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# International Spillovers from Euro Area Monetary Policy to Advanced Small Open Economies: Investment Behavior of Czech Firms

Volha Audzei, Michal Franta

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This paper contains research conducted within the network "Challenges for Monetary Policy Transmission in a Changing World Network" (ChaMP). It consists of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the European System of Central Banks (ESCB).

ChaMP is coordinated by a team chaired by Philipp Hartmann (ECB), and consisting of Diana Bonfim (Banco de Portugal), Margherita Bottero (Banca d'Italia), Emmanuel Dhyne (Nationale Bank van België/Banque Nationale de Belgique) and Maria T. Valderrama (Oesterreichische Nationalbank), who are supported by Melina Papoutsi and Gonzalo Paz-Pardo (both ECB), 7 central bank advisers and 8 academic consultants.

ChaMP seeks to revisit our knowledge of monetary transmission channels in the euro area in the context of unprecedented shocks, multiple ongoing structural changes and the extension of the monetary policy toolkit over the last decade and a half as well as the recent steep inflation wave and its reversal. More information about it is provided on its website.

Reviewed by: Mathias Klein (Riksbank)
Oxana Babecká-Kucharčuková (CNB)
Project Coordinator: Ivan Trubelík

# International Spillovers from Euro Area Monetary Policy to Advanced Small Open Economies: Investment Behavior of Czech Firms

Volha Audzei and Michal Franta*

**Abstract**

The paper examines international spillovers of euro area (EA) monetary policy to the real economy of an advanced small open economy with a high degree of credit euroization and close trade links with the EA. We focus on Czechia, as it has a similar degree of trade and financial integration with the EA as the rest of the non-EA countries in the region. Based on firm-level data and high-frequency identified monetary policy shocks, we assess the channels of EA monetary policy spillovers. More precisely, we estimate the responses of investment by Czech firms to EA monetary policy shocks using panel local projections and compare the responses for various groups of firms. The results suggest the presence of the trade channel of spillover transmission. Some evidence is found for the balance sheet channel. The foreign currency borrowing cost channel is detected after 2014, suggesting that the high degree of credit euroization in Czechia has altered the transmission of spillovers of EA monetary policy. Importantly, the overall spillovers from the EA have weakened significantly since 2014.

**JEL Codes**: C23, D22, E52, F41.

**Keywords**: Credit euroization, Investment of firms, International spillovers of monetary policy, Small open economy, Transmission channels.

* Volha Audzei, Czech National Bank, volha.audzei@cnb.cz
Michal Franta, Czech National Bank, michal.franta@cnb.cz
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# 1. Introduction

European countries outside the euro area (EA) have close trade and financial links to the EA. As a consequence, EA monetary policy affects the economies of these countries. Understanding the channels of international EA monetary policy spillovers and their evolution over time is of interest both to these countries and to the EA. While there is an extensive literature on US monetary policy spillovers (Georgiadis and Jarociński, 2025; Dedola et al., 2017), as well as some papers on EA monetary policy spillovers to emerging economies (Walerych and Wesołowski, 2021; Ca' Zorzi et al., 2020; Engler et al., 2024), spillovers to advanced European Union countries outside the EA have been studied less.[1] Such countries often exhibit high volumes of trade with the EA, and euro-denominated corporate credit makes up a significant proportion of total bank credit to firms.

In this paper, we contribute to the literature by studying EA monetary policy spillovers to an advanced small open economy with an independent currency and close economic and financial ties to the EA. We focus on the case of Czechia, as it exhibits a similar degree of trade and financial links to the EA as the rest of the non-EA countries in the region. The results of our study may therefore be of interest to other small open EU economies with independent currencies.

We analyze transmission to the real economy based on firm-level investment decisions. The granularity of the firm-level data allows us to focus on various channels of spillover transmission. For example, we exploit firms' balance sheet data to discuss the presence of a financial accelerator. With aggregate data, this would not be possible.

To the best of our knowledge, our study is the first to discuss channels of international EA monetary policy spillovers using a firm-level dataset. Another novel aspect of the study is that we try to shed some light on the role of two structural changes that happened during the last decade: the significant credit euroization of the Czech economy and the launch of unconventional monetary policy in the EA.

More precisely, we examine the heterogeneity of the investment behavior of Czech firms following EA monetary policy shocks. The shocks are obtained using high-frequency identification approach of Jarociński and Karadi (2020). As a robustness check to account for the multidimensionality of EA monetary policy after 2014, we use quantitative easing shocks as suggested by Altavilla et al (2019). The firm-level data cover firms from manufacturing and services, and our dataset spans the period 2008Q1–2020Q1. The panel comprises around 73,000 firm-quarter observations. We apply the firm-level differential approach: we compare the investment responses of different groups of firms to the shock to infer the existence of various channels of EA monetary policy spillovers. The comparison is carried out using panel local projections.

Investment behavior is especially suitable for our purposes because it allows us to discuss whether foreign monetary policy spills over to the real economy through foreign demand and whether the channel is amplified through the financial channels. Investment is an important component of the monetary policy transmission mechanism. Moreover, investment by firms is an economically important driver of fluctuations in GDP, so its evolution over time is of interest *per se*.

We focus on three channels through which foreign monetary policy may spill over to a small open economy with a high volume of foreign trade and a significant share of credit denominated in

[1] Babecká Kucharčuková et al. (2016) and Potjagailo (2017) study EA spillovers to advanced European economies. However, they draw on aggregate data and do not address the specific channels of EA monetary policy spillovers.

foreign currency: the trade channel, the balance sheet channel, and the foreign currency borrowing cost channel.

The export-related part of the trade channel (the external demand channel): A foreign monetary policy tightening translates to a fall in foreign demand. The latter affects production in the domestic economy through a drop in exports. Domestic firms facing lower demand invest less. To assess the relevance of this channel, we compare the investment of firms producing durable and nondurable goods after an EA monetary policy shock. In the literature, demand for durable goods is found to be more sensitive to interest rates than demand for nondurables (e.g., Peersman and Smets, 2005). By comparing the sensitivity of investment for firms producing durables and nondurables to an EA monetary policy shock, the export-related part of the trade channel can be detected.

On the other hand, exports can rise as the exchange rate depreciates and domestic goods become cheaper abroad. This phenomenon is examined by testing the sensitivity of the results to the inclusion of the exchange rate in the model specification.

The balance sheet channel: When financial conditions tighten, financially constrained firms cut investment more than financially unconstrained firms. This behavior is implied by financial frictions theories such as the financial accelerator of Bernanke, Gertler, and Gilchrist (1999). The tightening of financial conditions after a tightening of EA monetary policy is associated with a change in the value of firms' balance sheet items, i.e., their net worth, and is reflected in a rise in the external finance premium.

Our examination of the balance sheet channel involves comparing the investment behavior of financially constrained and financial unconstrained firms after an EA monetary policy shock. Following the literature, we consider several proxies for financial constraints—the age of the firm, leverage, liquidity, and the net worth of the firm.

The foreign currency borrowing cost channel: An EA monetary policy shock affects the cost of borrowing in euros for domestic firms through higher euro interest rates and a weaker exchange rate. This channel therefore combines the (foreign) interest rate channel and the exchange rate channel. To shed some light on this channel, we focus on firm size and argue that it is a proxy for a firm's propensity to borrow in euro. Comparing the investment behavior of small and large firms reveals the role of euro funding costs. This is especially important for an economy with a high degree of credit euroization; without loans denominated in euro, the channel would not exist.

The three channels—one real economy channel and the other two financial channels—provide a picture of how the Czech real economy is affected by EA monetary policy. In theory, credit euroization strengthens the financial channels and thus amplifies the effects of EA monetary policy shocks (Audzei et al, 2025).

**Results**

EA monetary policy spillovers represent an important influence of the external environment on the Czech real economy. The estimation results reveal an important role of EA monetary policy spillovers through the trade channel. Foreign demand is a driving force behind the spillovers. In addition, we find some evidence for the balance sheet channel, especially before 2014. EA MP shocks affect domestic investment through firms' balance sheets when financial conditions are tight. Financially constrained firms then reduce their investment after a monetary policy contraction in the EA.

On the other hand, the foreign currency borrowing cost channel has been relevant since 2014, when credit euroization of the Czech economy started to be significant. Firms with loans denominated in euro react more strongly to EA monetary policy shocks.

