Monetary policy, investment and firm heterogeneity

Elena Durante

European Central Bank & La Sapienza University of Rome

Annalisa Ferrando

European Central Bank

Philip Vermeulen*

Auckland University of Technology

*Corresponding author: philip.vermeulen@aut.ac.nz. School of Economics, WY Building(level 2), 120 Mayoral Drive, Auckland, New Zealand. Declarations of Interest: none.

Abstract

This paper provides new evidence on the channels of monetary policy transmission combining 9 million observations on firm level investment and high-frequency identified monetary policy shocks. We show that the reaction of firms' investment to a monetary policy shock is heterogeneous along dimensions that correspond to the two main channels of monetary policy transmission. First, we show that young firms are more sensitive to monetary policy shocks, supporting the existence of a credit channel of monetary policy. Second, we document large cross-sectional heterogeneity related to the industry the firm operates in. We find that firms producing durable goods react more than others, which is consistent with traditional interest rate channel effects of monetary policy. Third, we find that the effect of monetary policy shocks is longer lived for firms that are durable goods producers than for young firms indicating that demand effects last longer than credit effects.

Keywords: monetary policy transmission; monetary policy shocks; investment

JEL Classification: E22, E52

1 Introduction

There is widespread agreement that monetary policy affects the real economy through a number of different channels, of which the traditional interest rate channel and the credit channel (Bernanke and Gertler (1995)) are the most studied. Whereas the first affects output through the direct effect of changes in interest rates on interest-sensitive components of aggregate demand, the second operates through frictions in credit markets that amplify the effects of monetary policy on certain types of borrowers. The relative importance and strengths of these channels is however still uncertain. The aim of this paper is to provide evidence for both while also uncovering their relative strength and importance. We do this by documenting the heterogeneity of firms' investment reactions to monetary policy shocks. We focus on the effects of monetary policy shocks on investment since the traditional and the credit view of monetary policy imply the manifestation of different types of heterogeneity in the reaction of investment to shocks. Theory predicts that the strength of the traditional interest rate channel should depend on the interest-rate sensitivity of demand. Some components of spending, most prominently durable spending, are expected to be more interest-sensitive. Indeed, Ganley and Salmon (1996), Barth and Ramey (2002), Dedola and Lippi (2005) and Peersman and Smets (2005) provide empirical evidence that *output* of durable industries reacts much stronger to a monetary policy shock. As a corollary, the input demand of the durable industries should also be expected to react more. We expect that one implication of this is that the *investment* of durable industries should react stronger to monetary policy shocks. Hence, our test of the traditional interest rate channel consists in checking whether firms' investment in durable industries reacts more to monetary policy shocks.

The strength and importance of the credit channel depends on the sensitivity of external finance premia, which are unfortunately unobservable. The financial frictions literature stresses that some *observable* characteristics of firms are likely affecting external finance premia such as size, age, leverage and liquidity. These individual firm characteristics through credit frictions lead to heterogeneous reactions to shocks. Hence, our test of the credit channel consists in checking whether firms expected to be more financially constrained react more to monetary policy shocks.

Hence, whereas the traditional interest rate channel of monetary policy implies differences in the effect of shocks across industries (i.e. the type of output), the credit channel implies differences across firms' according to their characteristics (i.e. the type of firm). By uncovering the relative importance of these two types of heterogeneity, i.e. type of output versus type of firm, we provide evidence on the relative role of both channels.

To uncover the relative importance of these two channels we use micro firm level data from the four largest economies in the euro area (Germany, France, Italy and Spain). We use a large and rich dataset of more than 1 million firms which we observe over the period 2000-2016 providing us with roughly 9 million observations of firm level investment. We estimate the dynamic effect of monetary policy shocks on the investment of these firms. We use a monthly euro area monetary policy shock series from Jarociński and Karadi (2020). This series is constructed using high-frequency surprises in EONIA swaps. The exogeneity of these surprises allows us to identify the effect of monetary policy. We use these shocks in local projections as in Jordá (2005) following recent work by Cloyne et al. (2018), Jeenas (2019), Ottonello and Winberry (2020) and Crouzet and Mehrotra (2020). We estimate the reaction of investment for a period up to 4 years after a shock. We find that firms reduce investment in a period between one and two year after the shock, in line with the macro literature.

To identify the different channels through which monetary policy operates, we estimate the effect of monetary policy shocks for different groups of firms. Since our dataset is large we have enough statistical power to identify differences. As employed by the recent literature (Cloyne et al. (2018)) we use age to identify more financially constrained firms. Young firms have shorter credit histories and should therefore be more vulnerable to financial frictions than older firms. Young firms also tend to be smaller, higher leveraged and less liquid, all characteristics correlated with higher financial vulnerability. Age is arguably the only purely *exogeneous* characteristic of firms that is related to financial frictions. Variables such as liquidity and leverage (and even size) are all endogenous and therefore highly problematic when serving on their own as indicators of financing constraints. We indeed find that younger firms react more to monetary policy shocks. We further look for evidence on the traditional interest rate channel of monetary policy by disaggregating our sample into different sectors such as manufacturing, construction and services and, even narrower, into 31 industries. In particular, we test whether firms in durable goods industries react more to monetary policy. We provide strong evidence that firms in the durables industries react more. We further test whether differences in the average reaction to monetary policy shocks in the 31 different industries can be explained by the average characteristics of firms in those industries. We find that they cannot. The only industry characteristic that significantly determines differences in reaction to monetary policy shocks across industries is the durability of the output. This strengthens our interpretation that our finding is driven by traditional interest rate channel effects.

By crossing the two characteristics age and sector we are able to identify the relative strength of both channels. Our findings are that both age and durability of output matter. However the "age" effect seems a bit weaker than the "durability" effect and is also shorter lived. Age-related differences in investment reactions to monetary policy occur only one year after the shock. Two years after the shock, these age-related differences disappear. Age-related differences in investment reactions are also not equally important everywhere: they seem to matter more in the construction and services sector, less so within manufacturing. Durability of output however matters quite strongly. Also, its effect is found to be stronger than the age effect. It is also longer lived. Two years after the shock, durables producing firms still invest less. We conclude therefore that both the traditional interest rate channel and the credit channel are alive and well. Our results confirm the notion that the credit channel amplifies the traditional interest rate channel but does not replace it, in line with Bernanke and Gertler (1995). Finally, our findings should be helpful in constructing better models of monetary policy transmission which should incorporate the relative strengths of both channels.

Our paper contributes to the literature that studies how the effect of monetary policy varies across firms. Earlier studies have stressed findings that are consistent with the existence of financial frictions which create heterogeneity across firms in the reaction to monetary policy. In a seminal article, Gertler and Gilchrist (1994) show that small firms' sales and inventories drop more than those of large firms after monetary policy tightening. Using firm level data from the US and the UK, Cloyne et al. (2018) show that the investment of younger firms that pay no dividends reacts more strongly to monetary policy shocks. Jeenas (2019) finds that monetary policy shocks create larger reactions in fixed capital formation, inventories and sales growth for firms with high leverage and low liquid assets. Bahaj et al. (2019) find that younger and more leveraged firms show larger employment responses to monetary policy. In a recent paper Ottonello and Winberry (2020) show that firms with low default risk are more responsive to monetary policy. The findings in this literature are generally consistent with theories of financial frictions that predict stronger reactions of financially constrained firms to monetary policy (Bernanke and Gertler (1989), Bernanke et al. (1999)).

The main novel result we bring to this literature is the large cross-sectional heterogeneity in the reaction of investment to monetary policy related to the industry the firm operates in. Our large dataset allows us to provide disaggregated estimates for twenty-four manufacturing industries, six services industries and the construction sector. We find that firms producing durable goods have much stronger investment reactions than others. Thus far, the literature has emphasized balance sheet or other characteristics of firms related to financial frictions (such as size, age and leverage). We also find that young firms react stronger to monetary policy, similarly as in Cloyne et al. (2018). However, our new result emphasises the type of good the firm produces. We are finding that this relatively underinvestigated feature of firm heterogeneity has substantial real effects. Our paper therefore complements the earlier findings related to financial frictions but does not contradict them. In addition, to the best of our knowledge, we believe our paper to be the first to investigate the heterogeneous firm investment reactions to monetary policy in the euro area.

The rest of the paper is structured as follows. Section 2 describes the firm level dataset and the monetary policy shocks. Section 3 shows the impact of monetary policy on aggregate investment. Section 4 describes the baseline econometric framework. Section 5 shows the heterogeneous effects of the monetary policy. Section 6 concludes.

2 Monetary Policy Shock and Firm Level Dataset

In this section we present our two main data sources: the firm level dataset and the monetary policy shock series. We also report summary statistics for the main variables of interest and we carefully explain the matching procedure we use to obtain the final dataset for the empirical analysis.

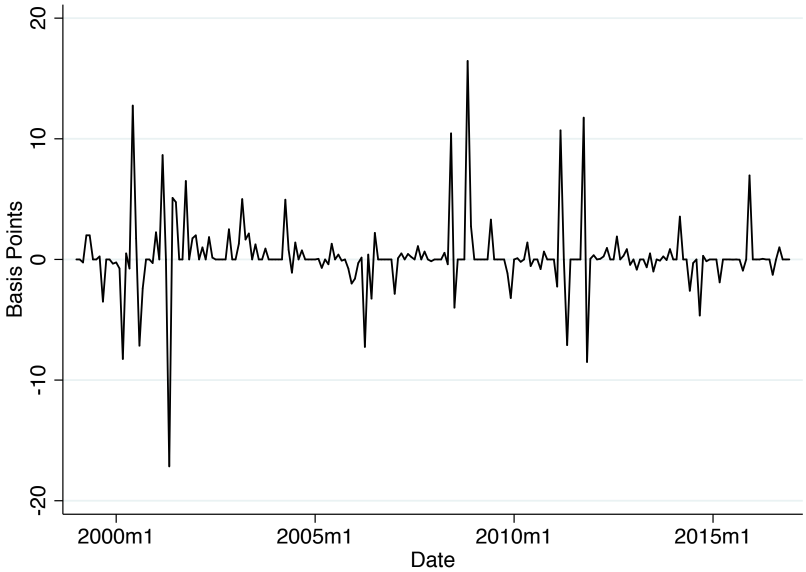
2.1 Monetary policy shock

Exogenous movements in the euro area policy rate are proxied by the high-frequency monetary policy shock series from Jarociński and Karadi (2020). The series is monthly and available from 1999 to 2016. The authors make use of a high-frequency identification strategy. In more detail, the series is constructed by measuring the reaction in the 3-month EONIA swaps[1] in a

[1]The EONIA is the average rate at which banks lend unsecured money to each other with a maturity of 1 day. The 3-month EONIA swap rate is the fixed rate at which a bank can swap the daily rate over a 3-month

30-minute window around press statements and a 90-minute window around press conferences[2]. More specifically, we use what Jarociński and Karadi (2020) call the poor man's sign restrictions series. The latter, takes the value of the changes in the 3-month EONIA swaps if the stock price surprises had the opposite sign to the high-frequency EONIA swaps changes, and zero otherwise. Figure 1 depicts the monetary policy shock series as originally created by Jarociński and Karadi (2020) from January 1999 to December 2016. The series reaches a maximum of 16.4 basis points in November 2008 and a minimum of -17.1 basis points in May 2001. A more detailed discussion of these shocks can be found in Jarociński and Karadi (2020).

Figure 1: Monetary Policy Shock series from Jarociński and Karadi (2020)



Since the frequency of the monetary policy shocks is monthly, whereas our firm level data is annual, we need to match frequencies. In this perspective, we take advantage of the information available in our firm level dataset on the month in which a certain firm is filing its account (the "closing month" variable). Then, we match the firm level data with a 12 month moving sum of the monthly monetary shocks series using the "closing month" variable. We choose a 12 month moving sum because the annual value of investment of a certain firm is unlikely to be affected just by the monetary policy shock in the month when the account is reported.

We explain in more detail the merging procedure between the 12 month moving sum with the

period. As the EONIA almost reacts one to one with movements in the ECB interest rate on the main refinancing operations (i.e. the policy rate) movements in the 3-month EONIA swap rates represent the markets' expectation of movements in the central bank policy rate in the next three months.

[2] Whenever there is a press conference after a press statements the surprise is the sum of the response in the two windows (Jarociński and Karadi (2020)).

firm level dataset in the following section. Figure 10 in the annex shows the 12 month moving sum series of the monetary policy shock.

