionally, instead of contributions of high- and low-MRPK firms to the industry-level entry and exit rates, we use the entry and exit rates corresponding to the two groups of firms as the dependent variable in the equation (5). When doing so, we obtain results which are qualitatively very similar to the ones discussed above; we present these results in the Appendix C.L.

Finally, we exclude years 2018–2019 from the analysis to mitigate the concern that the likelihood of mis-classifying non-reporting (but active) firms as exiters is increasing by the end of the main sample. We report the results in Appendix C.M. None of these alternative definitions affect significantly our main findings.

VI. CONCLUSIONS

Central banks' accommodative monetary policy stance has been a fundamental feature of the post-Global Financial Crisis policy scenario. However, although expansionary monetary policy has proved to be an essential crisis response to smooth the downturn and boost the recovery, it raised concerns about its potential unintended adverse effects on aggregate productivity.

This paper estimates the impact of monetary policy on capital misallocation and the transmission mechanisms. Using detailed micro-level data for Spain, we find that expansionary monetary policy decreases misallocation at the within-sector level. At the firm level, we show that more productive firms with higher MRPK increase their investment relatively more after an expansionary monetary policy shock. Furthermore, we analyse whether relaxation of financial frictions supports such reallocation. To this end, we first show that capital expansion by productive firms is accompanied by an increase in debt issuance. Second, we show that firms' MRPK outperforms the standard measures of financial constraints in explaining investment sensitivity to monetary policy shocks. Finally, by analysing the extensive margin, we show that expansionary monetary policy affects firm's entry and exit decisions only marginally without changing the composition of high- and low-MRPK entrants and exiters.

Overall, this evidence points to a decrease in misallocation following an expansionary monetary policy shock, mainly driven by a relatively larger increase in investment of high-MRPK firms thanks to the relaxation of financial frictions

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APPENDICES

A. DATA

A. Data Sources

Central de Balances Integrada (CBI). CBI is an administrative database of detailed financial reports of firms in Spain. The database is maintained by the CB Department of the Bank of Spain. The database contains obligatory filings of annual accounts obtained from mercantile registries and covers the quasi-universe of Spanish firms.

We prepare the CBI data as following (in this order):

1. We keep firms that have a status of a joint-stock company or a limited liability company, and index firms by their tax identifiers. We use all characters of the Spanish tax identifier (*CIF*) following the first letter of the id. Since the first letter indicates the firm's legal status, we effectively treat observations of a joint-stock company switching to a limited liability company (or vice versa) as observations of the same firm.
2. In cases when a firm has multiple records of its primary industry, we use the most frequent one.
3. Firms may have multiple records for the same year extracted from the current and future year's filings. In cases when financial reports are missing for some firm-years, we use the following year's filings from which we extract the past year's accounting data. In cases when both the current and the following period's filings are available, we prioritize the current year's values unless they are flagged as a "low-quality record" by the CB Department of the Bank of Spain, in which case we use the following year's values.

4. In cases when firms report multiple years of entry, we take the earliest year as the actual year of the start of the firm's business.
5. We drop records with negative capital, and deflate capital using industry-specific capital deflators. We deflate debt using industry-level value-added deflators.
6. We treat negative values of cash and debt as zero values. We winsorize investment at 1% level, and trim cash holdings and leverage at the level 1 and 2, respectively.
7. We exclude from the analysis all records flagged as a "low-quality record" by the CB Department of the Bank of Spain.

Directorio Central de Empresas (DIRCE). DIRCE is the primary Spanish data source covering the entire firm population and providing firm dynamics statistics at a yearly frequency. It is maintained by the Spanish Statistical Office (Instituto Nacional de Estadística, INE). DIRCE provides to the statistical office of the Bank of Spain the microdata they use for their aggregate statistics, which contains, among other information, the fiscal identifier of the firm, the year of firm "activation" (*altas*) or "deactivation" (*bajas*). INE uses data from the tax office, the central mercantile registry, and the social security office to compile the DIRCE micro-data file. We extract records from DIRCE that cover 1995–2020.

Since a temporary shut down of economic activity does not necessarily result in firms deregistering in the official mercantile registry, we sometimes observe more than one activation and deactivation year in DIRCE. Therefore, for each tax identifier, we keep only the first year of activation and the last year of deactivation and discard the rest status changes.

Table 1 contains variables' definitions. Table 2 reports the descriptive statistics.

Table 1: Variables definitions

Variable	Description	Source
<i>Firm-level variables</i>		
Investment	Change in the log of tangible capital	CBI
MRPK	Log of value added over capital	CBI
Employment	The average number of employees of a firm during the year	CBI
Age	The number of years since the firm's incorporation	CBI
Leverage	The ratio of total interest-bearing debt to total assets	CBI
Cash holdings	The ratio of cash holdings to total assets	CBI
Entry year	The minimum of <ul style="list-style-type: none"> • the first entry year recorded in DIRCE, • the incorporation year self-reported by firms to the CBI 	CBI, DIRCE
Exit year	The last year of exit recorded in DIRCE, unless the firm enters the bankruptcy procedure, in which case its exit year is set to be the first year of the bankruptcy process. The latter is defined as the first year of bankruptcy reported CBI, CIR, or RPC.	CBI, DIRCE, CIR, RPC
<i>Industry-level variables</i>		
Industry sales growth	The log growth rate of industry total sales	CBI
Entry rate	The number of firms entering the industry divided by the lagged number of active firms in that industry	
Exit rate	The number of firms exiting the industry divided by the lagged number of active firms in that industry	
<i>Aggregate variables</i>		
Unemployment rate	The rate of unemployment, all ages, all regions	INE
Inflation rate	HICP inflation rate	INE
Monthly MP shocks	MP surprises from the updated series of Jarociński and Karadi (2020)	Marek Jarocinski's Github page
Annual MP shocks	Monthly MP shocks aggregated to the annual frequency with the weighting scheme (1)	

CBI — Central de Balances Integrada (Integrated Central Balance Sheet Database)

DIRCE — Directorio Central de Estadística (Central Statistical Database)

RPC — Registro Público Concursal (Registry of Bankruptcy Procedures)

CIR — Central de Información de Riesgos (Central Credit Registry)

INE — Instituto Nacional de Estadística (National Statistics Institute)