Next, we detected a change—a significant weakening—in the strength of the spillovers in 2014. After this year, the investment response of an average firm to an EA monetary policy shock becomes virtually insignificant. The weakening of spillovers coincides with the period of unconventional monetary policy measures in the EA: negative interest rate policy (NIRP), forward guidance, and quantitative easing (QE), which the ECB started to implement around 2014. The transmission of these policies to the real economy or inflation has been found to be different and weaker than that of conventional instruments.[2] The weaker transmission of monetary policy shocks to the EA real economy implies a smaller effect on demand for Czech exports. Similarly, the loose financial conditions and credit inflows into the domestic economy after 2014 imply no effect of firms' financial constraints. The weakening is not offset by the emergence of the foreign borrowing cost channel, which strengthens the spillovers to the Czech real economy.

**Related literature**

Our paper contributes to the literature on monetary policy spillovers. There is a vast literature based on aggregate data that studies the effects of conventional and unconventional US and EA monetary policy shocks on the exchange rate and real variables in other countries; examples include Dedola et al. (2017), Georgiadis and Jarociński (2025), Miranda-Agrippino and Nenova (2022), and Ca' Zorzi et al. (2020). Engler et al. (2024) and Walerych and Wesołowski (2021) find that EA spillovers are much more powerful than US spillovers in selected Central and Eastern European (CEE) and emerging European countries. Significant spillovers to the six EU countries outside the EA are further confirmed by Babecká Kucharčuková et al. (2016). Moreover, Potjagailo (2017) finds a significant role of trade and financial integration for the strength of spillovers. We contribute to the literature by studying EA policy spillovers to a developed small open economy using disaggregated data and by zooming in to the channels of spillovers. Our approach is in line with the research stream using disaggregated data[3] to examine spillovers: Di Giovanni and Rogers (2023) and Arbatli-Saxegaard et al. (2025). In this paper, we extend their analysis to take into account domestic credit in euro and focus on EA monetary policy.

Our study relates to the literature on unconventional monetary policy spillovers. Babecká Kucharčuková et al. (2016) find that in contrast to conventional monetary policy, the spillovers of unconventional policies to the real economy are delayed and muted, though heterogeneous. Heterogeneity is further confirmed by Engler et al. (2024) for emerging European economies and by Moder (2019) for economies in Southeastern Europe. The greater heterogeneity in response to QE and QT could be explained by the targeting of specific segments of EA financial markets, to which countries are exposed differently (Babecká Kucharčuková et al., 2016). McQuade et al (2015) and Bluwstein and Canova (2016) find positive financial spillovers from unconventional monetary policy shocks; Moder (2023) shows that euro retail rates outside the EA are related to euro area shadow rates, which indicates spillovers through the financial sector. We differ from this literature by studying spillovers to the real economy, and using disaggregated data. We do not intend to compare spillovers from conventional and unconventional policies, but rather observe that the

[2] Examples include but are not limited to Altavilla et al., 2022 who show that the banks pass on NIRP to deposit and lending rates, but the pass-through is weaker than in the positive territory; Borio and Gambacorta, 2017 and Fungačová et al, 2023, show weaker NIRP transmission through the bank lending channel; Laine and Pihlajamaa, 2024, show muted NIRP transmission to inflation.

[3] The disaggregated data take the form of firm-level or industry-level data.

spillovers were smaller during the episode, in which unconventional monetary policies were implemented.[4]

Predictions from structural models on QE spillovers depend on whether the stimulative effects of a rise in foreign demand exceed the contractionary effects of an appreciation followed by quantitative easing (Kolasa and Wesołowski, 2020; Alpanda and Kabaca, 2020; Hashmi and Nsafoah, 2024). We find that the spillovers are weaker after 2014, when the ECB was implementing unconventional policies.

Our empirical strategy draws on the literature that uses disaggregated firm-level data to examine the transmission channels of monetary policy: Durante et al. (2022) and Cloyne et al. (2023). Similar disaggregation at the industry level is employed in Choi et al. (2024). We extend the analysis by looking at foreign monetary policy instead of domestic monetary policy to study the role of spillovers.

The paper is structured as follows. In Section 2, we start by describing the connectedness between the small open economy in question—Czechia—and the EA, showing that the Czech case is relevant for other economies neighboring the EA. Section 3 describes the data, and we set our empirical strategy in Section 4. In Section 5, we describe the results. The last section concludes.

## 2. Setting the Stage: Czech Economic Links to the EA

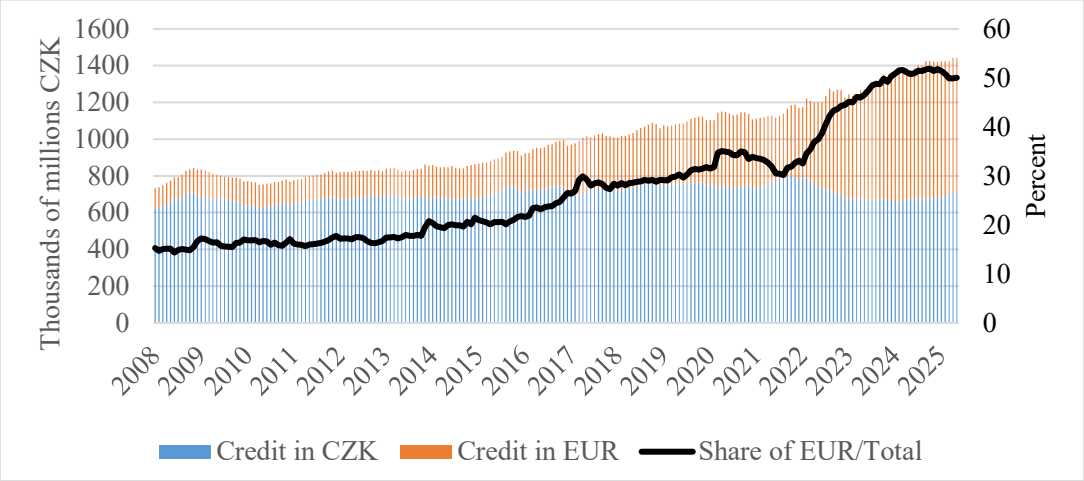
The Czech economy is an example of a small open economy with an independent currency. It is closely connected with the EA through trade. The EA has been its major trade partner over the last twenty years—exports to the EA account for about 40 percent of Czech GDP. This makes the Czech economy heavily dependent on demand from the EA.[5]

Czechia also has strong financial links with the EA. One aspect of this is domestic credit issued in euro. The share of euro-denominated loans provided by Czech banks to Czech non-financial corporations has grown over the last ten years (starting in 2014), while credit in other currencies—mostly the Czech koruna (CZK)—has been fairly stable (Figure 1). The year 2014 was marked by two major events, both of them with a potential impact on EA monetary policy transmission. One was the commencement of NIRP by the ECB (followed by QE and QT) and the other was the launch of the Czech exchange rate commitment (November 2013–April 2017). Euro-denominated loans currently make up about half of all loans issued by domestic banks to firms domiciled in Czechia. Firms' credit euroization can alter the transmission channels of both domestic monetary policy and EA monetary policy spillovers, as discussed in Audzei et al. (2025).

[4] In general, comparing the impact of conventional and unconventional policies is not straightforward, as they affect interest rates at different maturities. Georgiadis and Jarociński (2025), when comparing conventional instruments and forward guidance for the Fed policy spillovers show that if a policy tool is normalized to impact 2-year Treasury yield by the same amount, the spillover of conventional instrument to rest of the world output is twice larger. The same exercise for 1-year Treasury yield results in spillovers being similar for forward guidance and traditional policy tools.

[5] Around 75 percent of value added in Czech industry is produced in manufacturing, with manufacture of motor vehicles, manufacture of fabricated metal products, and manufacture of electrical equipment being the largest contributors.

***Figure 1. Composition of Total Loans (Left-Hand Scale) and Share of Loans in Euro (Right-Hand Scale) to Nonfinancial Institutions vis-à-vis Domestic Banks, Percent***




***Note:*** The series are from the Czech National Bank ARAD database: client loans: monthly, residents—non-financial corporations, total, balance (left-hand scale); the share of loans in euro (right-hand scale) is calculated as the share of loans issued in euro in total loans issued, all in CZK million.