2.2 Firm level dataset

Since our goal is to document the heterogeneous effect of monetary policy, we use micro data. We obtain granular firm level annual information on companies' financial accounts for the big four euro area countries (Germany, France, Italy and Spain) for the period 2000-2016 from Orbis database provided by Bureau van Dijk (BvD). The database contains detailed information on all balance sheet and income statement components of each individual firm. Moreover, the database includes all industries (both services and manufacturing) and covers much of the corporate universe of the countries considered. One of the major advantages of such a rich database is the presence of both stock market listed and unlisted companies (including very small firms) implying a dataset (after cleaning) of more than 1 million firms. This allows us to have enough statistical power to identify differences across different groups of firms in various dimensions (such as e.g. size, age, industry).

Our focus is on nonfinancial corporations which excludes banks and other firms in the financial sector. We drop a few sectors with atypical behaviour such as agriculture and mining and sectors with high government ownership, such as administration. We keep the following sectors: Manufacturing (NACE Rev. 2 Section C), Construction (F), Wholesale and retail trade (G), Transportation and storage (H), Accommodation and food activities (I), information, communication and R&D (J and M) and other business activities (M and N).

We follow carefully the procedures in Kalemli-Ozcan et al. (2015) to obtain a nationally representative firm level dataset. We first drop firms when they report negative total assets, negative employment, misreported employment (greater than 2 million employees), negative sales or negative tangible fixed assets. Moreover, we drop firm-year observations when: total assets takes the value zero; age (measured as years since incorporation) is negative; fixed assets is missing, negative or zero; tangible fixed assets is missing or negative; or, intangible fixed asset is negative.[3] Thereafter, we eliminate firm-years that show clear mistakes in the balance sheet identities.[4] Finally, as we are interested in the dynamic effect of monetary policy shocks and

[3] In addition, we also eliminate firm-year observations when firms report negative values of non current liabilities, long term debt, current liabilities, loans, capital, creditors, debtors, other current liabilities, current assets, other fixed assets, stock and other current liabilities.

[4] See Kalemli-Ozcan et al. (2015) and Orbis userguide for more info about accounting identities.

use lags in our regressions we keep only firms with at least 5 years of observations. Our final sample contains 1,364,339 firms. Overall, we have more than 9 million observations.

Table 1: Descriptive statistics of the micro firm level dataset

	Germany	France	Italy	Spain	Pooled
		Tangible net investment (percent)			
mean	8.50	11.21	8.54	7.61	9.31
sd	46.35	76.45	63.28	54.23	66.21
min	-54.58	-59.92	-53.89	-47.62	-59.92
max	285.88	307.65	285.87	224.95	307.65
		Total assets (log euro)			
mean	16.34	13.09	14.07	13.51	13.54
sd	2.01	1.52	1.55	1.53	1.62
min	7.64	4.51	6.06	4.62	4.51
max	24.64	26.22	25.31	24.41	26.22
		Age (years)			
mean	33	19	17	20	19
sd	32	12	9	13	12
min	4	4	4	4	4
max	733	219	145	1005	1005
Obs	114,604	2,912,334	3,719,179	2,645,813	9,391,930
N. firms	23,313	402,639	533,439	404,948	1,364,339

Source: own calculations. Orbis database.

Our benchmark measure of firm level investment is the tangible net investment rate,[5] $\frac{I_{i,t}}{K_{i,t-1}}$, which is the net investment in tangible assets of firm i at year t, I_{it}, divided by the net capital stock, $K_{i,t-1}$, at end of year t-1.[6] To reduce the impact of outliers, we winsorize all the ratios calculated from balance sheet variables. We follow the literature and winsorize each variable by country, year and industry at the percentage level needed so that the distribution of the variable has a kurtosis below 10. This is the same procedure as followed by Kalemli-Ozcan et al. (2018).

Table 1 reports basic summary statistics for our main variables of interest. The average net investment rate is 9.31 percent with a standard deviation of 66.21 percent. The average firm is 19 years old (with a standard deviation of 12). Note that the minimum age of the firm is 4 years old. This is simply due to the fact that we use lags in our regressions, i.e. observations of these firms when they are below 4 years of age are still used to construct the lags.[7] As is

[5] We use this measure to construct our dependent variable in the empirical analysis.

[6] Note that by year t we mean here the accounting year that corresponds to the closing date of the accounts of the firm. E.g., consider a firm which closes its accounts on 31st of May of year t. I_{it} for that firm is the tangible net investment over the period 1st of June of year t-1 until 31st of May of year t. Firms report the net book value of tangible assets at closing date of the accounts at year t, NTA_t. We define the tangible net investment rate at year t as $[NTA_t - NTA_{(t-1)}]/NTA_{(t-1)}$.

[7] To construct an investment rate we need two years of balance sheets. Since we control for lagged investment in our regressions we cannot simply say anything meaningful on the investment dynamics of firms that are age 3

common with firm level data, there is a wide variation reflecting a heterogeneous firm landscape. Average statistics on investment, size and age are relatively similar across countries with the sole exception of Germany where firms tend to be larger. It is quite well known that very small German firms in the Orbis database are somewhat under-represented. Notwithstanding this small caveat, our sample is very large and contains practically the entire firms landscape, which is rather exceptional compared to what is usual in the firm micro literature where mostly only large listed firms are in the sample (such as in Compustat). Given that one of the goals of our paper is to understand the role of the credit channel in the monetary transmission, having a broad coverage of small and medium-sized enterprises (SMEs) is certainly important and advantageous.

A key feature of the dataset is that firms close their accounts at different months during the year. Hence, two firms that close their accounts in the same year but in different months will have experienced a different sequence of past shocks.[8] As stated in section 2.1 we construct a 12 month moving sum of the monthly series obtained from Jarociński and Karadi (2020). We match the 12 month moving sum of the monetary policy shock with the variable "closing date" of each individual firm in each country dataset in order to capture as much time variation as possible. More precisely, let $m_{i,t}$ be the month of closing of the accounts of firm i in year t. Then the 12 month moving sum of the monetary policy shock for firm i at year t is defined as $\epsilon_{i,t} = \sum_{k=0}^{11} \epsilon_{m_{i,t}-k}$. A similar procedure is used in Cloyne et al. (2018).

Table 2: Descriptive statistics of 12 month moving sum of the monetary policy shock matched with the firm level dataset (basis points)

	Germany	France	Italy	Spain	Pooled
Mean	2.52	3.44	2.91	3.33	3.14
Std	8.69	8.49	8.05	8.17	8.33

As the distribution of closing dates differs across countries this implies also that average statistics of the 12 month moving sum differs across countries. Table 2 shows descriptive statistics of our monetary policy shock (i.e. the 12 month moving sum) when matched with our firm level data. In the dataset obtained by pooling together all the countries, the mean value of the shock is 3.14 basis points and the standard deviation is 8.33.

or below.

[8] Most firms close their accounts at the 31st of December each year. The time variation is not very large for Italy, Spain and Germany while for France is more pronounced. However, the big volumes of our data reassure us to have enough time variation in our dataset.

3 Aggregate Investment Response to Monetary Policy

Before discussing our econometric specification, we study how our monetary policy shock series affect aggregate investment using time series data. Aggregate investment of country j in quarter q, $GFCF_{jq}$, is available from the national accounts.[9] Note that we use subscript q to denote time in quarters.

To match frequencies, we first sum the monthly shock series over each quarter q and merge it with the aggregate investment series. Then, we estimate the impulse response of aggregate investment in reaction to the monetary policy shock using local projections following Jordá (2005). We use the following specification:

$$log(GFCF)_{j,q+h} - log(GFCF)_{j,q-1} = \alpha_j^h + \beta^h * \epsilon_q + u_{j,q+h} \tag{1}$$

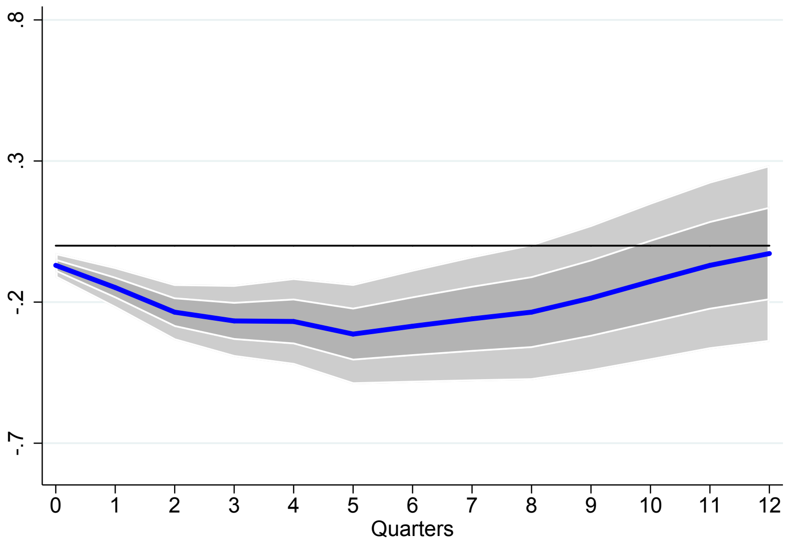
where j denotes the country and h the horizon. The coefficient β^h measures the effect of a 1 basis point change in the 3 month EONIA swaps on aggregate investment at horizon h.

$u_{j,q+h}$ is a mean zero error term capturing other shocks and α_j^h is a country fixed effect. Note that the quarterly monetary policy shock ϵ_q does not have the j subscript as it is identical across countries.

We estimate regression (1) for each horizon $h \in (0,1...,12)$. The impulse response function is then given by the sequence of estimates $\hat{\beta}^0, \hat{\beta}^1, \hat{\beta}^2, ..., \hat{\beta}^{12}$. Figure 2 reports the aggregate investment response pooling all the four countries together. We can clearly observe that an upward surprise leads to a decrease in aggregate investment. In particular, a 1 basis point change in the 3 month EONIA swaps (i.e in the surprise) leads to a 0.31 percentage point (pp) drop in aggregate investment after 5 quarters. The effect remains large 2 years after the shock, i.e. in quarters 6, 7 and 8. At the end of the third year the effect disappears. These findings are consistent with the VAR evidence for the US provided by Bernanke and Gertler (1995) where the bulk of the response of business fixed investment after a monetary policy shock occurs between 6 and 24 months.

[9] Unfortunately, an aggregate investment series restricted to non-financial firms does not exist for euro area countries. We use the available national accounts series for total investment which includes government investment, and in national accounts terminology is called Gross Fixed Capital Formation, chain linked volume.

Figure 2: Aggregate investment response to monetary policy shock



Note: shaded areas represent 90 and 95 percent confidence bands.

Figure 11 in the annex depicts the impulse response functions for Germany, France, Italy and Spain. For each country individually we find a similarly shaped impulse response function as the one shown above. The peak effects are again around quarter 5. The effect is also estimated to be of roughly equal magnitude for all the countries. We can conclude that a contractionary monetary policy shock leads to a decrease in aggregate investment in all the four economies considered.

These results are reassuring us that the proxy we use for the monetary policy affects as expected aggregate investment in all countries. It provides us with a good benchmark for our micro analysis.