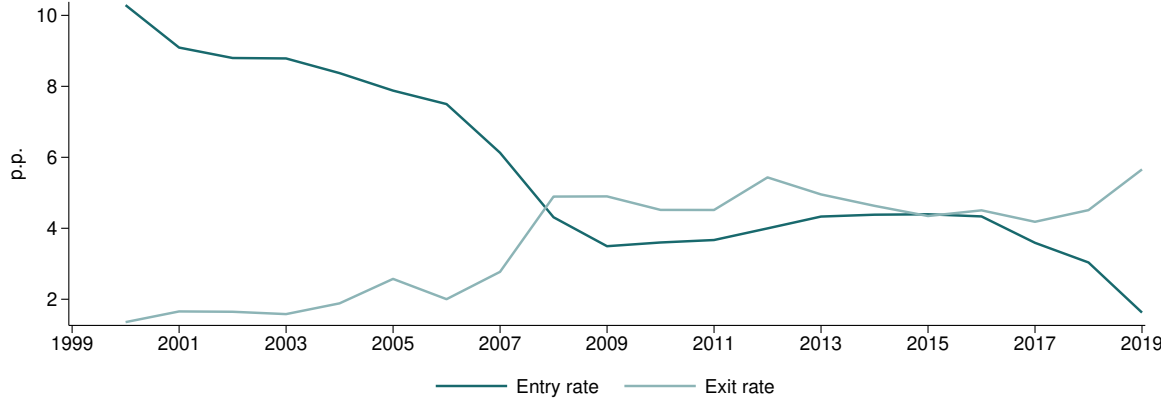
Table 2: Descriptive statistics

	Mean	SD	25%	50%	75%
<i>Firm panel</i>					
Investment	-0.0035	0.582	-0.20	-0.06	0.04
MRPK	0.640	2.024	-0.60	0.64	1.91
Employment, # employees	12.72	229.9	1.0	3.0	7.41
$\log(1 + \text{Employment})$	1.495	1.108	0.69	1.39	2.13
Age, # years	12.33	9.304	6.0	10.0	17.0
$\log(1 + \text{Age})$	2.358	0.710	1.95	2.40	2.89
Leverage	0.225	0.288	0.00	0.10	0.37
Cash holdings	0.144	0.189	0.01	0.07	0.20
Industry sales growth	-0.032	1.954	-0.73	-0.04	0.76
Unemployment rate	16.28	5.656	11.25	15.26	21.39
Inflation rate	1.958	1.459	0.70	2.45	3.20
Annual MP shocks	-2.814	9.425	-6.96	0.68	3.88
<i>Industry panel</i>					
log Var MRPK	1.157	0.357	0.93	1.18	1.40
Entry rate	0.056	0.048	0.029	0.045	0.072
Exit rate	0.039	0.019	0.018	0.033	0.049
Industry sales growth	-0.0361	1.654	-0.43	-0.01	0.34
Unemployment rate	15.89	5.526	11.25	15.26	19.86
Inflation rate	2.110	1.409	1.41	2.45	3.20
Annual MP shocks	-2.643	9.580	-6.96	0.68	3.88
Monthly MP shock [†]	-0.329	3.293	-1.54	0.0	0.78

Upper panel: summary statistics of the firm-year panel; the number of observations is 9,047,649; the number of firms is 1,323,799. The table reports the descriptive statistics of a sample of firms included in the baseline regression estimating the on-impact effect of monetary policy on firm investment.

Lower panel: summary statistics of the industry-year panel; the number of observations is 1512; the number of industries is 72.

[†] Summary statistics of the time series of monetary policy surprises from the updated file of [Jarociński and Karadi \(2020\)](#).

Figure A.1: Aggregate firm entry and exit rates in Spain, 2000-2019

B. Aggregation of monetary policy shocks

This section discusses the aggregation of monetary policy shocks from a higher frequency (HF) to a lower frequency (LF). First, we show that a sequence of HF marginal effects implies a particular aggregation scheme. We then discuss the quantification of economic effects employed in the main part of the paper.

Assume a simple HF process of the form

$$y_{\tau} = \sum_{k=0}^K \tilde{\beta}_k x_{\tau-k} + \tilde{u}_{\tau}, \quad (\text{A.HF})$$

where $\tau = 0, 1, \dots$ indexes HF calendar time. In the context of the main part of the paper, we treat τ as month, y_{τ} as the (unobserved) monthly log growth of capital, and x_{τ} as the monetary policy shock corresponding to month τ . The sequence $\{\tilde{\beta}_k\}_{k=0}^K$ captures potential delays in adjustment to monetary policy shocks.

To aggregate the process to LF, we first recast both indices, τ and k , in terms of the LF periods. To do this, we assume that the LF-period spans L HF-periods, and let $K \equiv LP$, where P is the number of LF lags affecting current y (in the main analysis, we have $L = 12$ months

per year, and $P = 4$ years). With this notation, we can rewrite the HF process as

$$y_\tau = \sum_{p=0}^P \sum_{l=0}^{L-1} \tilde{\beta}_{Lp+l} x_{\tau-(Lp+l)} + \tilde{u}_\tau.$$

To recast the HF index τ in terms of the LF one, denote with t the LF-period, and with m the m -th HF-period within the LF one. In the context of the paper, $t = 0, 1, \dots$ indexes years, while $m = 0 \dots 11$ indexes months within a year. We have $\tau = Lt + m$. Hence, the HF process can be further rewritten as

$$y_{Lt+m} = \sum_{p=0}^P \sum_{l=0}^{L-1} \tilde{\beta}_{Lp+l} x_{Lt+m-(Lp+l)} + \tilde{u}_{Lt+m} = \sum_{p=0}^P \sum_{l=0}^{L-1} \tilde{\beta}_{Lp+l} x_{L(t-p)+m-l} + \tilde{u}_{Lt+m}.$$

The HF y is not observed, but we can operate with the LF aggregate, Y_t , of the form $Y_t = \sum_{m=0}^{L-1} y_{Lt+m}$. Using the above definition of y , we thus have

$$Y_t = \sum_{p=0}^P \sum_{l=0}^{L-1} \tilde{\beta}_{Lp+l} \sum_{m=0}^{L-1} x_{L(t-p)+m-l} + u_t,$$

where $u_t \equiv \sum_{m=0}^{L-1} \tilde{u}_{Lt+m}$. Note that, with this notation, HF shocks that happen in the beginning of the LF period $t - p$ are $x_{L(t-p)}$.

The above specification involves LP marginal effects corresponding to the $\tilde{\beta}$ s in (A.HF). Given relatively short time span of the data, estimation of all LP parameters without further restrictions is not feasible. We proceed by restricting $\tilde{\beta}$ s such that

$$\tilde{\beta}_{Lp+l} = \check{\beta}_p, \quad \forall p = 0, \dots, P, \quad l = 0, \dots, L-1, \quad (\text{A.}\check{\beta})$$

i.e., we assume that marginal effects are constant within the LF-period but may differ between LF-periods. With this specification, we have

$$Y_t = \sum_{p=0}^P \check{\beta}_p \check{X}_{t-p} + u_t, \quad \text{where} \quad \check{X}_{t-p} \equiv \sum_{l=0}^{L-1} \sum_{m=0}^{L-1} x_{L(t-p)+m-l}. \quad (\text{A.LF})$$

Inspecting the double summation in the definition of \check{X}_{t-p} , we see that there are L elements $x_{L(t-p)+m-l}$ such that $m-l=0$, $L-1$ elements such that $m-l$ is 1 or -1 , $L-2$ elements such that $m-l$ is 2 or -2 (and so on for $L > 3$). For instance, for $L=3$ we have

$$\check{X}_{t-p} = x_{L(t-p)-2} + 2x_{L(t-p)-1} + 3x_{L(t-p)} + 2x_{L(t-p)+1} + x_{L(t-p)+2},$$

and a similar pattern of weights for x would “mount” around $m=0$ for $L=12$. That is, we have

$$\check{X}_{t-p} = \sum_{j=0}^{L-1} (L-j)x_{L(t-p)\pm j}. \quad (\text{A.Aggregation})$$

To gain some intuition about the aggregation scheme, consider the simplest case of $P=0$ and $L=3$, i.e.,

$$y_\tau = \tilde{\beta}_0 x_\tau + \tilde{\beta}_1 x_{\tau-1} + \tilde{\beta}_2 x_{\tau-2} + \tilde{u}_\tau.$$

and for concreteness let τ correspond to March of a particular year. Then the quarterly aggregate for the first quarter t of that year is

$$\begin{aligned} Y_t &= y_{3t} + y_{3t+1} + y_{3t+2} \\ &= \tilde{\beta}_0 x_{3t} + \tilde{\beta}_1 x_{3t-1} + \tilde{\beta}_2 x_{3t-2} + \tilde{u}_{3t} \\ &\quad + \tilde{\beta}_0 x_{3t+1} + \tilde{\beta}_1 x_{3t} + \tilde{\beta}_2 x_{3t-1} + \tilde{u}_{3t+1} \\ &\quad + \tilde{\beta}_0 x_{3t+2} + \tilde{\beta}_1 x_{3t+1} + \tilde{\beta}_2 x_{3t} + \tilde{u}_{3t+2} \\ &= \tilde{\beta}_2 x_{3t-2} + (\tilde{\beta}_1 + \tilde{\beta}_2)x_{3t-1} + (\tilde{\beta}_2 + \tilde{\beta}_1 + \tilde{\beta}_0)x_{3t} + (\tilde{\beta}_0 + \tilde{\beta}_1)x_{3t+1} + \tilde{\beta}_0 x_{3t+2} + u_t. \end{aligned}$$