***Figure 2. Share of Foreign Currency Loans***

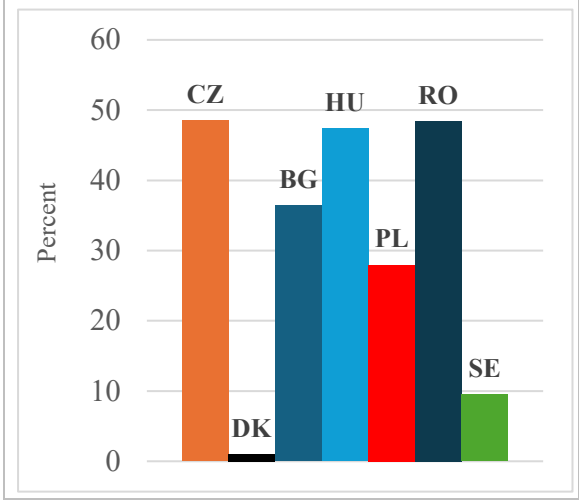
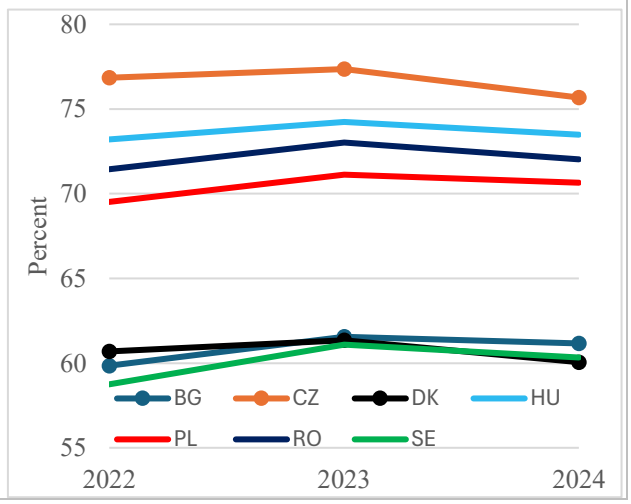



***Figure 3. Share of Trade with EU***




***Note:*** The series of foreign currency loans are taken from the ECB for September 2025. These are loans to non-financial corporations—domestic residents provided by monetary and financial institutions. The share of trade with the EU is taken from Eurostat and is calculated as exports plus imports to the EU market over total exports plus imports. The two-letter EU country codes are as follows: Bulgaria (BG), Czechia (CZ), Denmark (DK), Hungary (HU), Poland (PL), Romania (RO), Sweden (SE).

When compared to other EU member countries with independent currencies, Czechia can be viewed as a typical example in terms of the share of loans in foreign currency and trade links to neighboring EU countries. Figure 2 shows that the share of credit in euro is large in Central and Eastern European countries and is non-negligible in Scandinavian countries. All these countries are closely integrated with the rest of the EU, as shown in Figure 3.

# 3. Data

In this section, we describe the data used in our empirical exercise. We use firm-level data together with macroeconomic variables and monetary policy shocks.

## 3.1 Firm-Level Data

The firm-level balance sheet data are taken from the Quarterly Survey of Financial Indicators conducted by the Czech Statistical Office. The series start in 2008. The survey covers non-financial corporations. We keep only those firms which are in the survey for at least 8 quarters in a row and we drop observations with negative, zero, missing values for fixed assets and those for which total assets are different from total liabilities. We focus on manufacturing (durables and nondurables) and services. See Appendix A.1 for the exact definition of sectors.[6] Finally, we end our sample in 2020Q1 in order to avoid discussing phenomena related to the COVID-19 pandemic and Russia's invasion of Ukraine. Extreme uncertainty and fiscal policy have presumably affected firms' behavior significantly since 2020Q1 and could blur our general analysis of the transmission channels of international spillovers.

Table 1 reports the basic characteristics of the firm-level dataset. The average amount of assets per firm in the dataset is CZK 2,596 million, with fixed assets comprising less than half (CZK 1,158 million). Average net investment in fixed assets per quarter is CZK 27 million. The total number of firms in the dataset is 2,458. The average number of firms in a quarter over 2008Q1 to 2020Q1 is 1,488, the minimum occurring in 2008Q1 (966 firms) and the maximum in 2015Q4 (1,577 firms). On average, a firm stays in the survey for 30 quarters, with the largest bin being 49 quarters, comprising 613 firms. The total number of firm-quarter observations is 72,913.

***Table 1: Summary Statistics***

| | Assets (mil CZK) | Fixed assets (mil CZK) | Investment (mil CZK) |
|---|---|---|---|
| Mean | 2,596.23 | 1,158.51 | 26.99 |
| Std | 7,452.48 | 3,669.94 | 194.34 |
| Min | 0.27 | 0.00 | -2,406.97 |
| Max | 238,024.99 | 94,955.71 | 18,041.12 |

Notes: Sample covers period 2008Q1–2020Q1, construction dropped.

Fixed assets are tangible and intangible fixed assets in quarter *t*, $TIFA_t$. The dataset does not allow us to distinguish between these two components of fixed assets. The investment rate in quarter *t* is computed as follows:

$$I_t \equiv \frac{TIFA_t - TIFA_{t-1}}{TIFA_{t-1}}.$$

The observed investment rates suggest that investment is lumpy (Figure 4). The vast majority of firms invest between 0 and 5 percent per quarter, with additional peaks around 20 and 25 percent. Investments take the form of a big investment once every few years. A discussion of the coverage

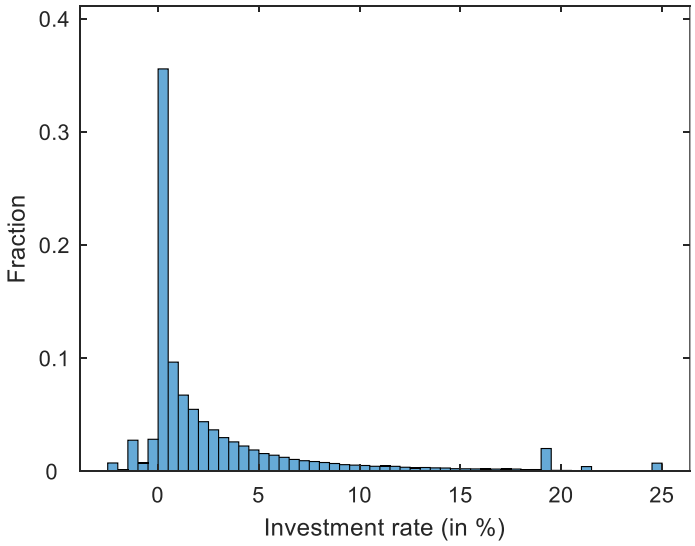
[6] We drop the construction sector from our analysis. The Czech construction sector demonstrates a long-term decline in value added, with its dynamics seemingly unrelated to monetary policy and short-term fluctuations but rather driven by structural factors such as population growth, a declining number of building permits issued, and frictions in urban planning. For details, see Grossmann et al. (2025).

of our firm-level dataset and a demonstration of its national representativeness can be found in Appendix A.3. The composition of the average firm balance sheet and its evolution over time is presented in Appendix A.2. It turns out that the composition of the average balance sheet does not change much over time.

In addition, we compute several balance sheet characteristics (net worth, leverage, and liquidity). Net worth is calculated as liquid assets (cash, inventories, assets with maturity less than a year, and stocks) plus fixed assets less liquid liabilities (bonds, credit, and other liabilities with maturity less than a year) over total assets. Leverage is long-term debt over total assets. Finally, liquidity is defined as liquid assets over total assets. All characteristics in the form of ratios are winsorized in order to get rid of the influence of outliers. The size of a firm is the log of its total assets.

We use the age of a firm as one of several proxies for its financial constraints. The age of a firm is taken from the Registry of Economic Subjects, where a firm's identification number can be linked to its year of establishment.[7] Firms which ceased to exist more than four years before the current date are not included in the dataset. As a result, we are not able to link around 10 percent of firms to their date of establishment and hence their age. Therefore, the sample size for regressions with the age of firms is smaller.