4 Empirical Framework

4.1 Baseline specification: panel OLS local projections

To estimate the dynamic reaction of firm investment to monetary policy shocks, we use the panel local projection approach (OLS-LP) proposed by Jordá (2005). We define our dependent variable $\Delta^*_h I_{i,t-1}$ as the h-year forward difference in the investment rate, i.e. $\Delta^*_h I_{i,t-1} = I_{i,t+h} - I_{i,t-1}$. We are interested in the effect of a monetary policy shock in year t (i.e. $\epsilon_{i,t}$) on our dependent variable at horizons $h \in (0,1...4)$. Note that at time t, $I_{i,t-1}$ is pre-determined so that we can interpret the effect as the response of the future investment rate (i.e. the dynamic causal effect of the monetary policy shock on investment). To test whether the investment rate of different groups of firms react less or more to the shock we define the dummy variable $Dg_{i,t-1}$ which selects the firms' group of interest. In particular, it takes value 1 if at time $t-1$ the firm i belongs to the group g and 0 otherwise. We interact these dummy variables with our monetary policy shock $\epsilon_{i,t}$. Our baseline empirical specification follows Cloyne et al. (2018):

$$\Delta_h^* I_{i,t-1} = \alpha_i^h + \sum_{g=1}^{G} \beta_g^h * D_{i,t-1}^g * \epsilon_{i,t} + \sum_{g=1}^{G} \gamma_g^h * D_{i,t-1}^g + \Gamma^h \Delta X_{i,t-1} + u_{i,t+h} \tag{2}$$

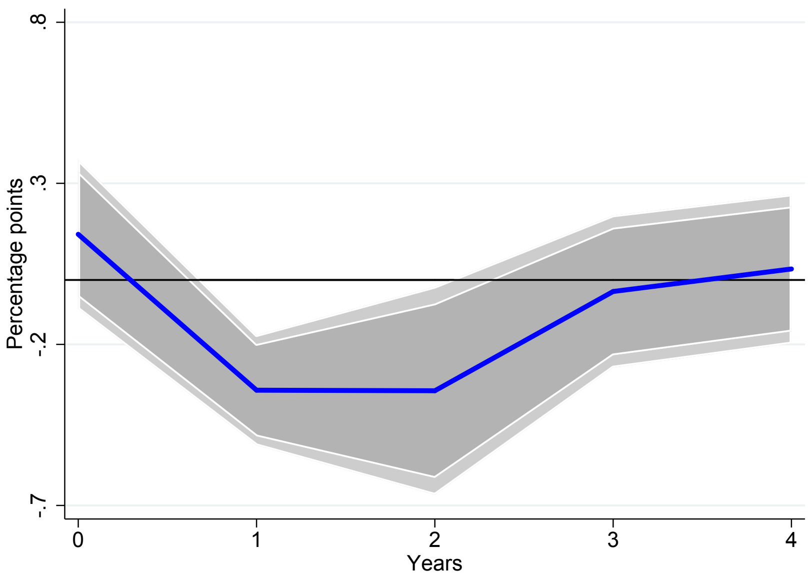
with the firm fixed effect α_i^h, which controls for heterogeneity in the investment rate across firms for each horizon h and $\Delta X_{i,t-1}$ a vector of additional control variables. This flexible specification ensures us to capture the heterogeneous effects of monetary policy across different groups. In particular, we are interested in the values of β_g^h which give us the impulse response for group g at the forecast horizon $h \in$ (0,1...4). The coefficients γ_g^h control for different level effects of group membership (but note that when group membership doesn't change over time, these drop out of the regression as we include firm fixed effects in all regressions). The control vector $\Delta X_{i,t-1}$ contains past shocks $(\epsilon_{i,t-1}, \epsilon_{i,t-2})$ and firm specific controls: lagged investment differences $(\Delta I_{it-1}, \Delta I_{it-2})$, lagged sales growth differences$(\Delta SG_{i-1}, \Delta SG_{it-2})$, lagged cash flow differences $(\Delta CF_{it-1}, \Delta CF_{it-2})$. Note that in principle the monetary policy shocks are exogenous and so control variables are only needed to improve efficiency of the estimates. We expect sales growth to positively affect investment as it captures demand factors and growth opportunities and similarly cash flow which represents internal sources of funding should have a positive effect. Note that in the regressions we measure shocks in basis points while our investment series are measured in percentages. The coefficients β_g^h we report in the regression tables therefore are estimates of percentage points reactions of investment to a 1 basis point shock. Finally, we cluster standard errors at firm and time (month where the firm file its account) level.

4.2 The average effect

We first report the estimated average effect of the monetary policy shock in our full sample. This will be our benchmark. To estimate the average effect, we drop the group dummy $Dg_{i,t}$ from equation (2) and replace the group specific coefficient β_g^h with a single parameter β^h at horizon h. The average impulse response function is then given by the sequence of estimates $\hat{\beta}^0, \hat{\beta}^1, ..., \hat{\beta}^4$. Table 3 shows the estimation results of the five regressions (h=0,...4). In line with our expectations sales growth and cash flow are generally estimated to positively affect investment. Lags of investment differences have a negative effect on the h-year investment differences. This is likely due to the lumpy nature of investment where investment bursts are followed with lower investment.

Figure 3 shows the average impulse response function for the full sample i.e. it shows at each horizon h (X-axis) the estimated effect in percentage points (Y-axis) on the net investment rate at the firm level of a 1 basis point upward surprise.

Figure 3: Average firm level investment response to monetary policy shock



Note: Shown is the effect of a 1 basis point upward surprise on the net investment rate. Shaded areas represent 90 and 95 percent confidence bands.

In the same year as the shock, i.e. at horizon $h = 0$, there is no statistically significant effect. This is expected since investment is generally planned in advance so that an instantaneous reaction is unlikely a priori. The shock has an economically and statistically significant negative effect in the first (at the 1 percent significance level) and second year (at the five percent significance level) after the shock. The point estimates imply that an upward surprise corresponding to a 1 basis point change in the 3 month EONIA swaps in year t, is followed by a drop in the investment rate in year t+1 and t+2 (relative to year t-1) of 0.34 pp. Importantly in year t+2, although the point estimate is identical as in year t+1 the precision of the estimate halves (i.e the standard error of the estimate at 0.16 almost doubles compared to year t+1, i.e. 0.09).

One possible interpretation of the higher standard error in year t+2 is that effects of monetary shocks dissipate faster for some firms than for others. Even with the large dataset we used here we can be much more confident about the effect of the shock after one year than after two year. This is important, as we will see, inference on differences of monetary policy effects across different groups after one year will be easier than inference on differences of the effect after two years. In the third and fourth year after the shock, instead, there are no longer any significant effects. This u-shaped pattern with a peak in year one and two after the shock, is consistent with our aggregate quarterly analysis. Therefore, using aggregate time series and firm level micro data give us the same message: the negative effect on investment of a contractionary shock happens in year one and two after the shock and the rebound happens three years after. The consistency between firm level micro response and the aggregate data gives us a meaningful benchmark to study the heterogeneous effect across firms belonging to different groups.

Before testing heterogeneous effects across groups, we first test whether pooling all countries in our full sample might obscure country differences in the strength of reaction to monetary policy shocks. We interact the monetary policy shock $\epsilon_{i,t}$ with country dummies and re-estimate regression 2. Table 10 in the annex reports the estimation results while Figure 12 reports the impulse response functions for each country. The pattern of the responses follows the u-shaped pattern for each of the countries. In all the four countries considered, the effect of an upward monetary policy surprise is largest in either year one or two. The point estimates for Spain and Italy are somewhat larger in absolute value, however are less precisely estimated. At the horizon of one and two year, F-tests at the 1 percent significance level for equality of the coefficients fail to reject equality. Only at a horizon of two years at the 5 percent level we can reject equality of the coefficient of Germany (-0.18) and Spain (-0.56) ($F_{1,155} = 5.49, p < .05$) and France (-0.11) and Spain (-0.56) ($F_{1,155} = 5.14, p < .05$). So Spanish firms seem to react stronger with some evidence of this in the effect two years after the shock. All in all, the evidence is not strongly in favour of notable country differences across countries. Dedola and Lippi (2005) also find that for output reactions to unanticipated monetary policy cross-industry differences are highly important but cross-country differences are not, so in the following we examine heterogeneity along different dimensions using the pooled full sample.

Table 3: Average effect of monetary policy shock on investment

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
ϵ_{it}	0.14	-0.34***	-0.34**	-0.04	0.03
	(0.12)	(0.09)	(0.16)	(0.12)	(0.12)
ϵ_{it-1}	-0.33***	-0.37***	-0.13	-0.04	-0.07
	(0.08)	(0.10)	(0.18)	(0.16)	(0.15)
ϵ_{it-2}	-0.17**	-0.13	-0.08	0.02	0.01
	(0.07)	(0.11)	(0.16)	(0.17)	(0.10)
ΔI_{it-1}	-0.66***	-0.67***	-0.67***	-0.67***	-0.67***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ΔI_{it-2}	-0.33***	-0.33***	-0.34***	-0.33***	-0.32***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ΔCF_{it-1}	0.30***	0.13***	0.07***	0.05***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
ΔCF_{it-2}	0.20***	0.08***	0.05***	0.03**	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ΔSG_{it-1}	0.04***	0.03***	0.03***	0.03***	0.03***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
ΔSG_{it-2}	0.03***	0.03***	0.02***	0.03***	0.02**
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Observations	9391930	7795739	6435191	5376790	4501547

standard errors clustered at firm and time level in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Heterogeneous Investment Response to Monetary Policy

5.1 Age as a good proxy for financial constraints

Financial frictions are an important potential source of heterogeneity in the transmission of monetary policy. They are a key determinant in the existence of the credit channel (Bernanke and Gertler (1995)). A large literature argues that financially constrained firms should have larger reactions to monetary policy shocks.[10] However, theories do not give any clear guidance on the exact identification of financial frictions.

Since financial frictions are not directly measurable, the literature has resorted to proxies or indicators. Various measures of information asymmetries (as these represent the main source of financial market imperfections) have been used as proxies for financial frictions. For instance, Gertler and Gilchrist (1994) use the firms' size postulating that "*the information frictions that add to the cost of finance apply mainly to younger firms, firms with a high degree of idiosyncratic risk, and firms that are not well collateralized. These are, on average, smaller firms.*"

Also other variables has been used to capture ways to cope with imperfect information, which hinders access to capital markets such as dividend policy, membership in a group or conglomerate, existence of bond rating, and concentration of ownership (see for instance Devereux and Schiantarelli (1990), Schiantarelli (1995) and Farre-Mensa and Ljungqvist (2016) for a more recent critical review of the most commonly used indicators of financing constraints).

For the purpose of this paper, the disadvantage of using the above mentioned variables (such as size, leverage and liquidity) is that they endogenously respond to shocks or vary over the cycle. Accordingly, it is hard to interpret any ex-post heterogeneity as being driven exclusively by ex-ante differences in these specific firm characteristics.

In order to overcome this issue, we select firms' age as an exogenous proxy for financial frictions. Gertler (1988) was one of the first to argue that firms' age is an important determinant of how much firms are financially constrained and that it is exogenous to any business cycle fluctuations or monetary policy shocks. Hadlock and Pierce (2010) reinforced the idea that age, together with size, is an important factor to determine whether firms are financially constrained. Moreover they found that below certain cut-off points there exists a quadratic relation between

[10] The mechanism goes as follows: capital market imperfections, such as e.g. imperfect information causes the access to finance (or terms of credit) of certain types of borrowers to be a function of their balance sheet. Say those borrowers have to pledge collateral. Monetary policy shocks move the value of that collateral and therefore the terms of credit.

size and constraints, while the relation is linear between age and constraints. More recently, age has been used by others as a proxy for the presence of financial frictions also in empirical work studying the monetary policy effect on various firms' outcomes (Cloyne et al. (2018) and Bahaj et al. (2019)).

According to Ferrando and Mulier (2015) firms that are more likely to be financially constrained are also less liquid, more leveraged (expressed in terms of total debt to asset ratio), less profitable and smaller. Less liquid firms are more exposed to liquidity shocks which increases the probability that banks will be unwilling to supply external finance. The expected relation between leverage and financing constraints is twofold. On the one hand, a high leveraged firm might feel unconstrained as it holds a lot of debt on its balance sheet, but on the other hand, this might make it difficult or costly for the firm to find new debt. Finally, more profitable firms should have easier access to external finance as they generate more cash flow which increases the likelihood that they will be able to repay their loans.

We test the quality of firms' age as a proxy for financial constraints studying how it correlates with size and other balance sheet characteristics identified in Ferrando and Mulier (2015). Figure 4 shows that in our dataset younger firms are on average smaller, more leveraged, less liquid and less profitable (lower EBITA).[11]

5.2 Results based on age

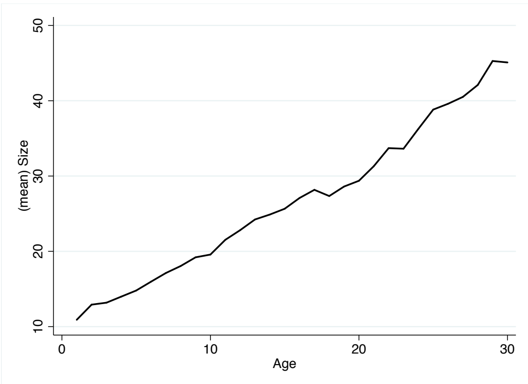
In order to study the heterogeneous response to monetary policy across firms with different age, we define three sub-groups: young, mature and old. We first define age as years since incorporation[12]: a firm is young when it is between 1 and 10 years old, mature from 11 up to 20 years and old from 21 onwards. In practice this implies that each group represents roughly one third of observations. Using those three age groups, we estimate equation (2) for each horizon $h \in (0,1...4)$. The group dummy variables D^g_{it} are D^y_{it}, D^m_{it} and D^o_{it} for respectively the young, mature and old firms. Note that we do not keep age fixed to define which sub-group a firm belongs to (e.g. when a firm turns 11 it switches from young to mature and similarly at age 21 from mature to old).