A unit shock that happens in March (i.e., at $\tau = 3t + 2$) only affects contemporaneous y_τ , hence, its effect on quarterly aggregate is $\tilde{\beta}_0$. A unit shock that happens in February (i.e., at $\tau = 3t + 1$) affects contemporaneous February $y_{\tau-1}$ by $\tilde{\beta}_0$ and — with one month of delay — the future (March) y_τ by $\tilde{\beta}_1$. Since the quarterly aggregate Y_t includes both February and March ys, the total effect of February shock on the aggregate is $\tilde{\beta}_1 + \tilde{\beta}_0$. Similarly, the January shock (i.e., the one that happens at $\tau = 3t$) affects all three HF ys included in the quarterly aggregate, so that its total effect on the latter is $\tilde{\beta}_2 + \tilde{\beta}_1 + \tilde{\beta}_0$. Finally, since the three HF y react to shocks with delays, the quarterly aggregate depends on shocks happened in the last two months of the previous quarter.

Note that so far we have not restricted the pattern of adjustment, $\{\tilde{\beta}_l\}_{l=0}^2$, in any way: the quarterly aggregate Y reacts to shocks happened in the previous quarter because these past shocks affect with delay the earliest HF outcomes included in the LF aggregate, and not because $\tilde{\beta}_2$ is larger in absolute terms than $\tilde{\beta}_0$. That is, since the LF Y includes three HF ys that are determined by overlapping sequences of past shocks, the effects of these shocks on the quarterly aggregate are “mounted” around the shock happening in the beginning of the LF period (in the example, January, $\tau = 3t$).

Under further the assumption (A. $\tilde{\beta}$), we have

$$Y_t = \check{\beta}_0 \check{X}_t + u_t, \quad \check{X}_t = x_{3t-2} + 2x_{3t-1} + 3x_{3t} + 2x_{3t+1} + x_{3t+2}, \quad \check{\beta}_0 = \check{\beta}_1 = \check{\beta}_2 = \check{\beta}_0.$$

That is, if HF marginal effects are constant within the LF period, then the aggregate LF shock, \check{X}_t , is a rolling weighted sum of HF shocks, x_τ s, where the weight on each shock is the number of HF outcomes, y_τ s, in the LF aggregate, Y_t , that are affected by this shock.

In the main analysis, we extend the above logic to the case where $P > 0$ and $L = 12$. To arrive to (1), we scale weights in the aggregation scheme (A.Aggregation) by L . Namely,

our LF aggregate shock, X_{t-p} , is defined as

$$X_{t-p} \equiv L^{-1} \check{X}_{t-p},$$

where \check{X}_{t-p} is defined in (A.Aggregation). The motivation behind this normalisation is twofold. First, with this normalisation, each HF shock is allocated between at most two consecutive LF periods, with the allocation weight to the current LF period being proportional to the number of HF periods the shock has to “act” in it (the normalisation ensures that the sum of allocation weights for each shock, ω_{past} and ω_{current} in (1), is unity). Second, with this definition, the LF specification is

$$Y_t = \sum_{p=0}^P \beta_p X_{t-p} + u_t,$$

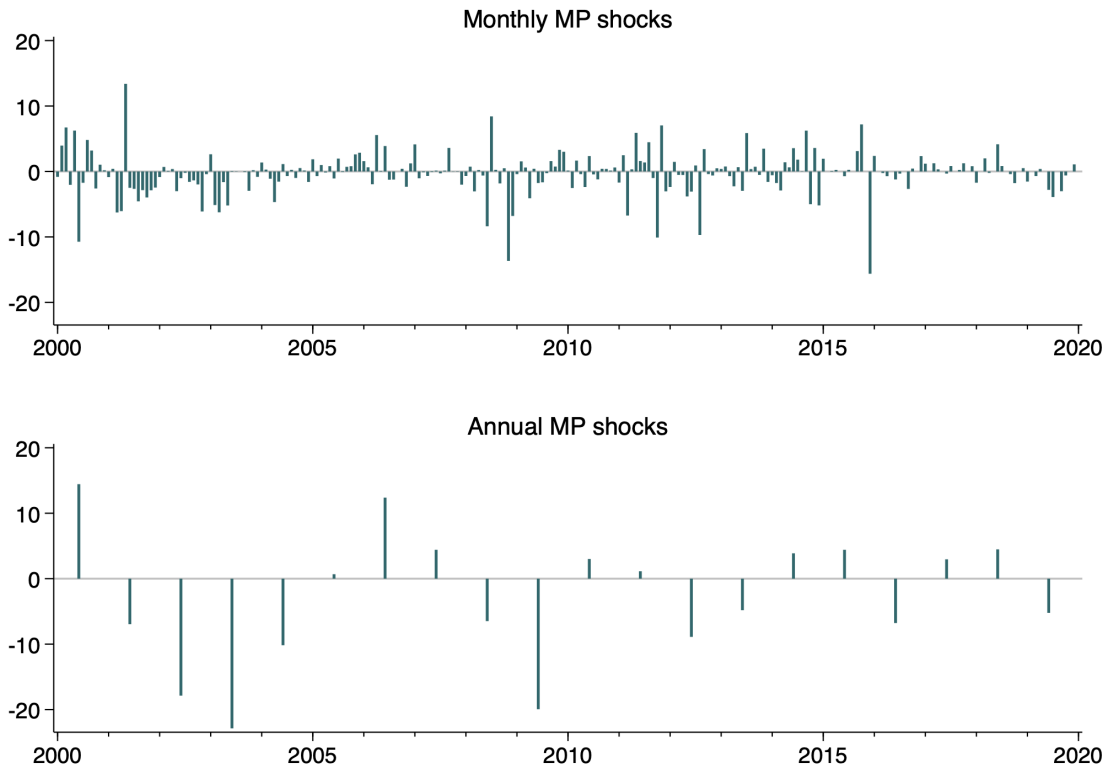
so that the parameters β_p can be interpreted as the dynamic effects on the LF aggregate of a unit change in HF shock happening in the very beginning of the LF period:

$$\frac{\partial Y_t}{\partial x_{L(t-p)}} = \beta_p \frac{\partial X_t}{\partial x_{L(t-p)}} = \beta_p L^{-1} \frac{\partial \check{X}_t}{\partial x_{L(t-p)}} = \beta_p L^{-1} L = \beta_p,$$

where the second to last equality follows from (A. $\tilde{\beta}$).²³ That observation motivates the use of one SD of HF monetary policy shocks as a measure of normal “quantity” of monetary policy shocks when quantifying the economic effect.

For illustrative purposes, we plot the time series of original monthly shocks and the resulting annual time series in Figure B.1.

²³The IRFs in the main analysis report cumulative rather than marginal effects discussed here.