***Figure 4. Sample Distribution of Investment Rates***




***Source:*** Own computations and Quarterly Survey of Financial Indicators, Czech Statistical Office.

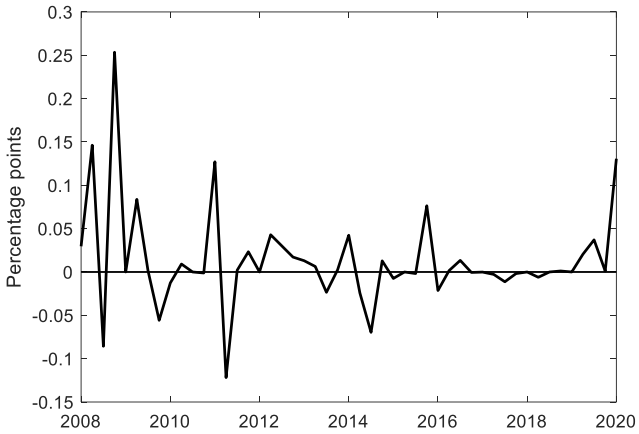
## 3.2 Monetary Policy Shocks and Other Macroeconomic Variables

We take the EA monetary policy shocks from Jarociński and Karadi (2020) and sum them to obtain quarterly shocks. Robustness checks with respect to the series of quantitative easing shocks can be found in Appendix B.4. Shocks from Jarociński and Karadi (2020) represent an exogenous movement in monetary policy and thus are suitable to be employed in local projections. The monetary policy shocks are based (among other variables) on three-month EONIA swap changes in a short time window around ECB press statement and press conference. This means that *all* monetary policy actions that are reflected in the rate are included in the dataset. This is important

[7] https://csu.gov.cz/produkty/registr-ekonomickych-subjektu-otevrena-data

because our analysis covers the period of the switch to negative rates, forward guidance, and quantitative easing/tightening, which affect longer interest rates. Non-zero shocks estimated after 2014 suggest that some aspects of unconventional measures are indeed present in the shocks measure (Figure 5).

***Figure 5. EA Monetary Policy Shocks***




***Note:*** Monetary policy shocks are taken from updated series of shocks from Jarociński and Karadi (2020).

In addition to the series of monetary policy shocks, we work with several macroeconomic variables. The proxy for the EA export intensity of a sector is based on the aggregate EA exports to GDP ratio, while the proxy for the share of domestic credit in euro in the total domestic credit of a subgroup of firms is based on the aggregate credit in euro to total credit ratio. We take the gap of the ratio (based on HP filtered series) in order to detrend the observed share and focus on business cycle phenomena.

Moreover, we use the CZK/EUR exchange rate, the domestic monetary policy rate represented by 3-month interbank rate (PRIBOR3M), the domestic medium-term interest rate (PRIBOR1Y), Czech GDP growth, EA GDP growth, the federal funds rate, the CZK/USD exchange rate, and the log of VIX. The VIX index is used to account for the global financial cycle. VIX has been found to be affected by US monetary policy surprises (see Rey, 2015, and Dedola et al., 2017). The federal funds rate is included because the international spillovers of US monetary policy are estimated to be strong for many economies (Arbatli-Saxegaard et al., 2025), so we aim to filter them out.

## 4. Empirical Model

We employ panel local projections (OLS-LP) from Jordà (2005) and estimate several specifications discussed in detail in the following subsections. In general, the empirical model looks like this:

$$\Delta^h I_{i,t-1} = \alpha_i^h + \sum_c \beta_c^h * D_{i,t-1}^c * Shock_t + \sum_c \gamma_c^h * D_{i,t-1}^c + \Gamma^h * \boldsymbol{X}_{i,t-1} + \Lambda^h * \boldsymbol{Z}_{i,t} + \delta_q^h + \varepsilon_{i,t+h}, \quad (1)$$

where the dependent variable $\Delta^h I_{i,t-1} \equiv I_{i,t+h} - I_{i,t-1}$ i.e., the $h$-quarter forward difference in the investment rate. Dummy variables $D_{i,t-1}^c$ indicate whether firm $i$ in quarter $t-1$ belongs to category $c$. If they are time invariant $\left(D_{i,t-1}^c = D_i^c\right)$, i.e., if the firm does not change its category

over time, they are included in the interaction with the shock only because the firm's fixed effects ($\alpha_i^h$) capture the same effect as the dummy for category *c*. The lagged value of the dummy variable is used to account for any change in the category of a firm after the monetary policy shock and the general economic shock in quarter $t$.

The variable $Shock_t$ denotes the exogenous EA monetary policy shock. EA monetary policy shocks by construction are not affected by EA macroeconomic factors. In addition, for the small open Czech economy it is reasonable to assume that domestic macroeconomic variables do not affect EA variables and thus are orthogonal to EA monetary policy shocks as well. The same goes for firm-specific variables.

The vector $\boldsymbol{X}_{i,t-1}$ includes one lag of the shock variable and one lag of the difference of the investment rate to deal with autocorrelation of residuals (and thus efficiency of estimates). Adding the vector does not affect the mean of the coefficient estimate for the shock variable because of the exogeneity of the shock.

Next, the vector $\boldsymbol{Z}_{i,t}$ is added, which contains additional macroeconomic variables and firms' balance sheet characteristics. The macroeconomic variables are used when estimating the particular channel of spillover transmission. Foreign monetary policy shocks presumably affect domestic monetary policy and the exchange rate systematically. We then need to control for a systematic relationship by adding the monetary policy rate and the exchange rate in quarter *t*. For example, we need to control for the exchange rate in order to distinguish between the balance sheet channel and the foreign currency borrowing cost channel. In various robustness checks, vector $\boldsymbol{Z}_{i,t}$ includes some additional variables, mainly to check robustness with respect to possible endogeneity.[8]

The specification also includes quarterly dummies $\delta_q^h$ to account for seasonality. Standard errors are clustered by firm and time.

In what follows, we present the difference in the responses between various categories of firms together with 95 percent confidence intervals. Confidence bands are obtained for these differences by changing the reference category in (1). For example, for young and old firms, the interaction of a firm's age with the shock is included for both young and old firms (the base category is the $Shock_t$ term alone). Changing the base category from $Shock_t$ to $Shock_t xD_{i,t-1}^{Old}$ allows for direct assessment of the statistical significance of the difference between the effects of the shock on old and young firms.

# 5. Results

## 5.1 Average Effect (and Its Evolution over Time)

We start with the average effect of the future investment rate after a restrictive EA monetary policy shock of size 1 percentage point (pp), employing the following variant of the model in (1):

$$\Delta^h I_{i,t-1} = \alpha_i^h + \beta^h * Shock_t + \Gamma^h * \boldsymbol{X}_{i,t-1} + \Lambda^h * \boldsymbol{Z}_{i,t} + \delta_q^h + \varepsilon_{i,t+h}. \quad (2)$$

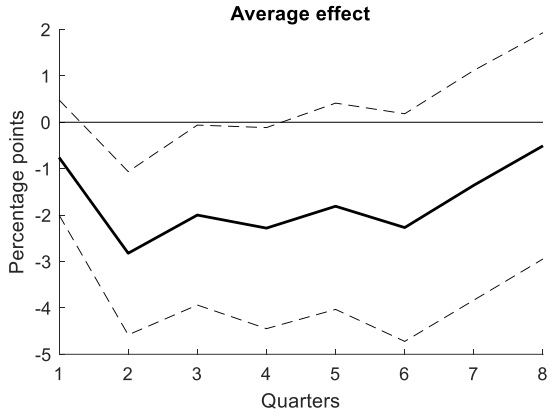
[8] Note that if we were able to employ a more diversified cross-sectional dimension of data, we would use fixed effects instead of macroeconomic variables to deal with endogeneity. This would be the case, for example, if we had a similar dataset for other countries as well. In such case, country-sector-quarter fixed effects could be employed instead of macroeconomic variables.

More precisely, taking the estimate of $\hat{\beta}^h$ for $h = 1, \dots, 8$ we obtain the dynamic effect of the shock on the future investment rate of an average firm over a horizon of 8 quarters. The average effect involves all channels of spillovers. Note that the size of the shock represents the surprise in three-month EONIA swap.

We control for a lag of the investment rate and a lag of the shock variable ($\boldsymbol{X}_{i,t-1}$) and the domestic short-term interest rate ($\boldsymbol{Z}_{i,t}$) to filter out the systematic reaction of domestic monetary policy to EA monetary policy shocks, i.e., to obtain the independent effect of EA monetary policy spillovers. The robustness check then includes specifications with $\boldsymbol{Z}_{i,t}$ extended for EA GDP growth, the log of VIX, and the federal funds rate.