Since age is exogenous we multiply the shock at year t with the age dummy of year t (and

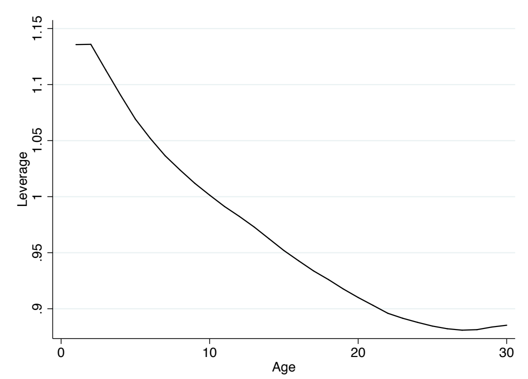
[11]Size is measured as the number of employees, leverage as total liabilities scaled by total asset, and liquidity as current assets minus stocks scaled by current liabilities. To obtain the summary statistics in Figure 4 we collapse our dataset in order to obtain the mean value of each firm characteristic by age.

[12]The variable name in the ORBIS database is 'years since incorporation'.

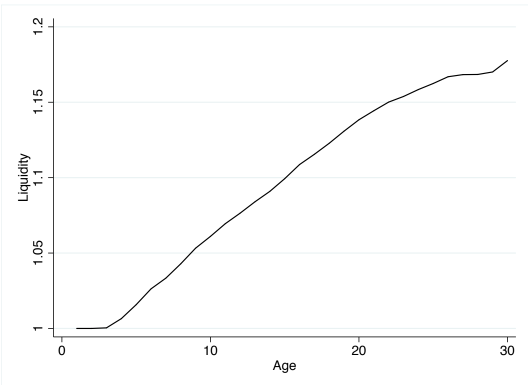
Figure 4: Correlation between age and firms' characteristics



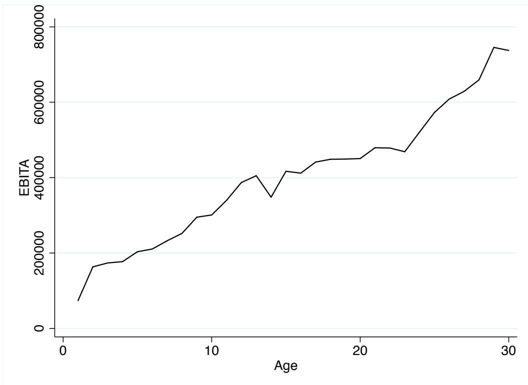
(a) Age vs Size



(b) Age vs Leverage

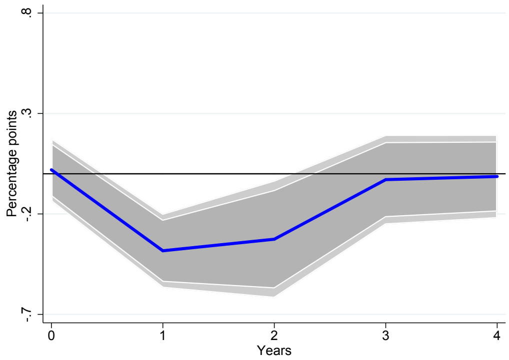


(c) Age vs Liquidity

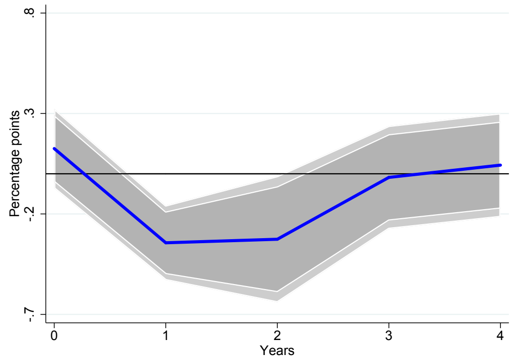


(d) Age vs EBITA

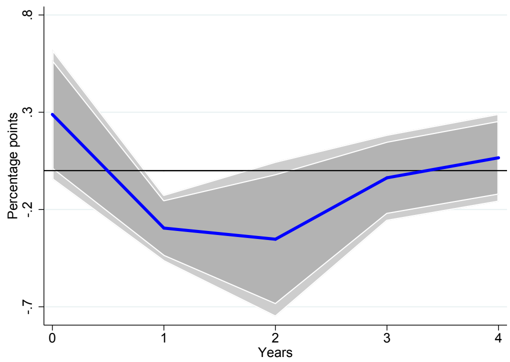
Figure 5: Firm level investment response to monetary policy shock by age



(a) Young



(b) Mature



(c) Old

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

not age dummy of year t-1). Table 4 shows the estimates of these regressions[13], while Figure 5 reports the impulse response functions for the groups of young, mature and old firms. Our first observation is that none of the groups has a significant contemporaneous reaction of investment, in line with our earlier results. At the horizon of one year, young firms react strongest with a point estimate of -0.38, compared to a point estimate of -0.34 for mature and -0.30 for old firms. Hence compared to an average firm, young firms have approximately a 10 percent stronger reaction whereas old firms have around 10 percent smaller reaction. The difference between young and old firms is significant at the 5 percent level ($F_{1,167} = 6.33, p < .05$). At the horizon of two years the reaction of young firms is essentially the same as the mature and the old firms. As before, three years after the shock the effect has vanished for all firms. In a robustness check

[13]Compared to Table 3 the coefficients of the control variables barely move, to save space we don't report them. We similarly don't report them in the tables that follow. They are available upon request.

Table 4: Effect of monetary policy shock on investment according to age

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^y_{it}$	0.02	-0.38***	-0.33**	-0.03	-0.01
	(0.08)	(0.09)	(0.15)	(0.11)	(0.11)
$\epsilon_{it} D^m_{it}$	0.13	-0.34***	-0.33**	-0.02	0.04
	(0.10)	(0.09)	(0.16)	(0.13)	(0.13)
$\epsilon_{it} D^o_{it}$	0.29*	-0.30***	-0.35*	-0.04	0.07
	(0.17)	(0.09)	(0.20)	(0.11)	(0.12)
D^y_{it}	-2.35	-1.32	-2.82	-4.60	-3.02
	(1.75)	(2.48)	(3.54)	(4.50)	(4.84)
D^m_{it}	0.04	0.80	0.05	-0.80	0.14
	(0.90)	(1.23)	(1.88)	(2.34)	(2.57)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

we lower the threshold for the young firms to 9, 8 or 7 year respectively, the regression results (shown in the Appendix) are very similar.

These findings support the existence of a credit channel that predicts an amplification effect of monetary policy, i.e. a stronger reaction of financially constrained firms. We can conclude that the financial frictions contribute to the heterogeneity of firms' investment responses to monetary policy. However the effect is not that strong. It is only present in the first year after the shock. Nevertheless it is likely that what we have estimated represents a lower bound on credit channel effects. Using observable characteristics it is clearly impossible to have a perfect separation of financially constrained versus unconstrained firms. Not all young firms will be financially constrained, and there are certainly firms that are mature or old that are financially constrained. Therefore the difference in the reaction of both groups is expected to be a lower bound of the credit channel effect.

We also report estimation results by grouping the sample of firms according to several (endogenous) balance sheet characteristics often used in the literature to characterize financial frictions, such as size (Figure 13), leverage (Figure 14) and liquidity (Figure 15)[14]. As these variables are endogenous we are careful in the interpretation of the results. The annex reports impulse response functions and estimation tables.

We find that size of the firm is not very informative to predict the reaction to monetary policy. At the horizon of 1 year large firms react the strongest with a point estimate of -0.39, the small firms react the weakest with -0.26, however the difference is not statistically significant. Similarly, at the horizon of 2 year large firms react the strongest with a point estimate of -0.44, the small firms react the weakest with a point estimate of -0.19, however the difference is only significant at the 10 percent level. The results for size are consistent with the findings of Crouzet and Mehrotra (2020) who similarly find no differences in reaction to monetary policy shocks for firms with different sizes. For leverage we find results in line with Bahaj et al. (2019) and Jeenas (2019) that higher leveraged firms react stronger. This is most visible at the horizon of two year, where the highest leveraged firms react the strongest with a point estimate of -0.48, the lowest leverage firms react the least with a point estimate of -0.24, the difference being statistically significant at the 5 percent level. If high leverage is interpreted as an indication of a higher external finance premium, this result is consistent with the interpretation that firms that are more likely to be financially constrained react more to monetary policy. For liquidity we do not find statistically significant differences.

5.3 Results based on sectors and industries

In this section, we analyse differences in the impulse response functions of investment across different sectors and industries. We start by considering three broad sectors: manufacturing (NACE rev.2 C), construction (NACE rev.2 F) and services. The latter, is obtained by pooling together the following NACE rev.2 sections: wholesale and retail trade (G), transport and storage (H), accommodation and food activities (I), information, communication and R&D (J) and other business activities (M and N). Then, we analyse several industries corresponding to the NACE rev. 2 two-digit Divisions within the three broad sectors. The idea is that by documenting differences in the responses at sectoral or industry level we can learn something

[14] For each of these endogeneous characteristics we group firms according to the distribution of the variable, i.e lower quartile, middle two quartiles and upper quartile.

Table 5: Effect of monetary policy shock on investment: manufacturing, construction and services

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D_i^{man}$	0.31	-0.38***	-0.47*	-0.08	0.08
	(0.20)	(0.10)	(0.24)	(0.15)	(0.14)
$\epsilon_{it} D_i^{con}$	0.06	-0.40***	-0.36**	-0.05	0.01
	(0.12)	(0.09)	(0.14)	(0.14)	(0.13)
$\epsilon_{it} D_i^{ser}$	0.10	-0.31***	-0.28*	-0.01	0.02
	(0.09)	(0.09)	(0.14)	(0.11)	(0.11)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

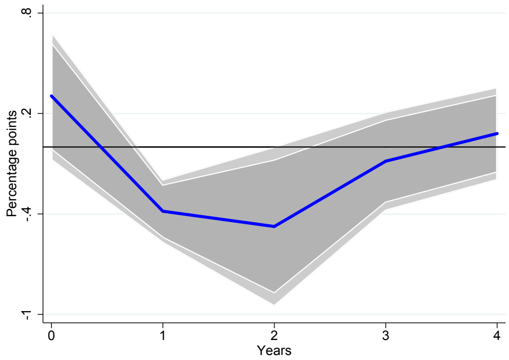
Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

about the transmission mechanism of monetary policy.

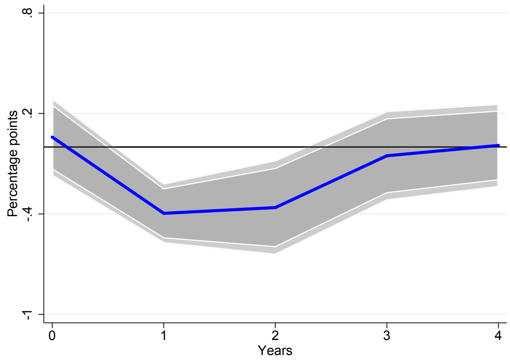
Defining firm membership to either the sector manufacturing, construction or services we estimate equation (2) for each horizon $h \in (0,1...4)$. The group dummy variables D_i^g are D_i^{man}, D_i^{con} and D_i^{ser} for respectively the manufacturing, construction and services firms. Table 5 reports the estimation results while Figure 6 shows the impulse response functions of manufacturing, services and construction separately.

One year after the shock, a 1 basis point upward surprise produces a decrease in the investment rate of 0.40 pp for construction sector firms and 0.38 pp for firms in the manufacturing sector. For firms operating in services, a 1 basis point surprise leads to a drop in the investment rate of 0.31 pp. An F-test rejects equality of the coefficients between construction (-0.40) and services (-0.31)($F_{1,167} = 23.27, p < .01$), and between manufacturing (-0.38) and services (-0.31) (at the 10 percent level) ($F_{1,167} = 2.77, p < .1$). Two year after the shock, the effect remains stronger for construction (-0.36) and manufacturing (-0.47) relative to services (-0.28). Likewise, an F-test rejects equality of the coefficients between construction and services ($F_{1,155} = 11.62, p < .01$) but not between manufacturing and services (p-value of 11.9 pct) ($F_{1,155} = 2.46, p > .1$). The temporary change in the investment rate after a contractionary shock is therefore the strongest for construction and manufacturing firms. We conclude that after a monetary policy surprise, construction and manufacturing firms react roughly one quarter stronger than firms in services.