Figure B.1: Monthly and annual monetary policy shocks

The chart shows the evolution of monetary policy shocks sourced from [Jarociński and Karadi \(2020\)](#) (the updated series) at monthly and annual frequencies. Aggregation to the yearly frequency is done using the weighting scheme described in Section II. The chart plots the annual shocks in the middle of the corresponding years. Monetary policy surprises are signed such that positive values indicate monetary policy easing.

B. HSIEH AND KLENOW (2009) FRAMEWORK

The baseline model of the empirical analysis is based on [Hsieh and Klenow \(2009\)](#). Hereby we outline the framework, but we refer the interested reader to their paper for further details. Firms face monopolistic competition, and output is aggregated at the industry level by a CES production function with the elasticity of substitution σ . At the firm level, firms

produce with a constant return to scale production function, with productivity z_{is} and with capital share at the industry level of α_s .²⁴

An efficient allocation of capital implies that, at the margin, the return to capital should be equalized across firms within the same sector because, in the absence of frictions, capital would move from low to high marginal revenue product firms. In the optimization problem of the firm, these frictions appear in the form of ‘wedges’, which we denote by $\tau_{ist}^k, \tau_{ist}^l$. Hence, the marginal product of capital and labor of firm i in sector s at time t is respectively given by:

$$\begin{aligned} MRPK_{ist} &= \alpha_s \left(\frac{\sigma - 1}{\sigma} \right) \left(\frac{P_{sit} Y_{sit}}{K_{sit}} \right) = \frac{r_t}{1 + \tau_{ist}^k} \\ MRPL_{ist} &= (1 - \alpha_s) \left(\frac{\sigma - 1}{\sigma} \right) \left(\frac{P_{sit} Y_{sit}}{L_{sit}} \right) = \frac{w_t}{1 + \tau_{ist}^l} \end{aligned} \quad (7)$$

Note that so far, we do not take a stand on where these frictions come from (financial frictions, regulations, etc.), although we will explore some of these mechanisms in the paper. Since within the same sector, firms should be equalizing MRPKs, the dispersion of MRPK is used as proxy for the misallocation of the sector. This dispersion of MRPKs and MRPLs maps directly into the dispersion of revenue TFP, that is:

$$TFPR_{ist} = P_{ist} z_{ist} \propto (MRPK_{ist}) \alpha_s (MRPL_{ist})^{1 - \alpha_s}. \quad (8)$$

After making some assumptions regarding the distribution of distortions, they show that

$$\log(TFPR_{st}) = \frac{1}{1 - \sigma} \log \left(\sum_{i=1}^{M_s} z_{ist}^{\sigma - 1} \right) - \frac{\sigma}{2} \text{var}(\log(TFPR_{ist})), \quad (9)$$

where z_{si} is the firms’ TFPQ. Hence, an increase in the variance of $\log(MRPK)_{ist}$ increases that of $\log(TFPR)_{ist}$, which directly maps to a decrease in aggregate TFP.

²⁴Hsieh and Klenow (2009) argue that, since we cannot separately identify the average capital distortion and the capital production elasticity in each industry, one could use the U.S. shares as the benchmark because we presume the United States is comparatively undistorted (both across plants and across industries).

The use of the dispersion of MRPK as a measure of misallocation has been criticized in the literature. For instance, [Asker, Collard-Wexler, and Loecker \(2014\)](#) demonstrate that an increase in MRPK dispersion does not necessarily indicate higher misallocation, as it might also arise from technology or sector-specific adjustment costs. [Haltiwanger, Kulick, and Syverson \(2018\)](#) argue that this metric is sensitive to model mis-specification, suggesting that the distortions it reveals might merely reflect demand shifts or movements along the firm's marginal cost curve, which could be profitable. Although these concerns are significant for identifying product wedges, we maintain that physical or technological frictions, such as adjustment costs, are structural and unlikely to be influenced by monetary policy shocks in the short run. Consistent with this, our findings of a correlation between MRPK dispersion and monetary policy (MP) shocks suggest that, despite potential measurement errors, MRPK variance provides valuable insights into capital misallocation.

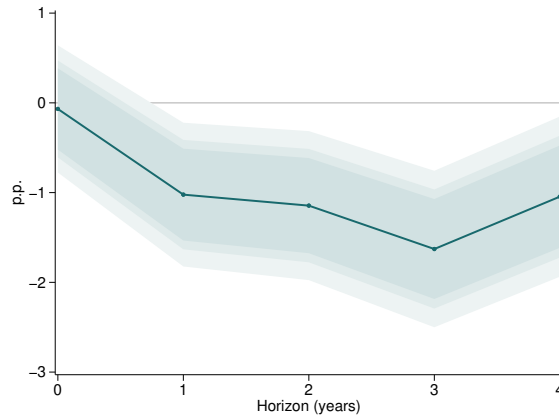
Furthermore, within this analytical framework, aggregate revenue Total Factor Productivity (TFPR) is inversely related to the dispersion of firm-level MRPK. Estimating the effects of MP shocks on MRPK dispersion offers insights into their ultimate impact on aggregate productivity. However, as our analysis does not extend to the MRPL, which is another crucial component for aggregate TFP in the framework outlined by [Hsieh and Klenow \(2009\)](#), the direct effects of expansionary MP shocks on TFP are not immediately apparent. To address this, we explore the impact of expansionary MP shocks on the dispersion of firm-level revenue TFPR in two ways. First, we estimate a reduced-form specification, similar to that in Equation 2, but with the sector average dispersion of TFPR as the dependent variable. This dispersion is constructed using industry value-added share weights, analogous to those used for MRPK. We observe a reduction in TFPR dispersion at least one year post-shock, with a magnitude comparable to previous findings. Second, we investigate the differential impact on high-productivity firms by using TFPR, which reflects not only the marginal product of capital but also of labor, as a proxy instead of MRPK. Notably, a firm's TFPR is a geometric average of MRPK and MRPL. By estimating Equation 3 with TFPR included as a term in the interaction, we achieve results similar to those observed with respect to MRPK.

C. ROBUSTNESS CHECKS

A. Alternative aggregation scheme of monetary policy shocks

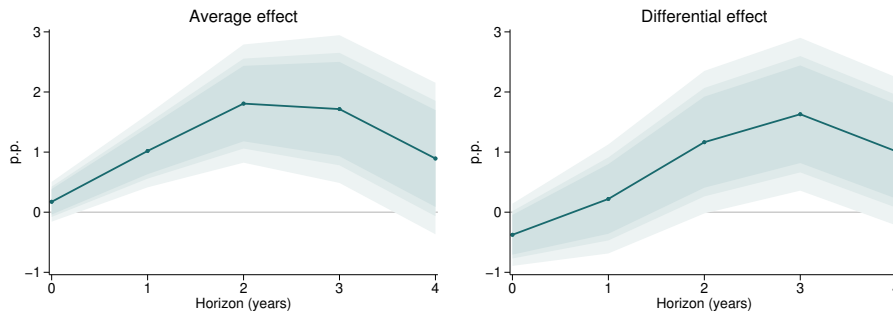
We consider a different aggregation of the monetary policy shocks, by aggregating current-year shocks with the same linear decreasing weights as in the main specification of the shock, but differently from the baseline case, we do not include the shocks from the previous year. This weighting reduces concerns of autocorrelation in the residuals since it aggregates shocks within the same year. Figure A.1 and A.2 shows that results are qualitatively similar and slightly quantitatively larger.

Figure A.1: Effect of monetary policy easing on MRPK dispersion, alternative aggregation of monetary policy shocks



The figure shows the dynamic effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on the within-sector dispersion of MRPK (the estimated β_1^h from the equation (2)). The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using robust standard errors. Annual monetary policy shocks are constructed as a moving average of within year shocks using linear decreasing weights.