After an unexpected monetary policy tightening in the EA, the future investment rate of an average Czech firm declines by up to 3 pp and then returns slowly (Figure 6). The profile of the response follows the usual findings in the literature. The magnitude of the effect is economically meaningful. A 3 pp decline well exceeds the median of the absolute QoQ changes in the investment rate in our dataset (1.04).[9]

***Figure 6. Average Firm Response of the Investment Rate to a Contractionary EA Monetary Policy Shock of Size 1 pp***



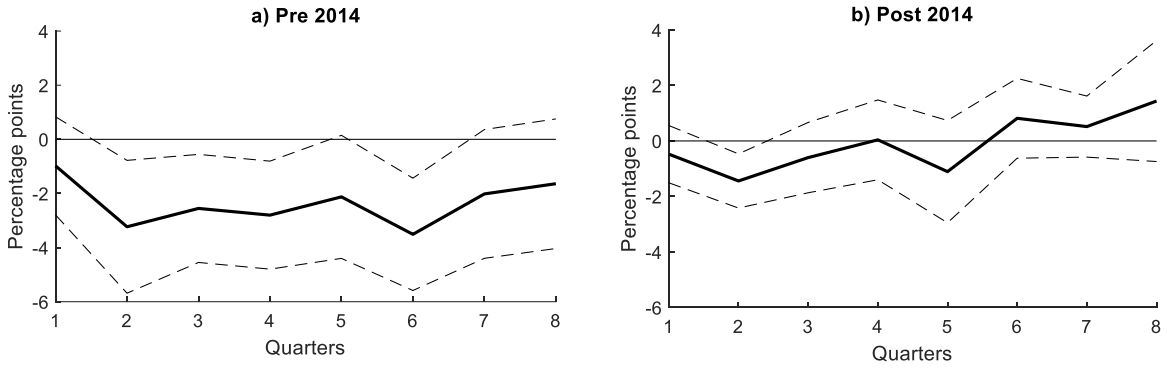

***Note:*** The dashed lines indicate the 95 percent confidence interval. Model estimated on 2008Q1–2020Q1.

In addition, the lagged investment rate coefficient is negative, reflecting the lumpy nature of firms' investment. The coefficient on the domestic monetary policy rate exhibits a negative sign, following the theoretical effect of a domestic monetary policy tightening on firms' investment. Appendix B.1 presents the full estimation results.

The results presented in the rest of this section reveal remarkable heterogeneity of firms' investment behavior across both time and firms. The average effect thus hides important regularities, suggesting the importance of using firm-level data. We start our examination of heterogeneity with a subsample analysis.

[9] The standard deviation of the dependent variable (*h*-quarters-ahead difference in investment rate) is between 5.46 and 6.10. Then the size of the effect (3 pp) represents a medium movement in the dependent variable. Durante et al. (2022) estimated the effect around 20 to 30 pp for firms in the euro area. Not surprisingly, spillovers account for smaller magnitude than direct effects estimated in the euro area.

***Figure 7. Average Firm Response of the Investment Rate to a Contractionary EA Monetary Policy Shock of Size 1 pp before 2014 and after 2014***




***Note:*** The dashed lines indicate the 95 percent confidence interval. Model estimated on subsamples 2008Q1–2013Q4 (panel a) and 2014Q1–2020Q1 (panel b).

There is strong evidence of a difference in the investment behavior of an average firm following an EA monetary policy tightening shock before and after 2014 (Figure 7). The response is stronger before 2014 than after it. After 2014, it is statistically significant only in the second quarter after the shock occurs. For the rest of the period, firms do not exhibit a statistically significant response. Spillovers of EA monetary policy to the Czech real economy almost disappeared after 2014. The finding is robust to the measure of monetary policy shock. When employing QE shocks from Altavilla et al. (2019), the negligible effect of shock on investment after 2014 remains. See Appendix B.4.

Note that the model in (2) is estimated separately for the two subsamples. This means that a firm's fixed effects can differ across the two subsamples. Moreover, we control for various balance sheet characteristics. The difference in the responses is thus not a consequence of unobserved or observed firm-level characteristics that are constant (averaged) over the subsample. Therefore, the reason should lie outside firms. Potential explanation could be low interest rates and the launch of unconventional monetary policy measures both in the EA and in Czechia.[10] The share of credit denominated in euro, which exhibits an increasing trend in the later subsample, should make the response to an EA monetary policy shock rather stronger. The observed weakening thus excludes the increasing share of credit in euro as a dominant factor behind the change of investment behavior.

In order to shed some light on the reasons behind the change of investment behavior around 2014, we separately examine the main channels of spillovers in the following subsections. We present impulse responses of the investment rate for different groups of firms. This differential approach helps us understand the relevance of various channels of spillovers and their change over time.

## 5.2 Export-Related Trade Channel

We start with the export-related trade channel of EA monetary policy spillovers. This channel is related to EA demand for domestic goods and services.

[10] Another possible reason for the change in investment behavior before and after 2014 is domestic macroprudential policy, which could have affected firms through the supply of bank credit. However, macroprudential measures in Czechia often take the form of borrower-based measures focused on households. Czech banks have a capital surplus, and a change in capital buffers is not expected to have a strong effect.

We focus on the difference in the investment responses after an EA monetary policy shock between firms producing durable goods and those producing nondurable goods. Empirical studies (e.g., Peersman and Smets, 2005) show that sectors producing durable goods are affected more strongly by EA monetary policy than sectors producing nondurable goods, i.e., demand for durables is more interest rate sensitive than demand for nondurables. Durable goods consumption can be postponed and thus falls more significantly than nondurable goods consumption after an interest rate increase.

The different sensitivity of demand is reflected in exports from the Czech economy—firms exporting durable goods are more strongly affected by an EA monetary policy shock through EA demand. Consequently, Czech firms producing durable goods have different investment behavior than those producing nondurables. If we control for the different export intensity of an average firm producing durables and an average firm producing nondurables, the difference in investment is consistent with the existence of the trade channel of EA monetary policy spillover transmission. Note that we use aggregate export intensity interacted with the dummy for firms producing durables (nondurables) as a proxy for export intensity in the sector of durables (nondurables).

Foreign monetary policy shocks could systematically affect domestic monetary policy and the exchange rate and consequently the investment of firms. To estimate the difference in investment behavior related solely to the export-related trade channel, we need to filter out the effect of domestic monetary policy. In addition, to distinguish between the direct effect of EA demand on investment and the effect of exchange rate depreciation, we estimate specifications with the exchange rate (the benchmark) and without it. The benchmark specification of the empirical model thus includes the exchange rate and the domestic monetary policy rate in quarter *t*.

Investment of firms producing durables falls more than that of firms producing nondurables (Figure 8). While the effect on investment is economically and statistically significant for the first year after the shock for firms producing durable goods, the response for firms producing nondurable goods exhibits a moderate fall in the investment rate after a year. The difference in the responses suggests the existence of the export-related trade channel of EA monetary policy spillovers.[11]

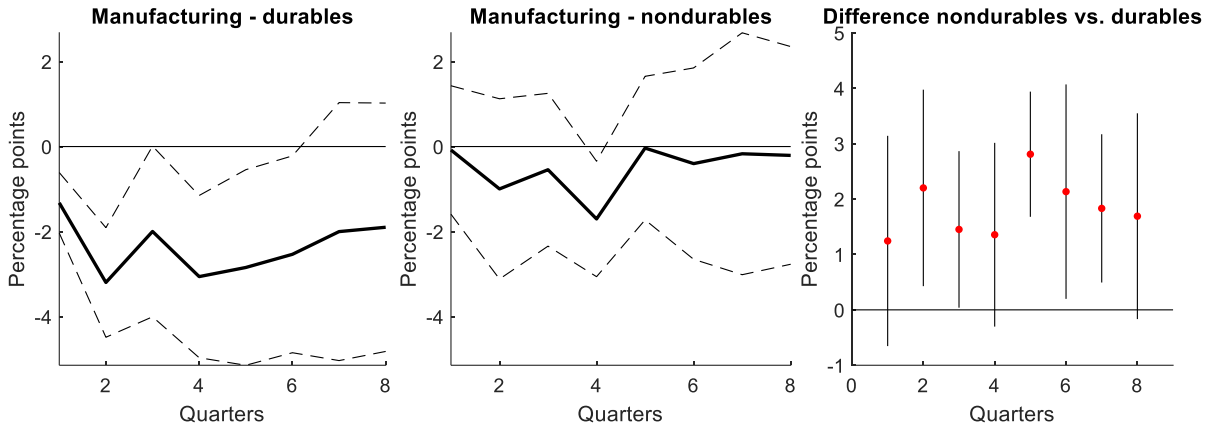
As a robustness check, we add domestic and EA GDP growth, VIX, and the federal funds rate to the specification to account for the possibility that EA monetary policy shocks are not truly exogenous. Similarly, we add the CZK/USD exchange rate in order to control for change in demand related to the CZK/USD exchange rate being affected by EA MP shocks via the EUR/USD exchange rate. The results are unaffected when we test additional macroeconomic variables in the specification.