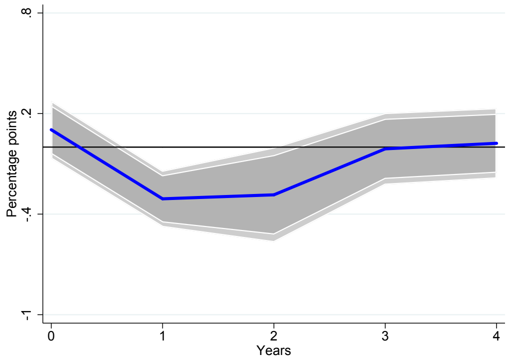
Figure 6: Sectoral response to monetary policy shock



(a) Manufacturing



(b) Construction



(c) Services

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Given the impulse response functions shown in Figure 6 one may wonder about the different mechanisms behind the stronger reaction of construction and manufacturing firms. Although this stronger reaction is consistent with the effects of the traditional interest rate channel (e.g. durables are part of manufacturing), it might also be consistent with the credit channel if these two sectors contain more financially constrained firms relative to services.

One of the most consistent findings in the literature on heterogeneity of *output* effects of monetary policy shocks is that within the manufacturing sector durable goods industries react more strongly than industries producing non-durables (See Dedola and Lippi (2005) and Peersman and Smets (2005)). Also, Ganley and Salmon (1996) and Barth and Ramey (2002)) provide further evidence on industry differences in output reactions to monetary policy. This strand of literature has found that heterogeneous responses across industries are related to a number of characteristics that are either linked to the traditional interest rate channel or the credit channel.

Dedola and Lippi (2005) found that the magnitude of the output response to monetary policy shocks is systematically related to industry characteristics such as output durability, financing requirements, borrowing capacity and average firm size in the industry. This suggests that both channels of monetary policy are operating.

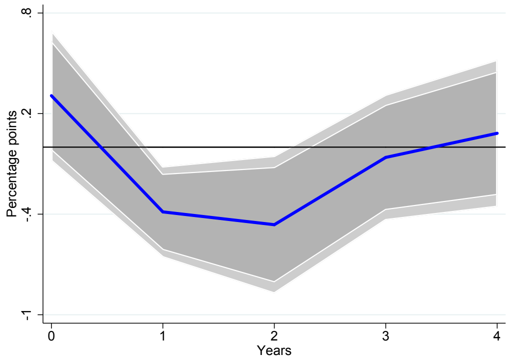
In order to investigate whether similar industry differences, as were found for output in Dedola and Lippi (2005), are at work when we consider investment spending we proceed as follows. Given the theoretical reasoning that durable goods demand should react stronger to interest rates (due to user cost effects) paired with the consistent finding in the earlier literature discussed above that output of durable goods producing industries react stronger to monetary policy shocks we first analyse whether the *investment* of manufacturing firms that produce durables also reacts stronger after a monetary policy shock. Thereafter, we estimate the effect for 31 industries and try to explain cross-industry differences with industry characteristics that are related to the credit channel, *controlling for durability.*

For our first analysis, we define the new group dummy variables durables, D_i^{dman} and non-durables, D_i^{ndman} (i.e. each manufacturing firm belongs to one of these groups) and re-estimate equation (2) using the now four groups (durables manufacturing, non-durables manufacturing, construction, services).[15] Estimation results are presented in Table 6. We find that indeed, the stronger reaction of manufacturing firms we found earlier is due to the durables producing firms. At a horizon of one year, a 1 basis point upward surprise produces a decrease in the investment rate of 0.45 pp for durable producing firms. For non-durable producing firms, the investment rate drop is 0.31 pp which is similar to that of services firms. An F-test rejects equality of the effect for durables versus non-durables producing firms ($F_{1,167} = 15.72, p < .01$).

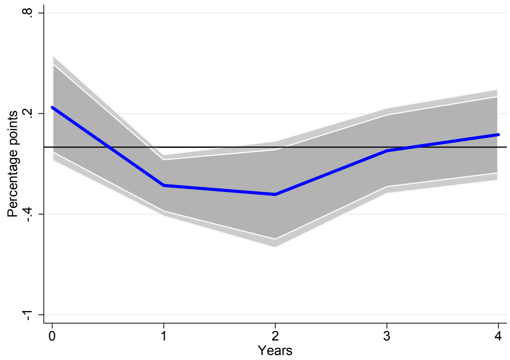
Figure 7 shows the impulse response functions for firms operating in the durable and non-durable manufacturing industries, construction and services separately. The stronger reaction of investment of firms in the durable-manufacturing industries is immediately visible, especially when compared with non-durable manufacturing industries and services firms.

[15]The durable industries are: manufacture of basic metal, manufacture of computer and electronic products, manufacture of electronic equipment, manufacture of fabricated metal products, manufacture of other non metallic minerals, manufacture of wood and products of wood and cork, manufacture of furniture, manufacture of machinery and equipment, manufacture of motor vehicles and trailers, manufacture of transport equipment. All the others are the non-durable industries.

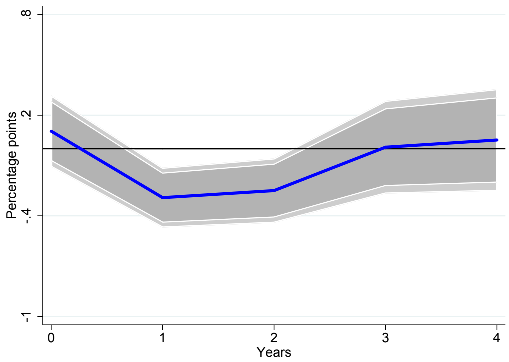
Figure 7: Firm level investment response to monetary policy shock: durable, nondurable, construction, services



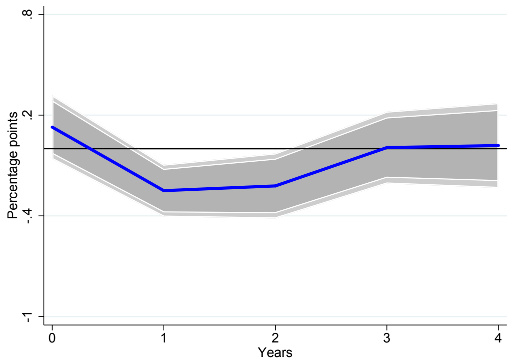
(a) Manufacturing Durable



(b) Manufacturing Non-durable



(c) Construction



(d) Services

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Table 6: Effect of monetary policy shock on investment: manufacturing durables and non-durables, construction and services

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D_i^{dman}$	0.36	-0.45***	-0.56**	-0.09	0.10
	(0.23)	(0.10)	(0.28)	(0.17)	(0.17)
$\epsilon_{it} D_i^{ndman}$	0.25	-0.31***	-0.38*	-0.07	0.06
	(0.16)	(0.09)	(0.20)	(0.13)	(0.11)
$\epsilon_{it} D_i^{con}$	0.06	-0.40***	-0.36**	-0.05	0.01
	(0.12)	(0.09)	(0.14)	(0.14)	(0.13)
$\epsilon_{it} D_i^{ser}$	0.10	-0.31***	-0.28*	-0.01	0.02
	(0.09)	(0.09)	(0.14)	(0.11)	(0.11)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

Table 7: Reaction to monetary policy at horizon 1 and 2 year for 31 industries at country level

	Germany		France		Italy		Spain	
	h=1 β^1	h=2 β^2	h=1 β^1	h=2 β^2	h=1 β^1	h=2 β^2	h=1 β^1	h=2 β^2
Manufacturing								
Durable goods								
Basic metal	-0.74***	-0.42***	-0.21	-0.27*	-0.37***	-0.62***	-0.36***	-0.48***
Computer and electronic products	-0.48***	-0.36***	-0.31***	-0.27**	-0.23***	-0.45***	-0.53***	-0.54***
Electronic equipment	-0.43***	-0.20**	-0.20*	-0.02	-0.39***	-0.59***	-0.55***	-0.64***
Fabricated metal products	-0.59***	-0.45***	-0.45***	-0.26***	-0.40***	-0.64***	-0.40***	-0.62***
Other non metallic minerals	-0.21***	-0.21***	-0.18**	-0.24***	-0.15***	-0.57***	-0.43***	-0.52***
Wood and products of wood and cork	-0.32***	-0.16*	-0.29***	-0.26***	-0.26***	-0.47***	-0.33***	-0.42***
Furniture	-0.43***	-0.26**	-0.36***	-0.27***	-0.24***	-0.61***	-0.24***	-0.38***
Machinery and equipment	-0.53***	-0.43***	-0.35***	-0.12	-0.43***	-0.63***	-0.41***	-0.53***
Motor vehicles and trailers	-0.68***	-0.41***	-0.20*	-0.18	-0.28***	-0.47***	-0.23***	-0.35***
Transport equipment	-0.38*	-0.08	-0.16	-0.18	-0.43***	-0.60***	-0.22	-0.33**
Non durable goods								
Basic pharmaceutical products	0.02	-0.07	-0.23	-0.14	-0.06	-0.21	-0.09	-0.25
Beverage	-0.16	-0.30***	-0.11	-0.11	0.03	-0.34***	-0.30***	-0.30***
Chemical and chemical products	-0.30***	-0.19**	-0.17*	0.07	-0.23***	-0.55***	-0.31***	-0.31***
Coke and petroleum products	-0.58	-0.13	0.14	1.13*	-0.14	-0.50***	0.96*	0.38
Food products	-0.06	0.05	0.01	0.02	0.02	-0.25***	-0.23***	-0.25***
Leather	-0.29	0.05	-0.37**	-0.16	-0.47***	-0.58***	-0.33***	-0.30***
Paper and paper products	-0.39***	0.14	-0.28**	-0.13	-0.27***	-0.45***	-0.25***	-0.37***
Rubber and plastic	-0.41***	-0.19***	-0.32***	-0.19**	-0.25***	-0.42***	-0.36***	-0.47***
Textile	-0.46***	-0.22*	-0.26**	-0.14	-0.23***	-0.54***	-0.34***	-0.47***
Tobacco products	-1.13	-1.31*	-1.34	-0.45	0.49	0.22	-0.36	-0.26
Wearing apparel	-0.28	-0.16	-0.36***	-0.08	-0.36***	-0.54***	-0.28***	-0.32***
Other business activities	-0.28***	-0.14***	-0.28***	-0.09***	-0.22***	-0.37***	-0.39***	-0.44***
Other	-0.15**	-0.07	-0.01	0.09	-0.17***	-0.32***	-0.11	-0.15*
Services								
Printing or reproduction	-0.19**	-0.17*	-0.23***	-0.16**	-0.33***	-0.43***	-0.37***	-0.64***
Accommodation and food services	-0.19***	-0.08	-0.12***	-0.01	-0.12***	-0.32***	-0.24***	-0.24***
Information, communication and R&D	-0.39***	-0.15***	-0.31***	-0.06	-0.16***	-0.25***	-0.43***	-0.49***
Repair and installation	-0.42***	-0.49***	-0.29***	-0.28***	-0.49***	-0.63***	-0.33***	-0.53***
Retail trade	-0.19***	-0.04	-0.10***	-0.04*	-0.19***	-0.30***	-0.27	-0.29***
Transport, storage	-0.55***	-0.16***	-0.37***	-0.14***	-0.30***	-0.41***	-0.48***	-0.81***
Wholesale trade	-0.40***	-0.19***	-0.13***	-0.03***	-0.25***	-0.41***	-0.31***	-0.37***
Construction								
	-0.27***	-0.13***	-0.25***	-0.09***	-0.22***	-0.39***	-0.39***	-0.42***

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1

The granularity of our firm level dataset allows us to further disaggregate the manufacturing sector into 24 two-digit NACE code industries and the services sector into 6 two-digit NACE code industries.[16] Table 7 shows the values of estimated coefficients β^h from equation (2) at one and two year horizon for the 31 industries in each country. Since the previous results show that the average effect of monetary policy at the firm level is concentrated around year one and two after the shock, we present these detailed results only referring to those two years.

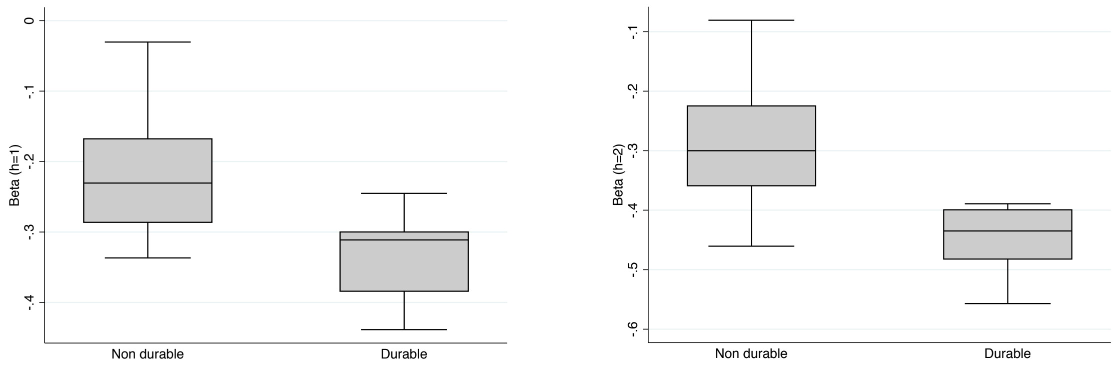
Looking across the 248 estimated coefficients, we can observe that the effect of an upward surprise leads almost everywhere to a decrease in the investment rate, since the coefficient values have almost all a statistically significant negative sign. However, there are clear differences across industries in the strength of the effect. For instance, in Germany at the horizon of one year, the most sensitive industry is the manufacture of basic metal (-0.74) whereas some low (statistically significant) sensitive industries are other non-durable goods (-0.15), accommodation and food services (-0.19) and retail trade (-0.19). Similar large differences can be observed across industries within the other countries. This finding suggests that, while country-specific differences seem to be not so relevant, marked differences appear across industries. This result is also in line with industry level findings on *output* by Dedola and Lippi (2005). To the best of our knowledge, our findings on *investment* are new.