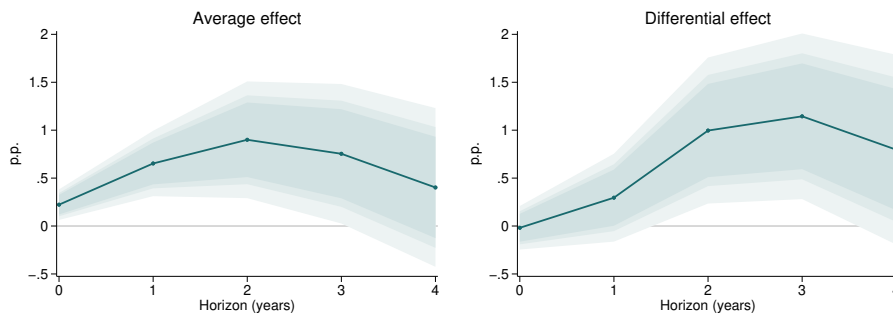
Figure A.2: The effects of monetary policy easing on firm investment, alternative aggregation of monetary policy shocks



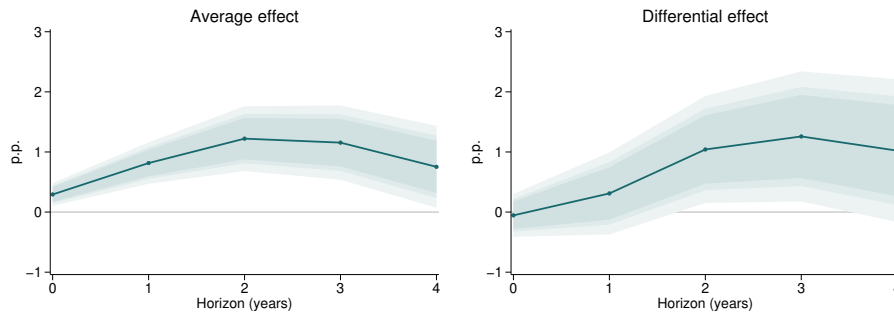
The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. Annual monetary policy shocks are constructed as a moving average of within year shocks using linear decreasing weights.

B. Intensive margin: Alternative demeaning of MRPK

Figure B.1: The effects of monetary policy easing on firm investment—no demeaning of MRPK



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. MRPK is measured in levels (and scaled to have unit SD) and not demeaned by industry as in the main text

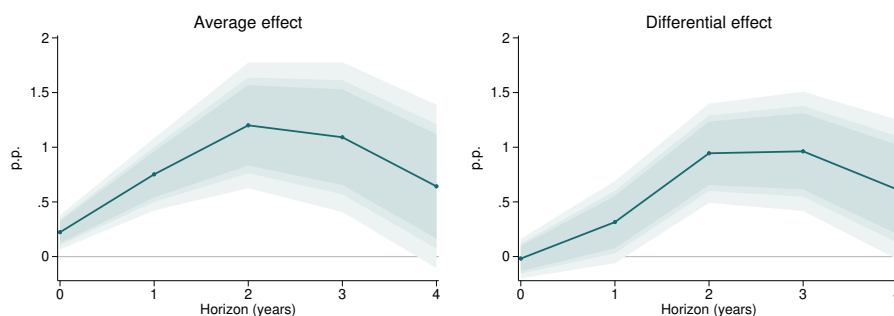
Figure B.2: The effects of monetary policy easing on firm investment—demeaning of MRPK by firm

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and firm fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. MRPK is demeaned by firm (and scaled to have unit SD) and not by industry as in the main text

C. Intensive margin: Additional interactions

To make sure that the differential response we find is not driven by different business cycle patterns of high- and low-MRPK firms, we add to the baseline specification the interaction of the firm-level MRPK variable with the aggregate controls: sector-level sales growth, aggregate unemployment rate, inflation rate. As Figure C.1 shows, this does not change our results.

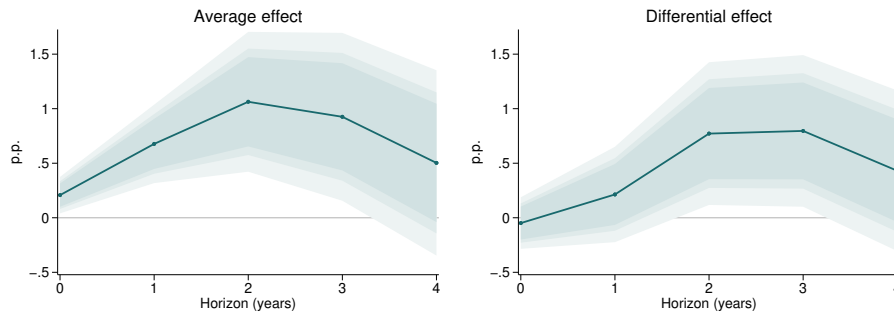
Figure C.1: The effects of monetary policy easing on firm investment—additional controls for interactions of MRPK with aggregate variables



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. The specification includes additional controls for interactions of MRPK with aggregate variables.

Furthermore, in order to make sure that the differential results we find are not driven by the differential effects of monetary policy associated with other covariates, we interact monetary policy shocks with the following lagged firm characteristics: employment, leverage, age, liquidity. As Figure C.2 shows, this does not change our results.

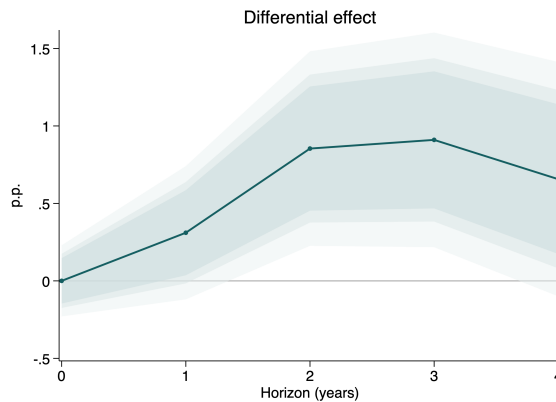
Figure C.2: The effects of monetary policy easing on firm investment—additional controls for interactions of monetary policy shocks with firm-level variables



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. The specification includes additional controls for interactions of monetary policy shocks with firm-level variables.

D. Sector-year fixed effects

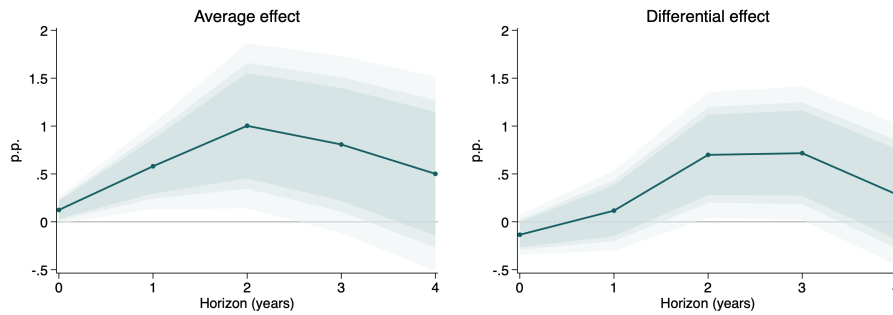
Figure D.1: The differential effects of monetary policy easing on firm investment—industry-year fixed effects



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry-year fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