The existence of the trade channel is confirmed when we extend the sample for firms in services (Appendix B.2). Similarly to demand for nondurables, demand for services is less interest rate sensitive than demand for durable goods. The smaller response of the investment rate for firms in services than for firms producing durables reaffirms the existence of the trade channel.

To examine the role of the trade channel in the weakening of EA monetary policy spillovers documented in Section 5.1, we look separately at the difference in the effect for firms producing durables and nondurables before and after 2014 in Figure 9

[11] The specification without the exchange rate shows almost the same results; the coefficient on the exchange rate is not statistically significant for almost all horizons. This could be related to the fact that exporters are often importers, so a depreciation means cheaper exports but also more expensive imports. Another explanation could be the high portion of Czechia's trade with the euro area invoiced in EUR.

***Figure 8. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Firms Producing Durables and Nondurables***




***Note:*** The left and central panels show the response of the investment rate, while the right panel shows the difference between the two responses. The dashed lines in the left and central panels indicate the 95 percent confidence interval. The vertical lines in the right panel indicate the 95 percent confidence intervals. The dataset covers 2008Q1–2020Q1.

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The existence of the export-related trade channel is shown in both subsamples—before and after 2014 (Figure 9, upper and lower panels). The difference in investment behavior between firms producing durables and those producing nondurables remains, although the uncertainty related to the post-2014 estimation is notably higher. The channel exists both before and after 2014.

However, the response of the investment rate for firms producing both durables and nondurables weakens after 2014.[12] After a monetary policy tightening in the EA, Czech firms cut investment less. The reason could be the observed weakening of the interest rate channel in the EA during the period of unconventional monetary policies (see footnote 2). When EA monetary policy transmission to the EA real economy is weaker, demand for exports is weaker as well. This results in a weaker reaction of Czech exporters regardless of the durability of their products.

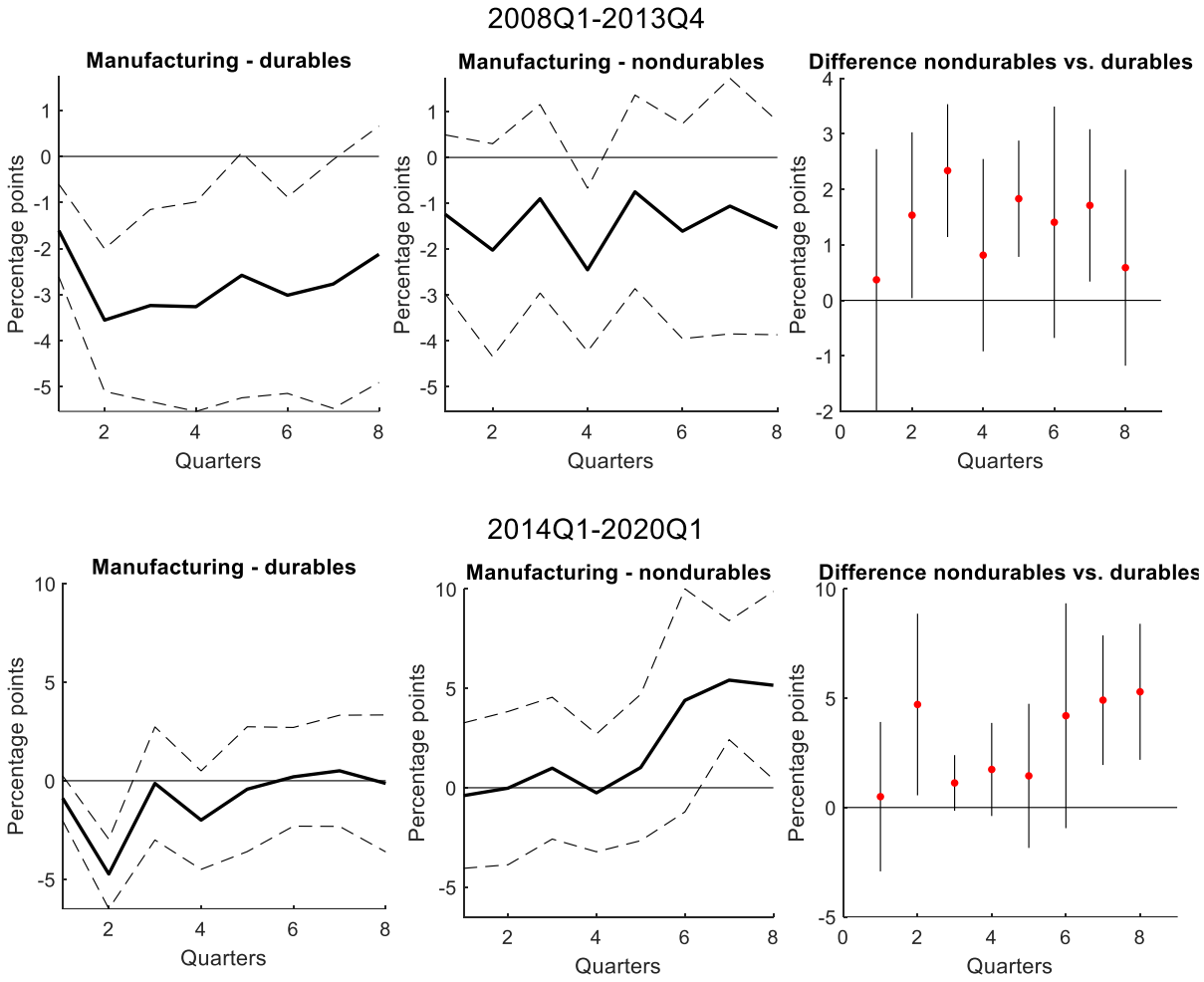
## 5.3 Balance Sheet Channel

The presence of the balance sheet channel is revealed by comparing the investment behavior of financially constrained and financially unconstrained firms. Financially constrained firms react more strongly to the change of financial conditions brought about by a monetary policy shock. In the literature, several proxies for financial frictions are employed (e.g., leverage, liquidity, and net worth)—see Durante et al. (2022) and di Giovanni and Rogers (2023). The problem is that those proxies may be endogenous. Even if we take a lagged proxy, it may still follow the business cycle like investment does, for example.

When examining the balance sheet channel, we include the exchange rate and the log of VIX as controls in the specifications. The former is meant to distinguish between the balance sheet channel and the foreign currency borrowing cost channel and the latter to filter out the global financial cycle, which is related more to US monetary policy than to EA monetary policy. As above, we also control for domestic monetary policy.

[12] The statistical significance is shown in Appendix B.3.

***Figure 9. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Firms Producing Durables and Nondurables and for Subsamples 2008Q1–2013Q4 and 2014Q1–2020Q1***