Not surprisingly, the durability of the output is associated to the strength of the reaction of investment to monetary policy. Figure 8 plots the distribution of the estimated 31 coefficients from equation (2) at horizon one (Panel a) and two year (Panel b) using the pooled sample. We group separately firms operating in durable industries and the ones that do not (i.e the non-durables manufacturing, construction and services industries). Figure 8 shows that for both horizons, the distribution of the estimated coefficients for the group of durable producers are significantly more concentrated around larger negative values.

The second step in our investigation on the differences across industries is to consider additional industry characteristics. We use the results in Table 7 to regress the sensitivity to the surprises of each industry, on specific balance sheet characteristics. Industry specific characteristics are measured by taking the median values of each financial indicator considered. Although this regression loses detailed information at the firm level, it still exhibits patterns that help to identify the exact monetary policy transmission channel that drives the heterogeneity across

[16] We end up with a total of 31 industries: 24 two-digit NACE code industries for the manufacturing sector, 6 two-digit NACE code industries for the service sector and the construction sector.

Figure 8: Firm level investment response to monetary policy shock for 31 industries grouped into durable and non-durable producing



(a) h = 1 **(b)** h = 2

Note: The figure plots the distribution of the estimated coefficients β^1 and β^2 from equation (2) using the pooled sample.

industries.[17]

We follow Dedola and Lippi (2005) in the choice of the balance sheet characteristics. First, we include variables that measure liquidity and financing requirements. In particular, we use loans to debt, leverage, debt burden and log total assets as a measure of size. A significant relationship with the reaction to monetary policy with these variables would suggest the operation of the credit channel. Second, we include working capital. If industries with higher working capital requirements react more to policy this would suggest the existence of the cost channel (Barth and Ramey (2002)). Finally, we include a durability dummy to indicate the durables producing industries.

The results of this regression are presented in Table 8. The durability dummy is highly significant and has an independent effect controlling for all other factors, suggesting that the traditional interest rate channel is operating. It is telling that no other within-industry characteristic is significant.

All in all, our industry level estimates show that output durability is the most important factor in determining the strength of the reaction of *investment* to monetary policy shocks. This is consistent with the role of durability in the *output* reaction to monetary policy found by an earlier literature. The double sensitivity (output and investment) shows that demand of durable

[17] In more detail: we firstly construct the median values of each financial variable at industry level and then, we run a regression taking the estimated β^1 and β^2 from Table 7 as dependent variables. The regression is therefore, estimated at industry level.

Table 8: Explaining cross-industry differences in reaction to monetary policy

Variables	β^1 **(h=1)**	β^2 **(h=2)**
Durability dummy	-0.105***	-0.139***
	(0.0332)	(0.0311)
Working capital	-0.158	-0.307
	(0.274)	(0.293)
Loans to debt	0.0487	0.381
	(0.244)	(0.325)
Log total assets	-0.00988	-0.00441
	(0.0539)	(0.0686)
Leverage	1.453	0.860
	(0.942)	(1.159)
Debt Burden	0.168	0.428
	(0.744)	(0.812)
Country fe	Yes	Yes
Obs	124	124
R-squared	0.687	0.727

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1

products *and* investment of durable goods producers drop more after a policy shock relative to other industries. As shown in Table 8 the fact that financial or other industrial characteristics are irrelevant strongly suggests that the interest rate channel of monetary policy matters more than other factors associated with the presence of financial frictions. However these might still be important to determine differences *within* industries, something we test in the next section.

5.4 Results combining sector and age

In the previous sections, we found that both the age of the firm and whether it produces durables matter for the strength of the effect of monetary policy shocks on investment. This suggests that both the credit channel and the interest rate channel are operative. To identify which channel is likely to be the strongest we interact the age grouping (young, mature, old) with the sectoral grouping (durable manufacturing, non-durable manufacturing, construction, services) to obtain twelve distinct groups of firms. We re-estimate equation (2) using the now twelve groups. Estimates of the effect of monetary policy for each of these groups are reported in Table 9. Figure 9 shows the impulse response functions for all twelve groups of firms.

Consistent with our earlier results, in the first year after the shock, the group of young firms in the durables manufacturing sector reacts the strongest with a reduction in the investment rate by 0.50 pp. The group of old firms in the non-durables manufacturing sector and services sector react the least (0.27 pp), which is almost half the reaction of the strongest reacting group. All other groups have a reaction strength in between those two groups.

Within sector, age matters depending on the sector. In the first year after the shock, the investment of young firms always drops the most. The difference in the point estimate between the young and the old firms is respectively -0.08 for the durables manufacturing sector, -0.06 for the non-durables manufacturing sector, -0.12 for the construction sector and -0.11 for the services sector. An F-test rejects equality of the effect of the shock between young (-0.44) and old (-0.32) for construction ($F_{1,167} = 8.58, p < .01$) and between young (-0.38) and old (-0.27) for the services sector ($F_{1,167} = 12.46, p < .01$). Within these two sectors the effect for the young is more than one third larger than for the old. The differences between the young (-0.50) and old (-0.42) in the durables and likewise between young (-0.33) and old (-0.27) in the non-durables manufacturing sector are small and both are not statistically significant. (The respective F-test results are $F_{1,167} = 2.26, p > .1$ and $F_{1,167} = 1.56, p > .1$.) Two years after the shock, age does not matter anymore. Indeed the difference in the point estimate between young and old firms becomes smaller and F-tests never reject equality of the effect of the shock.

In contrast, within each age category, there are large differences across sectors. Firms in the durables manufacturing sector always react the most. For young firms the differences in the point estimates between the durables manufacturing sector and the non-durables manufacturing, construction and services sector are respectively -0.17, -0.06, -0.12. Furthermore, for mature firms these differences are -0.11, -0.03, -0.15 and for the old firms these differences are -0.15, -0.10, -0.15. F-tests show that most of these differences are statistically significant. Differences between young companies from durables manufacturing (-0.50) and construction sectors (-0.44) are not statistically significant ($F_{1,167} = 1.39, p > .1$), confirming once again a similar reaction of firms in these two sectors. Two years after the shock, the differences in the point estimates between the durables manufacturing sector and the other sectors remain large and in most of the cases statistically significant.

Table 9: Effect of monetary policy shock on investment: durability and age

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^{dmany}_{it}$	0.17	-0.50***	-0.51**	-0.09	0.03
	(0.14)	(0.10)	(0.22)	(0.16)	(0.16)
$\epsilon_{it} D^{dmanm}_{it}$	0.26	-0.44***	-0.54**	-0.08	0.10
	(0.18)	(0.11)	(0.25)	(0.17)	(0.17)
$\epsilon_{it} D^{dmano}_{it}$	0.55*	-0.42***	-0.58*	-0.10	0.13
	(0.31)	(0.12)	(0.35)	(0.18)	(0.17)
$\epsilon_{it} D^{ndmany}_{it}$	0.07	-0.33***	-0.34**	-0.07	0.00
	(0.09)	(0.10)	(0.14)	(0.11)	(0.11)
$\epsilon_{it} D^{ndmanm}_{it}$	0.15	-0.33***	-0.34*	-0.07	0.03
	(0.12)	(0.09)	(0.19)	(0.13)	(0.11)
$\epsilon_{it} D^{ndmano}_{it}$	0.44*	-0.27***	-0.41	-0.06	0.11
	(0.23)	(0.10)	(0.27)	(0.14)	(0.12)
$\epsilon_{it} D^{cony}_{it}$	-0.01	-0.44***	-0.36**	-0.02	-0.01
	(0.10)	(0.10)	(0.15)	(0.13)	(0.11)
$\epsilon_{it} D^{conm}_{it}$	0.09	-0.41***	-0.37**	-0.03	0.04
	(0.12)	(0.11)	(0.15)	(0.16)	(0.16)
$\epsilon_{it} D^{cono}_{it}$	0.13	-0.32***	-0.32**	-0.08	-0.00
	(0.15)	(0.07)	(0.15)	(0.11)	(0.11)
$\epsilon_{it} D^{sery}_{it}$	-0.04	-0.38***	-0.32**	-0.07	-0.06
	(0.07)	(0.09)	(0.13)	(0.12)	(0.11)
$\epsilon_{it} D^{serm}_{it}$	0.12	-0.29***	-0.26*	0.02	0.05
	(0.08)	(0.09)	(0.14)	(0.12)	(0.12)
$\epsilon_{it} D^{sero}_{it}$	0.22*	-0.27***	-0.28*	0.00	0.05
	(0.12)	(0.09)	(0.17)	(0.10)	(0.10)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

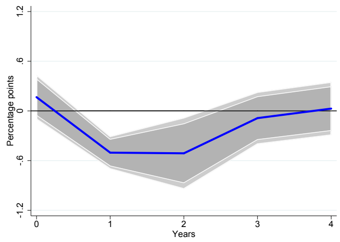
Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

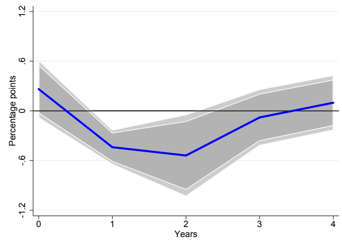
Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

Coefficients of dummy group variables not reported.

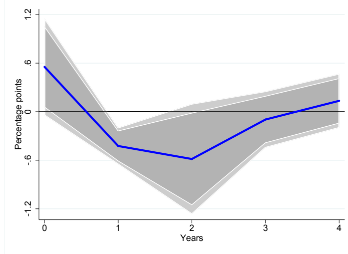
Figure 9: Joint effect of age and sector



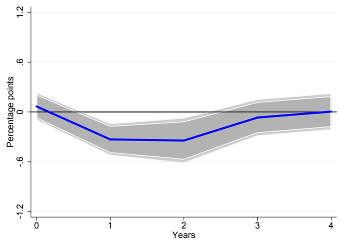
(a) Young - Durable manuf.



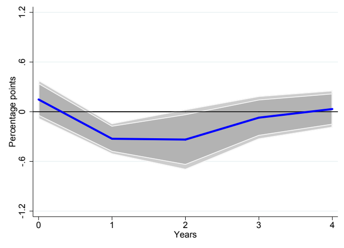
(b) Mature - Durable manuf.



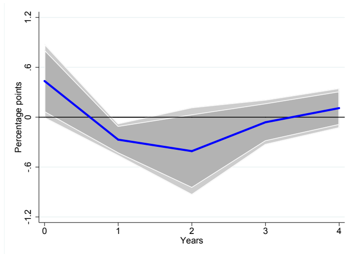
(c) Old - Durable manuf.



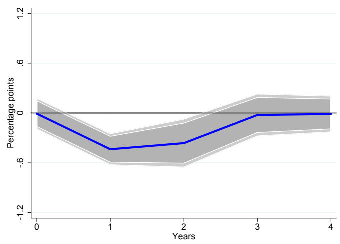
(d) Young - Non-durable manuf.



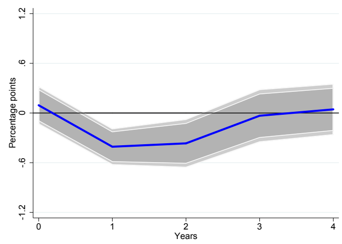
(e) Mature - Non-durable manuf.



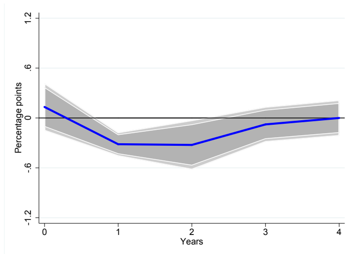
(f) Old - Non-durable manuf.