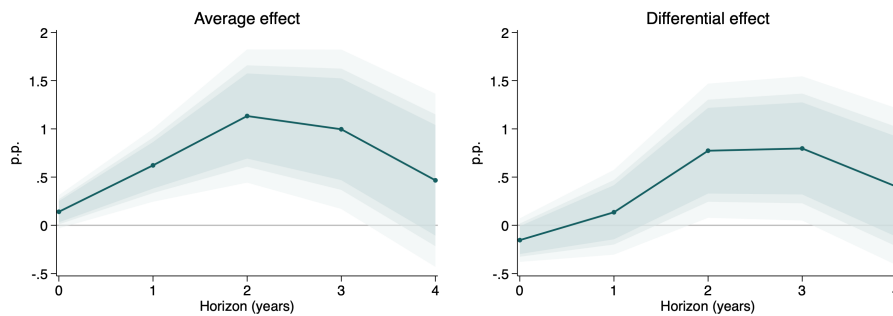
E. Lagged control variables

Figure E.1: The effects of monetary policy easing on firm investment—lagged macro- and sector-level controls



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), lagged sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

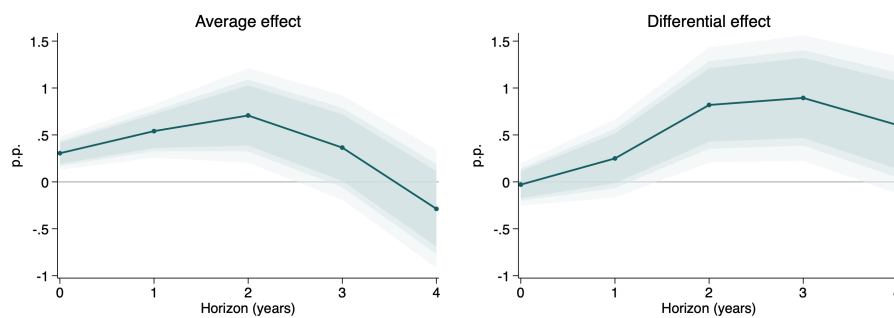
Figure E.2: The effects of monetary policy easing on firm investment—lagged dependent variable



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, industry fixed effects, and lagged one-year difference of log capital. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

F. Global Financial Crisis

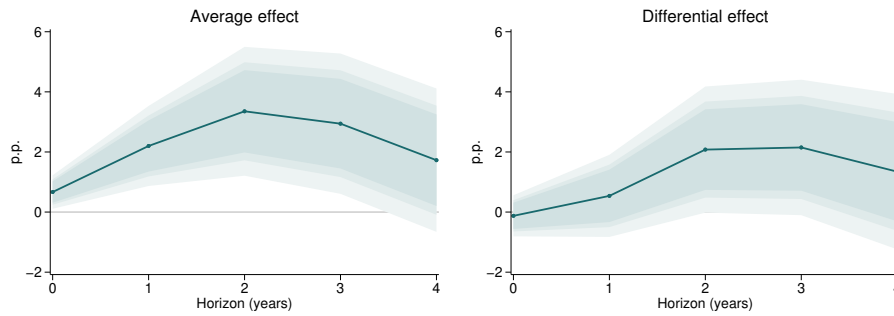
Figure F.1: The effects of monetary policy easing on firm investment—controlling for financial crisis 2008–2009



The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, industry fixed effects, as well as Global Financial Crisis indicator equal to 1 for years 2008-2009 and zero otherwise. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

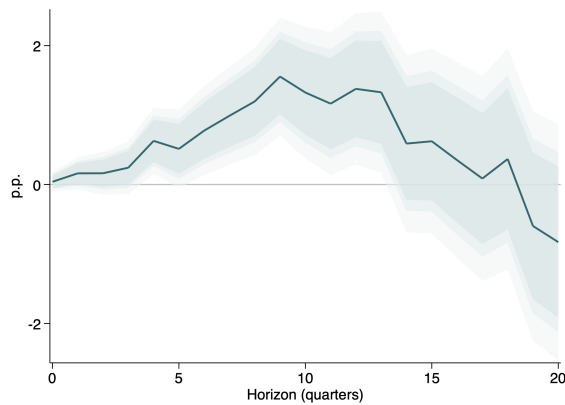
G. Instrumenting interest rate changes with monetary policy shocks

One key issue of the analysis of monetary policy shocks is how to interpret the shocks themselves. In order to ease interpretation, we reformulate our baseline specification and estimate the effects of changes in interest rate (1 month OIS rate) instrumented with the monetary policy shocks from the baseline version. When doing this, we use annual interest rate shocks aggregated from high-frequency interest rate changes around monetary policy announcement similarly to the monetary policy shocks. As Figure G.1 shows, the results are very similar to the baseline.

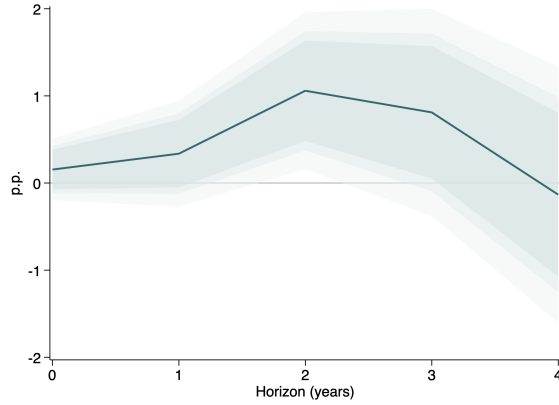
Figure G.1: The effects of interest rates on firm investment

The figure shows the dynamic effects of a decrease in the 1 month OIS by 1 SD (4.26bp) on firm investment (the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right, where changes in interest rates are instrumented with monetary policy shocks). The high-frequency changes in interest rates are aggregated to the annual frequency following the same weighting pattern as in the aggregation of monetary policy shocks, (1). The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

H. Quarterly panel

Figure H.1: The effects of monetary policy easing on average firm investment

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3)). The specification is identical to the one in Figure 3. The effects are estimated for a subsample of firms with available quarterly data. Monetary policy shocks are aggregated using a weighting scheme similar to (1) but at a quarterly frequency (Ottonello and Winberry, 2020).

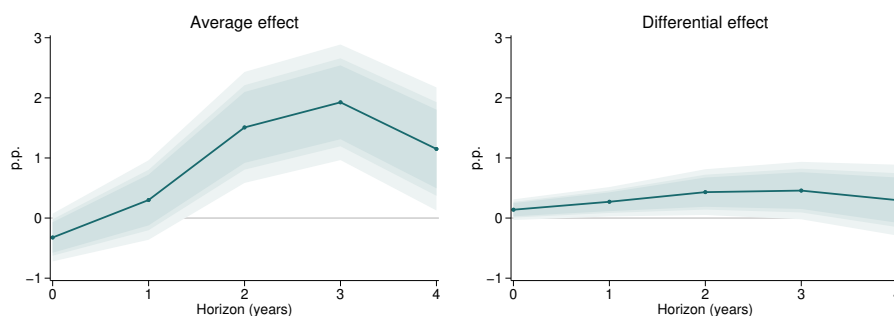
Figure H.2: The average effects of monetary policy easing on firm investment

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm investment (the estimated average effect β_1^h from the equation (3)). The specification is identical to the one in Figure 3. The effects are estimated for a subsample of firms with available quarterly data but using only end-of-year data. Monetary policy shocks are aggregated using the baseline weighting scheme described in (1).

I. Monetary policy, firm's net debt and MRPK

To test whether firms use internal cash buffers to finance their investment, we run equation (3) using the change in net debt as the dependent variable. That is, we use $\log(debt)_{i,t+h} - \log(debt)_{i,t-1} - (\log(cash)_{i,t+h} - \log(cash)_{i,t-1})$ as the dependent variable in the equation (3), where *debt* and *cash* are levels (stocks).