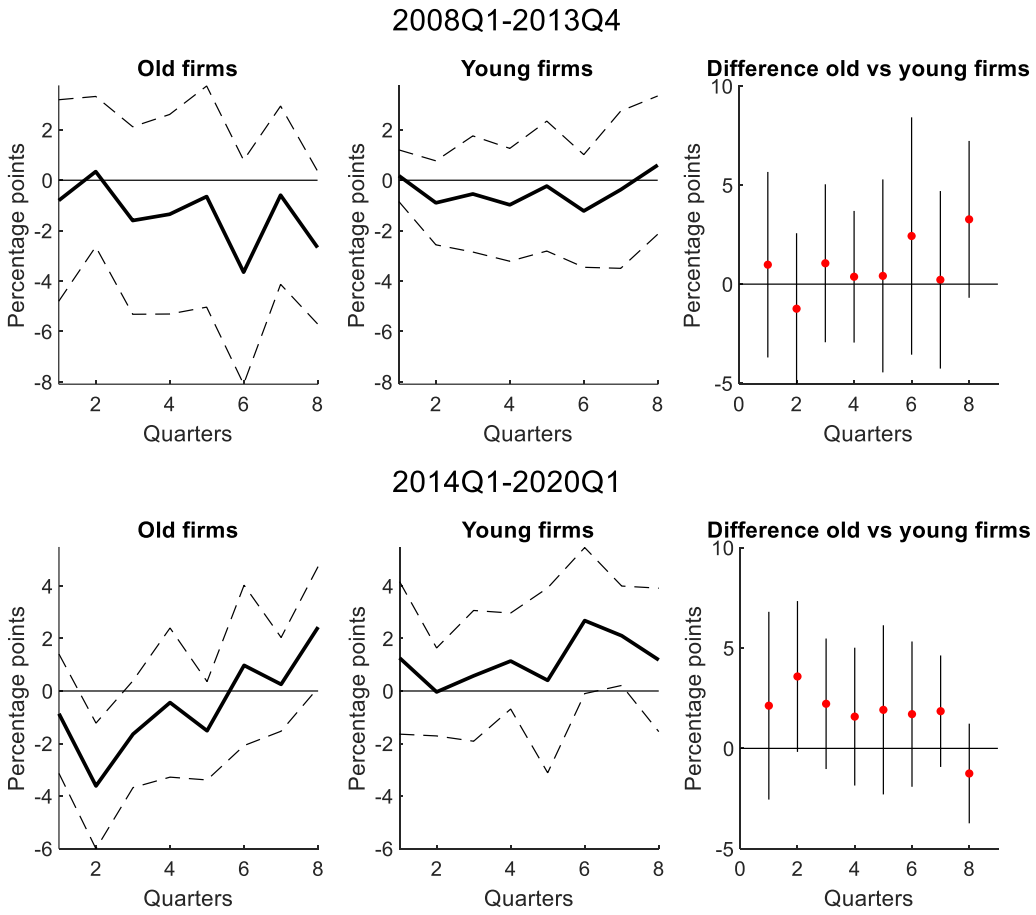

***Note:*** The left and central panels show the response of the investment rate, while the right panel shows the difference between the two responses. The dashed lines in the left and central panels indicate the 95 percent confidence interval. The vertical lines in the right panel indicate the 95 percent confidence intervals.

## Firm Age

The age of a firm often serves as a proxy for the extent of financial constraints (Cloyne et al., 2023; Durante et al., 2022). It is assumed that old firms are less financially constrained than young ones.

We find no evidence of different investment behavior between young and old firms (Figure 8). To examine the change in spillovers after 2014, we estimate the same specification before and after 2014Q1. Even though old firms react to the EA MP shock by reducing investment at the horizon of two quarters, there is no evidence that this reaction is statistically different from that of young firms (Figure 8, lower panels). The result is robust to the inclusion of balance sheet characteristics and the share of credit denominated in euro for old (young) firms, which is proxied by the aggregate share interacted with an age dummy. This is to control for differences in the share of euro credit and other balance sheet characteristics of an average young and old firm.

***Figure 10. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Old and Young Firms and for Subsamples 2008Q1–2013Q4 and 2014Q1–2020Q1***




***Note:*** The left and central panels show the response of the investment rate, while the right panel shows the difference between the two responses. The dashed lines in the left and central panels indicate the 95 percent confidence interval. The vertical lines in the right panel indicate the 95 percent confidence intervals.

## Other Proxies for Financial Constraints

One explanation of the same response for old and young firms is that there is no balance sheet channel of EA monetary policy spillovers. Of course, the other is that the age of a firm is not a relevant proxy for the extent of financial frictions in the case of Czech firms. This could be because the Czech banking sector went through a liberalization process in 1998 (some banks were privatized and the regulations were changed). Many of the old firms in our dataset were thus established at a time when all banks were state-owned. Their financial structure may have been set up to be heavily dependent on bank credit. This may not be the case for young firms established in the usual context of a private banking sector. In such circumstances, the age of a firm may not indicate the extent of financial constraints.

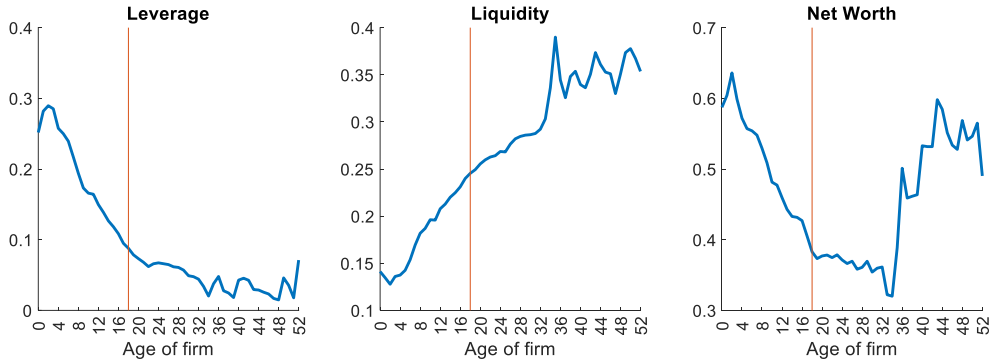
On the other hand, old firms are less leveraged on average, suggesting that bank credit is not a crucial element of their balance sheets (Figure 11, left panel). Figure 11 also suggests that young firms are more leveraged and less liquid than old firms (left and central panels). This observation is in accordance with the usual empirical findings (Ferrando and Mulier, 2015) and suggests that old firms are less financially constrained. Another aspect of using the age as a proxy for the extent of

financial constraints faced by a firm is whether the age is truly exogenous. As young firms that ceased to exist more than four years ago are not present in the current database of firm's age, estimation of specification with the age is affected if young (more financially constrained firms) leave the database after the tightening of monetary policy shock.

To shed some light on the contradictory suggestions based on the age of a firm, we estimate a specification with a firm's net worth. We do not estimate specifications with leverage and liquidity, as both are correlated with the age of a firm.[13]

Net worth is not clearly linked to age (Figure 11, right panel). It is defined as liquid assets plus fixed assets less liquid liabilities. In addition, net worth is normalized by the total amount of assets. Again, the specification includes the exchange rate in order to filter out the foreign currency borrowing cost channel. Endogeneity concerns related to balance sheet indicators are addressed by conducting robustness checks with specifications extended for other balance sheet items and macroeconomic variables. Finally, as in the specification with the age of a firm, we control for the share of credit in euro for firms with low (high) net worth by adding an interaction term for the aggregate share and a dummy indicating firms with low (high) net worth.

***Figure 11. Balance Sheet Characteristics According to Age of Firm, Ratio to Total Assets***



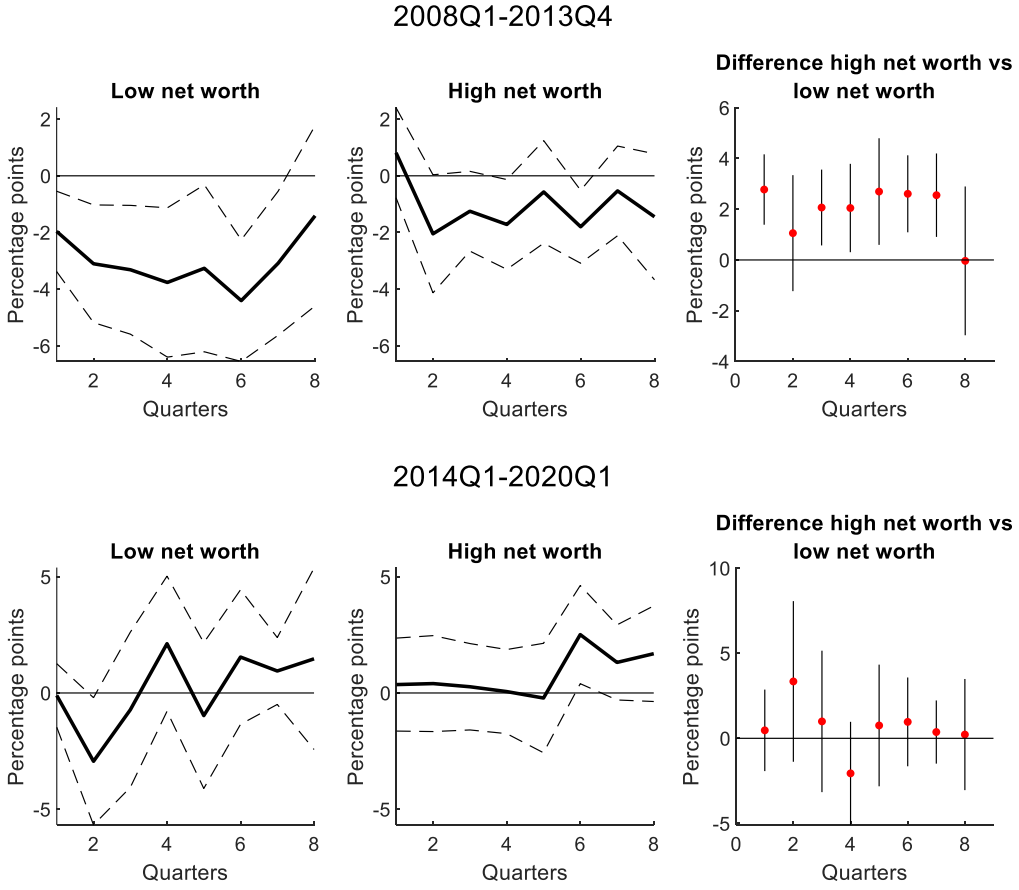

***Note:*** The figure reports the mean of the balance sheet characteristic over firms of a particular age relative to total assets. The horizontal axis reports the number of years since the establishment of the firm. The vertical lines indicate the distinctions between young and old firms (median age).