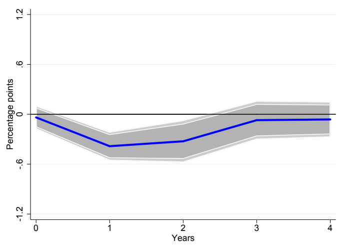
(g) Young - Construction



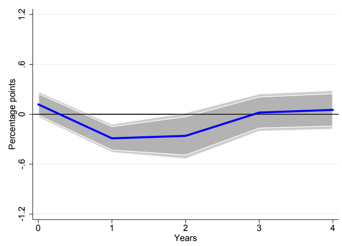
(h) Mature - Construction



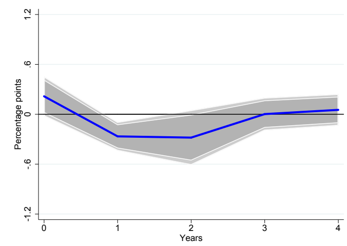
(i) Old - Construction



(j) Young - Services



(k) Mature - Services



(l) Old - Services

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

This leads us to conclude with a qualified picture. First, age matters. Young firms react the strongest and this is indicative of the presence of credit channel effects. However, the age effect is short lived as it seems to affect investment only one year after the shock. Second, age also seems to matter more for the construction and services sectors, less so within manufacturing. Third, durability of output certainly matters. Within each age category durables producing firms react the most. The durability effect on investment seems stronger than the age effect and it is definitely longer lived.

6 Conclusion

Our analysis has uncovered substantial heterogeneous effects of monetary policy on business investment. This way we shed new light on the relative importance of two different transmission channels through which monetary policy affects investment, i.e. the credit channel and the traditional interest rate channel.

First, we find that young firms react more to monetary policy shocks. An earlier literature has argued that age is a good exogenous proxy for financing constraints, with young firms being more likely constrained. Our finding therefore supports the existence of the credit channel. Second, we explore the heterogeneity of firms' reactions across various sectors and industries. We find that durable goods producers react more to monetary policy shocks compared to firms operating in other industries. Third, we further explore if other factors might explain cross-industry differences in the reaction to monetary policy. Our results suggest that *across* industries, output durability is the *only* factor determining the strength of the reaction of *investment* to monetary policy shocks. Average industry specific balance sheet characteristics do not seem to play a role in driving the heterogeneous response across industries. This evidence strongly suggests that at industry level, the interest rate channel of monetary policy matters more than other factors associated with the presence of financial frictions. Nevertheless, financial frictions matters *within* sectors. Fourth, whereas the recent literature has mainly investigated the importance of the credit channel of monetary policy to business investment (Cloyne et al. (2018), Jeenas (2019), Bahaj et al. (2019), Ottonello and Winberry (2020)), our analysis provides evidence of an equally strong role for the interest rate channel of monetary policy suggested by the large role played by *durability* in across-firm differences. We find that the age effect is shorter lived than the durability effect.

The substantial heterogeneity in the reaction to monetary policy shocks that we found can potentially be replicated in a macroeconomic model. Such a model should allow for multiple sectors with different interest rate sensitivities related to output characteristics such as durability combined with financial accelerator effects. Developing such a model which matches our evidence seems a fruitful future research agenda.

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We would like to thank Peter Karadi for discussion and kindly providing us with the monthly monetary policy shock series and Laurence Ball, Marzio Bassanin, Ursel Baumann, Luca Dedola, Urban Jermann, Fabiano Schivardi, Nicola Fuchs-Schündeln, Morten Ravn, Daniel Lewis, Nobuhiro Kiyotaki and Sergio Rebelo for valuable comments and suggestions. Elena would like to thank colleagues in the Capital Market and Financial Structure Division of the European Central Bank for their useful insights along various stages of the project. We also thank Valerio Di Tommaso for excellent research assistance. Any errors are solely attributed to the authors.

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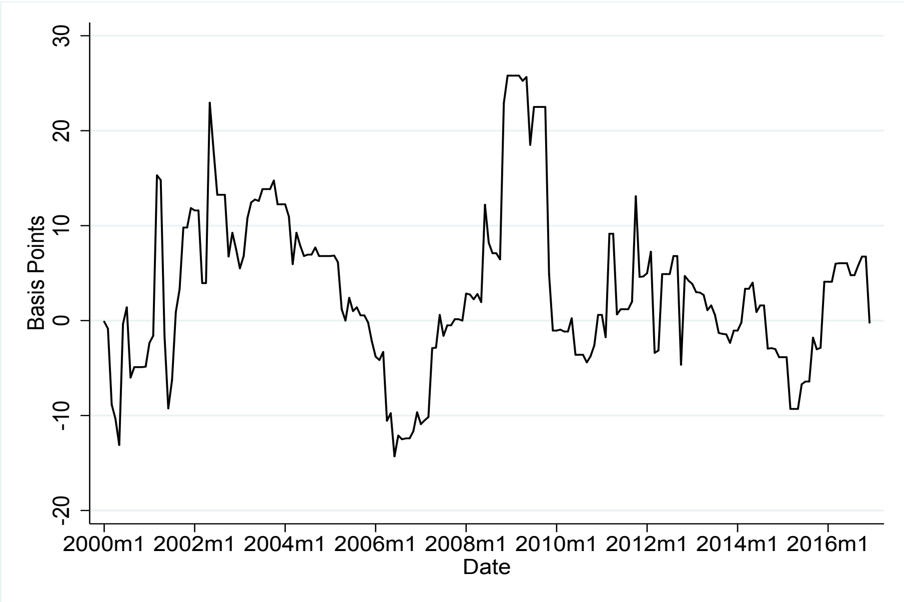
A The 12-month moving sum of the monetary policy shock

Figure 10: 12 month moving sum of monetary policy shock series from Jarociński and Karadi (2020)



B List of NACE rev.2 sectors and industries used in the paper

Sector: Manufacturing (C)

Durable industries:

Manufacture of basic metal

manufacture of computer and electronic products

manufacture of electronic equipment

manufacture of fabricated metal products

manufacture of other non-metallic minerals

manufacture of wood and products of wood and cork

manufacture of furniture

manufacture of machinery and equipment

manufacture of motor vehicles and trailers

manufacture of transport equipment

Non durable industries:

Manufacture of food products

manufacture of beverage

manufacture of tobacco products

manufacture of textile

manufacture of wearing apparel

manufacture of leather

manufacture of paper and paper products

printing of reproduction

manufacture of coke and petroleum products

manufacture of chemical and chemical products

manufacture of basic pharmaceutical products

manufacture of rubber and plastic

repair and installation,

Sector: Construction (F)

Sector Services (G, H, I, J, M and N):

Accommodation and food services (I),

information, communication and R&D (J and M)

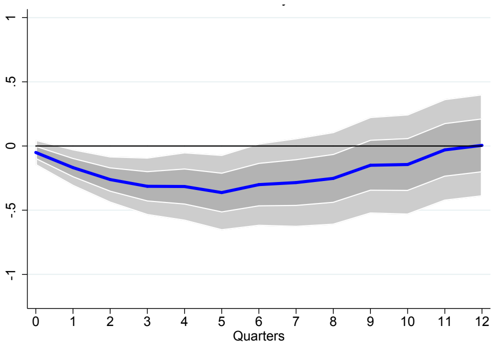
manufacture of other business activities (N)

retail trade, transport and storage (H)

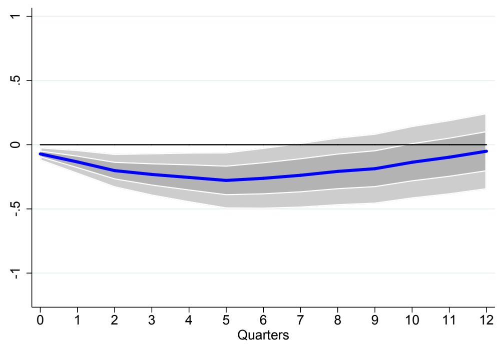
wholesale trade (G)

C Additional figures and tables

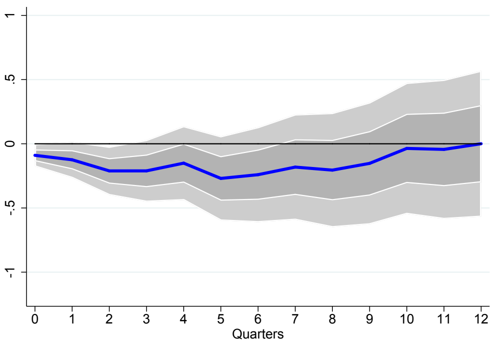
Figure 11: Aggregate investment response to monetary policy shock. Country level analysis.



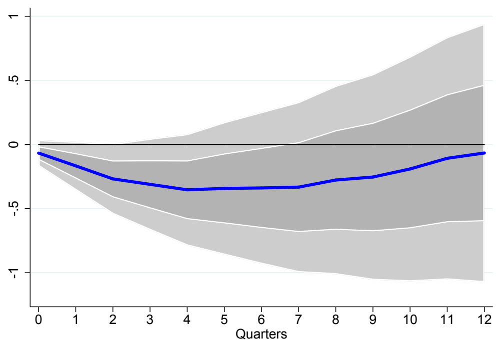
(a) Germany



(b) France



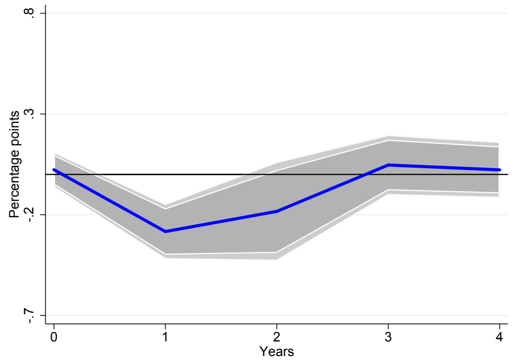
(c) Italy



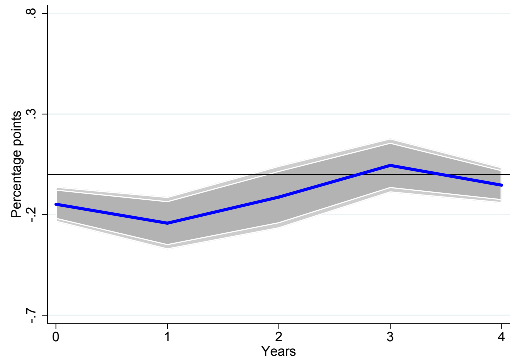
(d) Spain

Note: shaded areas represent 90 and 95 percent confidence bands.

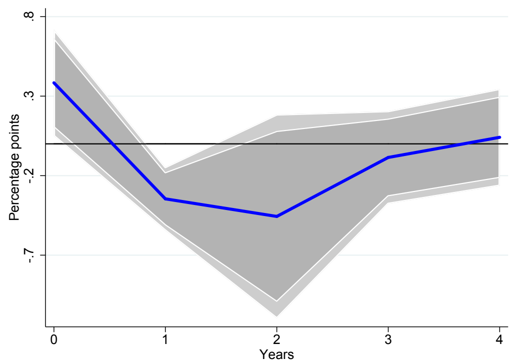
Figure 12: Average firm level investment response to monetary policy shock. Country level analysis.