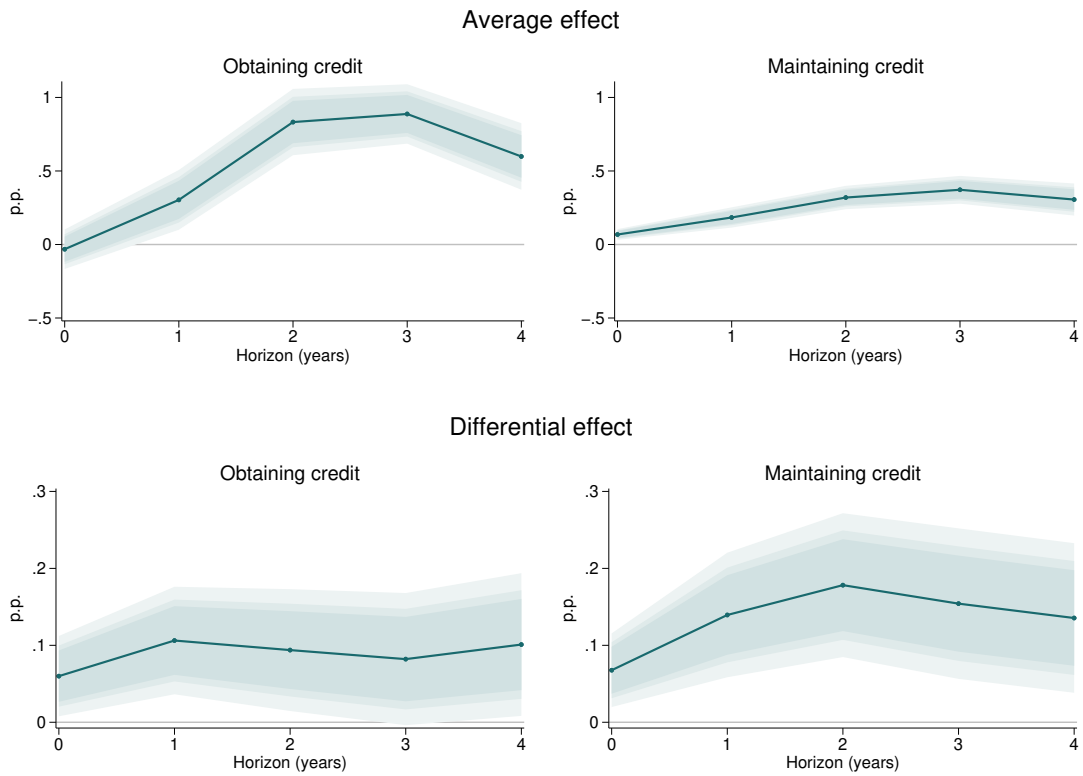
Results are shown on Figure I.1. We observe a pattern that is nearly identical to that debt (see Figure 4), which implies that cash holdings do not change significantly after an expansionary monetary policy shock, nor high-MRPK firms use cash relatively more to finance investment. These results reinforce the evidence pointing at the increase in debt being the main source of financing for the new investment of high-MRPK firms.

Figure I.1: The effect of monetary policy easing on net debt

The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm's net debt, defined as $\log(debt)_{i,t+h} - \log(debt)_{i,t-1} - (\log(cash)_{i,t+h} - \log(cash)_{i,t-1})$: the estimated average effect β_1^h from the equation (3) on the left, and the differential effect β_2^h on the right. The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year. The specification includes additional controls for interactions of monetary policy shocks with firm-level variables. Monetary policy shocks are aggregated using the baseline weighting scheme described in (1).

J. Monetary policy easing and firm's debt (extensive margin)

Figure J.1: The effects of monetary policy easing on obtaining and maintaining debt



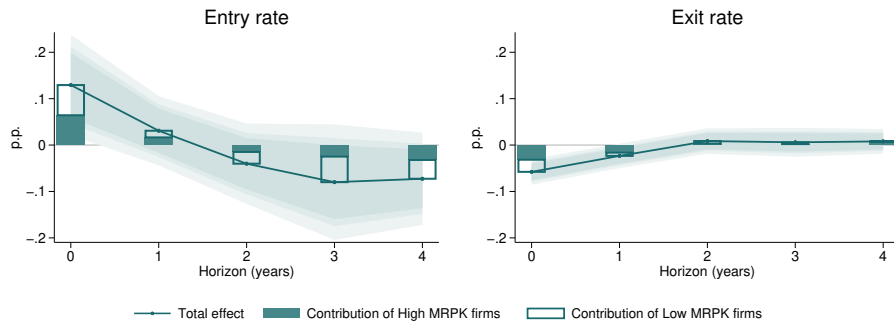
The figure shows the dynamic effects of monetary policy easing (one SD of high-frequency monetary policy shocks) on the probability of a firm having positive debt conditional on not having debt in the previous period, i.e., "obtaining credit" (the left column), or having debt in the previous period, i.e., "maintaining credit" (the right column). The estimated average effect β_1^h from the equation (3) is reported in the top panel, and the differential effect β_2^h is reported in the bottom panel. The specification controls for lagged firm characteristics (employment, leverage, age, liquidity), sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. Shaded areas represent 90%, 95%, and 99% confidence intervals calculated using two-way clustering by firm and industry-year.

K. Alternative imputation for missing observations

Since we source the year of entry and exit not only from CBI, but also from DIRCE, it can be the case that the firm balance sheet data used to calculate MRPK is missing for the years it enters or exits. In this case, we need to impute some value for firm's position in the MRPK distribution. In the main text, whenever the data for MRPK is missing, we impute the value of the high-MRPK indicator as the average value of this variable calculated using the periods for which the data is available. Consider a hypothetical example where we observe a firm for 10 years, including 8 years when it is classified as high-MRPK and 2 years as low-MRPK, and where we do not observe the firm in the exit year. In this example, we assign 0.8 to the high-MRPK category and 0.2 to the low-MRPK category for the exit year of this firm. This means that the sum of low- or high-MRPK firm indicators needs not to be an integer, but the sum of the two groups will always add up to the number of exiting firms. An advantage of this imputation scheme is that it allows to take into account all information about firm's MRPK status from the periods when it is observed.

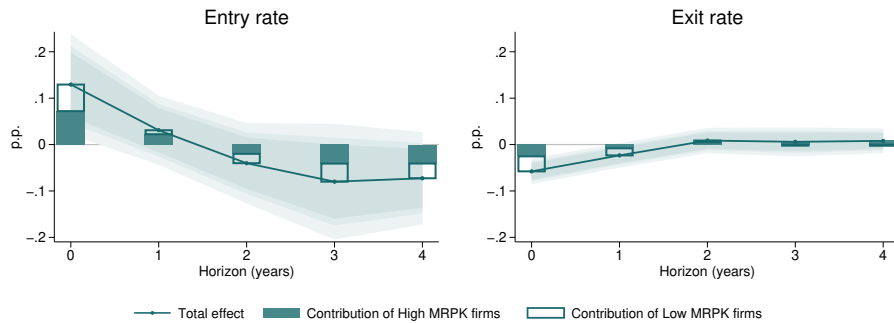
In these sub-sections, we assume different imputation schemes. First, we use the rounded value. That is, in the previous example, we would assign 1 to the high-MRPK group, and 0 to the low-MRPK group. Second, we set all missing observations equal to 0.5, so they contribute equally to high- and low-MRPK subgroups. As Figures [K.1](#) and [K.2](#) below show, using these alternative imputation schemes only has minor impact in the entry/exit composition effect of monetary policy easing.