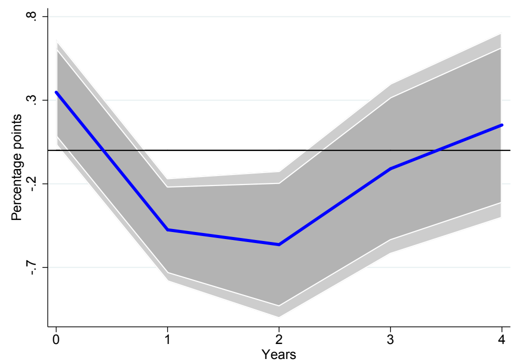
(a) Germany



(b) France



(c) Italy



(d) Spain

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Table 10: Average effect of monetary policy shock on investment: country level grouping

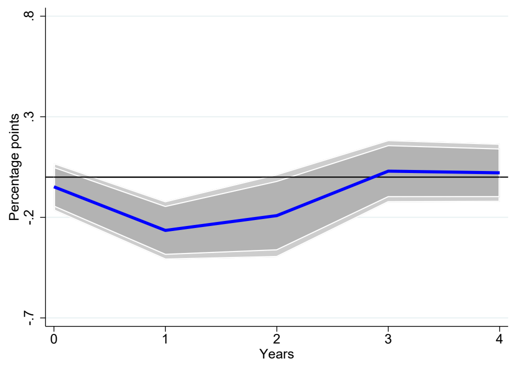
	ΔI^{*}_{it0}	ΔI^{*}_{it1}	ΔI^{*}_{it2}	ΔI^{*}_{it3}	ΔI^{*}_{it4}
$\epsilon_{it} D^{DE}_{it}$	0.02	-0.28***	-0.18	0.05	0.02
	(0.05)	(0.07)	(0.13)	(0.08)	(0.07)
$\epsilon_{it} D^{ES}_{it}$	0.35**	-0.47***	-0.56**	-0.11	0.15
	(0.16)	(0.16)	(0.23)	(0.26)	(0.28)
$\epsilon_{it} D^{FR}_{it}$	-0.15***	-0.24***	-0.11	0.04	-0.05
	(0.04)	(0.07)	(0.08)	(0.07)	(0.05)
$\epsilon_{it} D^{IT}_{it}$	0.38**	-0.35***	-0.46	-0.09	0.04
	(0.17)	(0.10)	(0.33)	(0.15)	(0.16)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

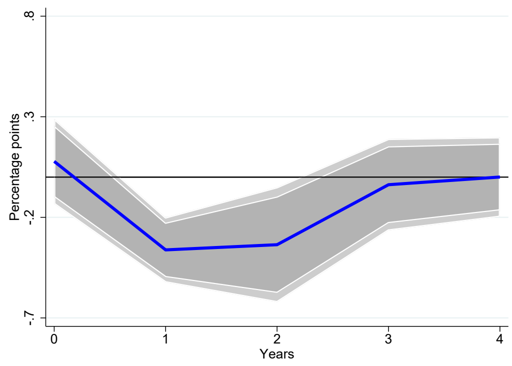
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

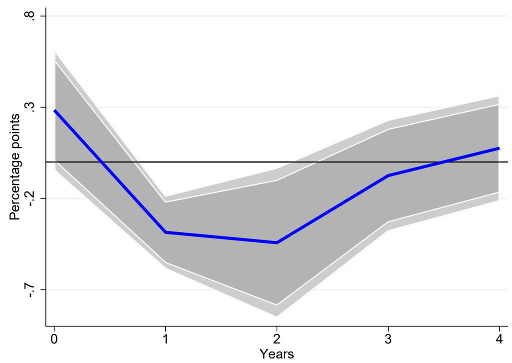
Figure 13: Firm level investment response to monetary policy shock. Allowing for size grouping



(a) Small



(b) Medium



(c) Large

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Table 11: Average effect of monetary policy shock on investment: size grouping

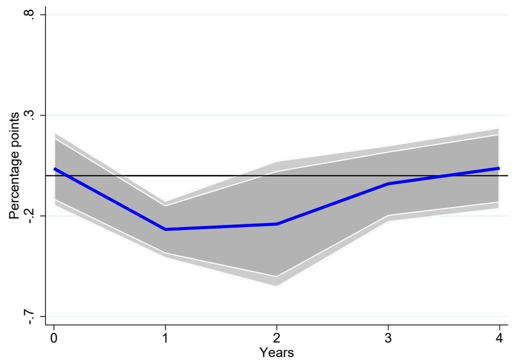
	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^{sm}_{it}$	-0.05	-0.26***	-0.19*	0.03	0.02
	(0.06)	(0.07)	(0.11)	(0.08)	(0.07)
$\epsilon_{it} D^{me}_{it}$	0.08	-0.36***	-0.34**	-0.04	0.00
	(0.11)	(0.08)	(0.15)	(0.12)	(0.10)
$\epsilon_{it} D^{la}_{it}$	0.28*	-0.39***	-0.44**	-0.07	0.08
	(0.17)	(0.10)	(0.21)	(0.16)	(0.15)
D^{sm}_{it}	50.05***	52.50***	46.94***	40.32***	36.14***
	(2.40)	(2.17)	(2.16)	(2.05)	(2.55)
D^{me}_{it}	20.92***	21.74***	20.05***	17.43***	16.60***
	(1.58)	(1.47)	(1.55)	(1.39)	(1.88)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

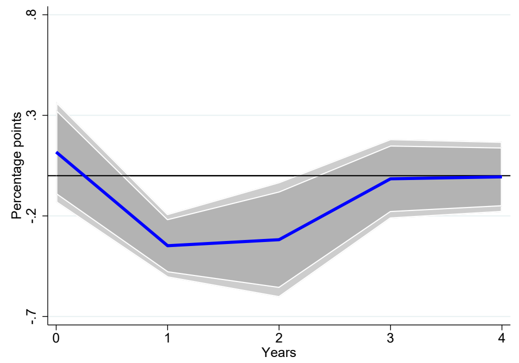
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

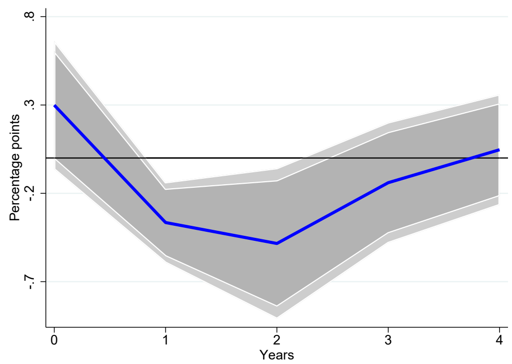
Figure 14: Firm level investment response to monetary policy shock. Allowing for leverage grouping



(a) Low leverage



(b) Medium leverage



(c) High leverage

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Table 12: Average effect of monetary policy shock on investment: leverage grouping

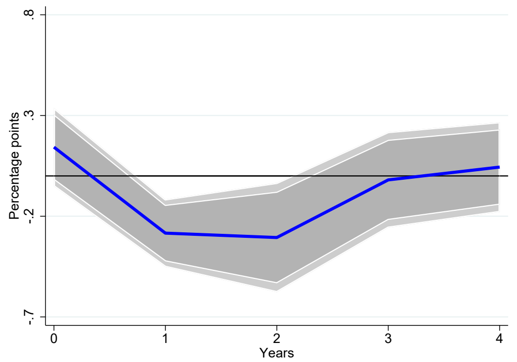
	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^{ll}_{it}$	0.04	-0.27***	-0.24	-0.04	0.04
	(0.09)	(0.07)	(0.16)	(0.10)	(0.10)
$\epsilon_{it} D^{ml}_{it}$	0.12	-0.35***	-0.32**	-0.02	-0.01
	(0.13)	(0.08)	(0.15)	(0.10)	(0.09)
$\epsilon_{it} D^{hl}_{it}$	0.30	-0.37***	-0.48**	-0.14	0.05
	(0.19)	(0.12)	(0.22)	(0.17)	(0.16)
D^{ll}_{it}	37.29***	28.82***	22.62***	19.66***	17.22***
	(1.91)	(1.54)	(1.16)	(1.01)	(1.15)
D^{ml}_{it}	17.80***	14.24***	10.96***	8.49***	8.25***
	(0.92)	(0.81)	(0.57)	(0.81)	(0.56)
Controls	YES	YES	YES	YES	YES
Observations	8769834	7201395	5898975	4890179	4053730

Standard errors in parentheses

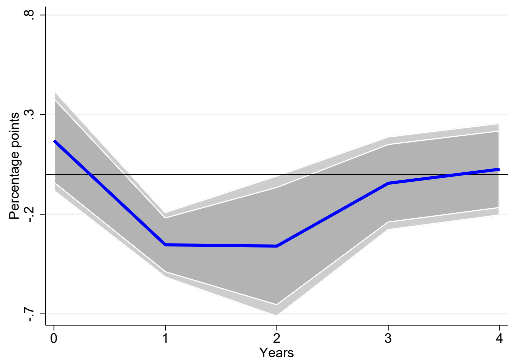
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

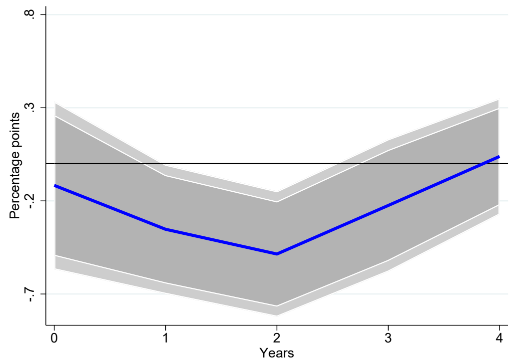
Figure 15: Firm level investment response to monetary policy shock. Allowing for liquidity grouping



(a) Low liquid



(b) Medium liquid



(c) High liquid

Note: shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm and time level.

Table 13: Average effect of monetary policy shock on investment: liquidity grouping

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^{lliq}_{it}$	0.14	-0.28***	-0.31**	-0.02	0.04
	(0.10)	(0.09)	(0.14)	(0.12)	(0.11)
$\epsilon_{it} D^{mliq}_{it}$	0.17	-0.35***	-0.36**	-0.04	0.03
	(0.13)	(0.08)	(0.18)	(0.12)	(0.12)
$\epsilon_{it} D^{hliq}_{it}$	-0.12	-0.35**	-0.49***	-0.22	0.04
	(0.23)	(0.18)	(0.17)	(0.18)	(0.16)
D^{lliq}_{it}	-27.99***	-18.91***	-15.18***	-13.89***	-12.37***
	(1.20)	(0.88)	(0.78)	(0.71)	(0.88)
D^{mliq}_{it}	-16.30***	-11.03***	-9.21***	-9.27***	-8.38***
	(0.78)	(0.72)	(0.68)	(0.56)	(0.66)
Controls	YES	YES	YES	YES	YES
Observations	9297320	7703287	6357323	5313562	4449717

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

D Robustness check age threshold

Table 14: Effect of monetary policy shock on investment according to age (threshold young: 9 year)

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^y_{it}$	0.02	-0.39***	-0.31**	-0.02	-0.01
	(0.08)	(0.10)	(0.15)	(0.11)	(0.11)
$\epsilon_{it} D^m_{it}$	0.12	-0.34***	-0.33**	-0.02	0.04
	(0.10)	(0.09)	(0.16)	(0.13)	(0.13)
$\epsilon_{it} D^o_{it}$	0.29*	-0.30***	-0.35*	-0.04	0.07
	(0.17)	(0.09)	(0.20)	(0.11)	(0.12)
D^y_{it}	-2.93*	-1.97	-3.96	-5.81	-4.40
	(1.74)	(2.46)	(3.52)	(4.43)	(4.75)
D^m_{it}	0.02	0.77	0.02	-0.82	0.16
	(0.92)	(1.24)	(1.89)	(2.36)	(2.57)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

Table 15: Effect of monetary policy shock on investment according to age (threshold young: 8 year)

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^y_{it}$	0.01	-0.39***	-0.31**	-0.03	-0.02
	(0.08)	(0.10)	(0.15)	(0.10)	(0.10)
$\epsilon_{it} D^m_{it}$	0.11	-0.34***	-0.32**	-0.02	0.04
	(0.10)	(0.09)	(0.16)	(0.13)	(0.13)
$\epsilon_{it} D^o_{it}$	0.29*	-0.29***	-0.35*	-0.04	0.07
	(0.17)	(0.09)	(0.20)	(0.11)	(0.12)
D^y_{it}	-3.97**	-2.97	-5.09	-7.36*	-5.97
	(1.73)	(2.46)	(3.44)	(4.33)	(4.62)
D^m_{it}	0.00	0.74	-0.01	-0.85	0.17
	(0.93)	(1.26)	(1.90)	(2.36)	(2.57)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}

Table 16: Effect of monetary policy shock on investment according to age (threshold young: 7 year)

	ΔI^*_{it0}	ΔI^*_{it1}	ΔI^*_{it2}	ΔI^*_{it3}	ΔI^*_{it4}
$\epsilon_{it} D^y_{it}$	0.00	-0.40***	-0.31**	-0.04	-0.03
	(0.07)	(0.10)	(0.15)	(0.10)	(0.10)
$\epsilon_{it} D^m_{it}$	0.10	-0.34***	-0.32**	-0.02	0.03
	(0.10)	(0.09)	(0.16)	(0.13)	(0.12)
$\epsilon_{it} D^o_{it}$	0.29*	-0.29***	-0.35*	-0.04	0.07
	(0.17)	(0.09)	(0.20)	(0.11)	(0.12)
D^y_{it}	-5.44***	-4.75*	-6.65*	-8.88**	-7.92*
	(1.73)	(2.46)	(3.39)	(4.15)	(4.38)
D^m_{it}	0.01	0.72	-0.03	-0.85	0.19
	(0.94)	(1.27)	(1.89)	(2.36)	(2.58)
Controls	YES	YES	YES	YES	YES
Observations	9391930	7795739	6435191	5376790	4501547

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controls: ϵ_{it-1}, ϵ_{it-2}, ΔI_{it-1} ΔI_{it-2} , ΔCF_{it-1}, ΔCF_{it-2}, ΔSG_{it-1}, ΔSG_{it-2}