Figure K.1: The effects of monetary policy easing on entry and exit rates, alternative imputation of MRPK status (rounded average)



The solid line in the figure shows the effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm entry rate (on the left) and on the exit rate (on the right), i.e., the estimated β_1^h from the equation (5). The stacked bars show the β_1^h from running the same specification, but having one of the two sub-group of firms entering (on the left) or exiting (on the right) over the total number firms as the dependent variable: the contribution of the low-MRPK firms to the total effect of monetary policy easing is plotted in light green bars, while the one of the high-MRPK firms is plotted in dark green bars—see equation (6). Shaded areas represent 90%, 95%, and 99% confidence intervals of the total effect calculated using robust standard errors. The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend. Missing high-MRPK values are imputed as the average of non-missing observations rounded to 0 or 1.

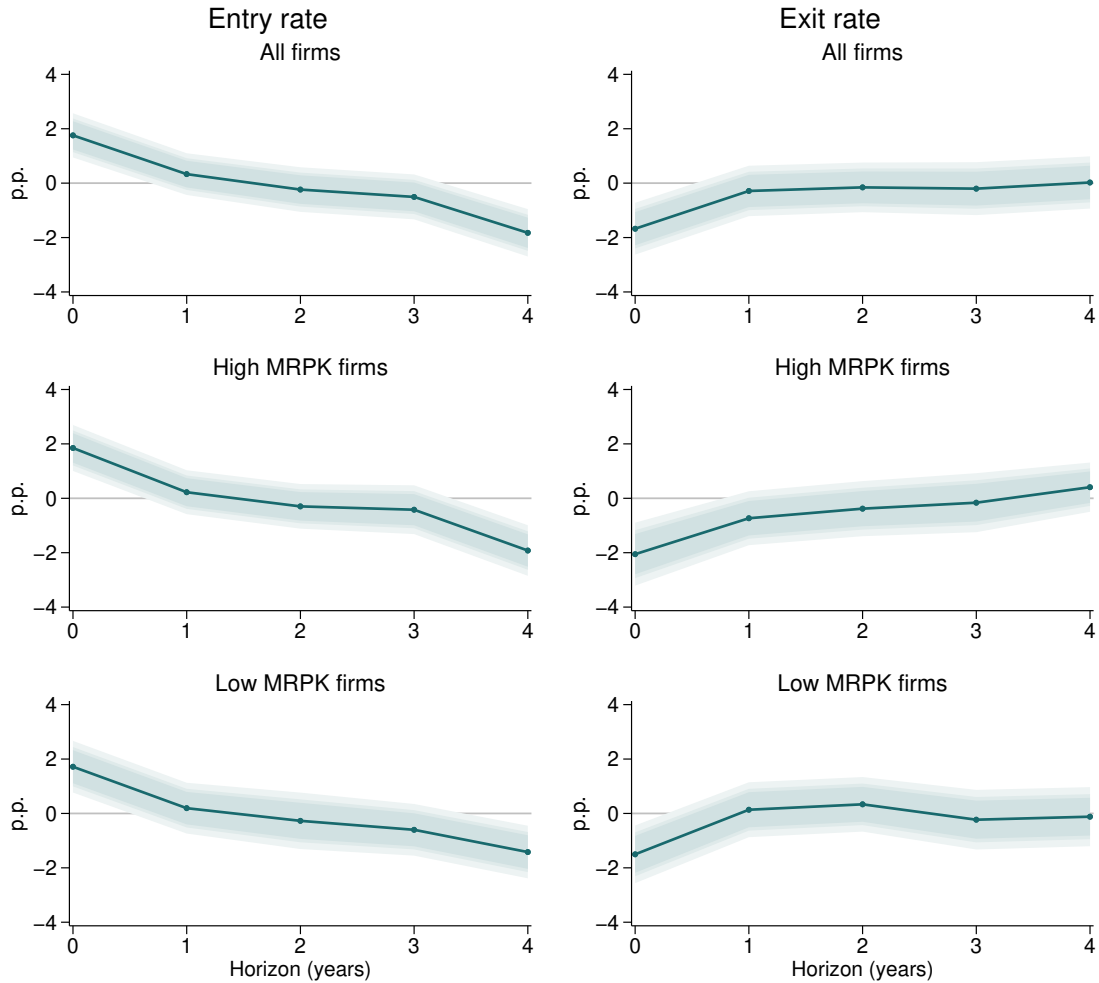
Figure K.2: The effects of monetary policy easing on entry and exit rates, alternative imputation of MRPK status (equal weights)



The solid line in the figure shows the effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm entry rate (on the left) and on the exit rate (on the right), i.e., the estimated β_1^h from the equation (5). The stacked bars show the β_1^h from running the same specification, but having one of the two sub-group of firms entering (on the left) or exiting (on the right) over the total number firms as the dependent variable: the contribution of the low-MRPK firms to the total effect of monetary policy easing is plotted in light green bars, while the one of the high-MRPK firms is plotted in dark green bars—see equation (6). Shaded areas represent 90%, 95%, and 99% confidence intervals of the total effect calculated using robust standard errors. The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend. Missing high-MRPK values are imputed as 0.5.

L. The effects of monetary policy easing on entry and exit rates

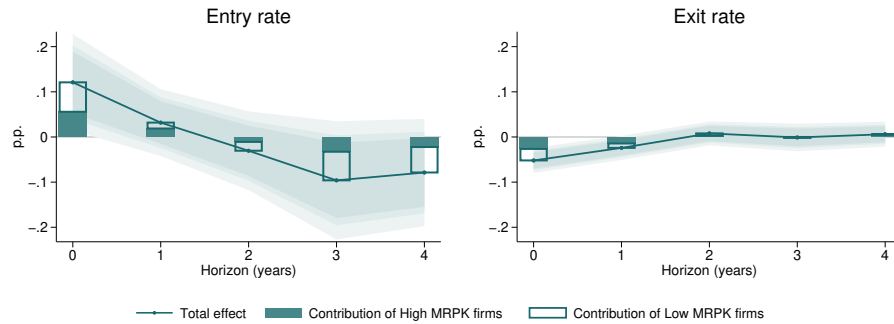
Figure L.1: The effects of monetary policy easing on log entry and exit rates



The solid line in the figure shows the effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm log entry rate (on the left) and on the log exit rate (on the right), i.e., the estimated β_1^E from the equation (5). The MRPK-specific entry (exit) rates are calculated as the number of entering (exiting) high- or low-MRPK firms over the lagged number of active high- or low-MRPK firms in the industry. Shaded areas represent 90%, 95%, and 99% confidence intervals of the total effect calculated using robust standard errors. The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. All regressions include time trend.

M. The effects of monetary policy easing on entry and exit rates, a shorter sample

Figure M.1: The effects of monetary policy easing on entry and exit rates, excluding years 2018-2019



The solid line in the figure shows the effect of monetary policy easing (one SD of high-frequency monetary policy shocks) on firm entry rate (on the left) and on the exit rate (on the right), i.e., the estimated β_1^h from the equation (5). The stacked bars show the β_1^h from running the same specification, but having one of the two sub-group of firms entering (on the left) or exiting (on the right) over the total number firms as the dependent variable: the contribution of the low-MRPK firms to the total effect of monetary policy easing is plotted in light green bars, while the one of the high-MRPK firms is plotted in dark green bars—see equation (6). Shaded areas represent 90%, 95%, and 99% confidence intervals of the total effect calculated using robust standard errors. The specification controls for sector-level sales growth, aggregate unemployment rate, inflation rate, and industry fixed effects. The sample covers years 2000-2016.



PUBLICATIONS

A Tale of Two Margins: Monetary Policy and Capital Misallocation
Working Paper No. WP/2024/121