Firms with low net worth exhibit a greater reaction of investment to a contractionary monetary policy shock.[14] As shown in Figure 12, the effect is driven by the pre-2014 period. The finding is consistent with the existence of the balance sheet channel before 2014. After 2014, the financial conditions, represented, for example, by credit spreads, were loose due to unconventional monetary policy measures, so financial constraints (net worth) did not play a significant role. Quantitative easing pushed investors towards more risky credit via the portfolio-rebalancing channel. This explains why even low net worth firms do not reduce investment significantly and the balance sheet channel is not detected after 2014.

[13] Indeed, for leverage expressed as the ratio of long-term debt to total assets and liquidity, no clear-cut results are found (i.e., the majority of horizons do not exhibit a statistically significant difference between firms with no leverage and those with some leverage, and statistically significant differences show both directions).

[14] An average low net worth firm is more likely to be in the category of manufacturing producing durables, whereas a high net worth firm is more likely to be in services. When we estimate the specification for different sectors separately, the conclusions remain unaffected.

***Figure 12. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Firms with Low Net Worth and for Firms with High Net Worth and for Subsamples 2008Q1–2013Q4 and 2014Q1–2020Q1***




***Note:*** The left and central panels show the response of the investment rate, while the right panel shows the difference between the two responses. The dashed lines in the left and central panels indicate the 95 percent confidence interval. The vertical lines in the right panel indicate the 95 percent confidence intervals.

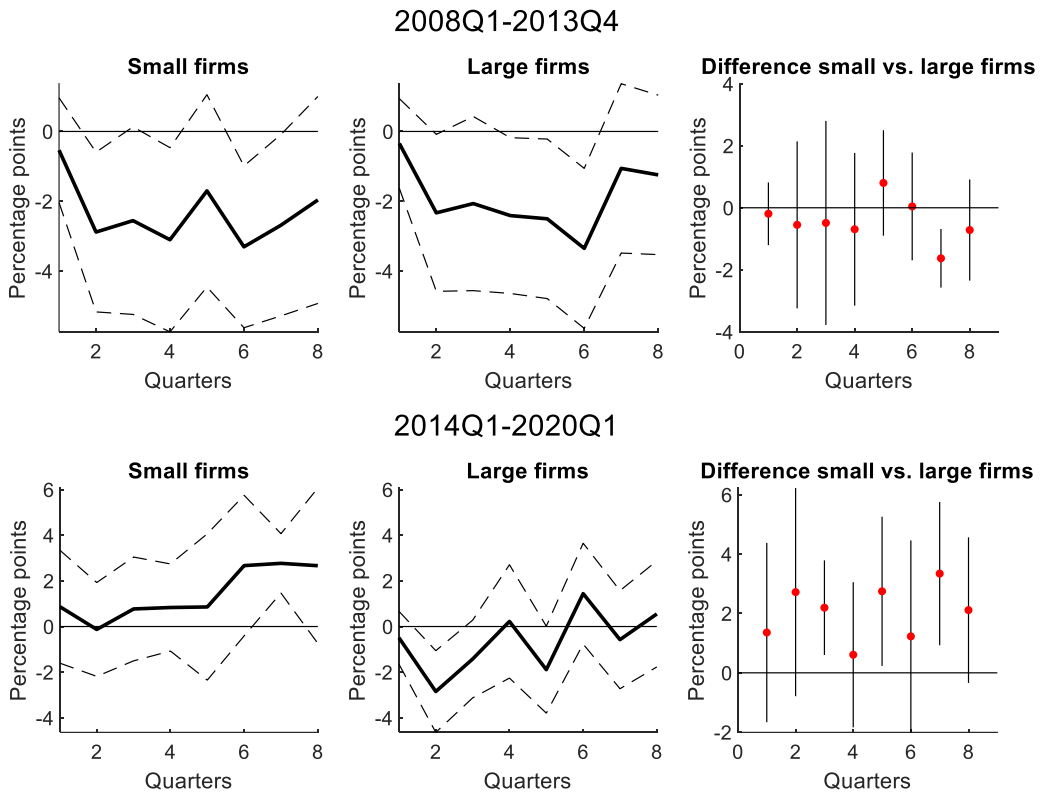
## 5.4 Foreign Currency Borrowing Cost Channel

The foreign currency borrowing cost channel affects investment decisions through the funding costs of debt denominated in euro. Credit euroization should thus imply an increasing role of the channel over time. The EA monetary policy tightening shock raises the koruna costs associated with debt denominated in euro through higher euro interest rates and due to depreciation of the domestic currency with respect to the euro. In the specification estimated in this section, we therefore do not control for the exchange rate. When we discussed the balance sheet channel in Section 5.3, the effect of the exchange rate on investment was filtered out by controlling for the exchange rate. In addition, the specification includes firms' net worth and the log of VIX to differentiate between the balance sheet channel and the foreign currency borrowing cost channel properly.

Applying the above differential approach, we compare the investment behavior of large firms with that of small firms. The motivation behind this is that in Czechia during 2019–2024, loans denominated in euro were usually big loans and were concentrated in large and medium-sized firms, while small loans were taken out by small firms and were denominated mostly in koruna (Gric et al., 2025).

In the literature (e.g., Cloyne et al., 2018), firm size is used as a proxy for financial constraints (large firms being less financially constrained than small ones). There is no clear link between size and age or net worth in our dataset.[15] We therefore view firm size as a relevant proxy for the propensity to borrow in euro not related to financial constraints.

***Figure 13. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Small and Large Firms and for Subsamples 2008Q1–2013Q4 and 2014Q1–2020Q1***




***Note:*** The share of credit is calculated relative to the size of the firm's balance sheet. The left and central panels show the response of the investment rate, while the right panel shows the difference between the two responses. The dashed lines in the left and central panels indicate the 95 percent confidence interval. The vertical lines in the right panel indicate the 95 percent confidence intervals.

The estimation shows that there is no difference in the investment response between small and large firms before 2014Q1 (Figure 11). However, after 2014, when the share of credit denominated in euro increased significantly, it is found that large firms cut investment more than small firms. Firms that rely more on borrowing in euro are affected more. This is consistent with the existence of the foreign currency borrowing cost channel.

While a difference arises after 2014, a weakening of the responses can be observed for both large and small firms, similarly to the trade and balance sheet channels. This means that the weakening of spillovers is not outweighed by the opening of the transmission channel related to borrowing costs, which makes the reaction of firms' investment in a highly credit-euroized economy stronger.

[15] The correlation between size and age is 0.07 and that between size and net worth is 0.02. The average age of small and large firms is 17 and 18 years, respectively. Net worth is also very similar for the two groups.

## 6. Conclusions

In this paper, we confirm the existence of EA monetary policy spillovers to firms' investment in a developed small open economy with an independent currency and strong trade and financial links with the EA. Using firm-level data for Czechia, we can assess the strength of different channels—trade and financial channels. Our results may be of interest to EA policy makers when considering spillovers to advanced small open economies outside but closely tied to the EA.

We find that the trade channel is the dominant channel of EA monetary policy spillovers, in the sense that it is present regardless of structural changes in the EA and Czechia. The effects of spillovers via other channels evolve over time. The balance sheet channel weakens during the period of loose financial conditions, while the foreign currency borrowing cost channel depends on the amount of loans denominated in euro.

We further find a weakening of EA monetary policy spillovers in the period of unconventional EA monetary policy. This finding is consistent with the literature indicating somewhat weaker transmission of some unconventional policies to the EA real economy.

In this paper, we discuss the role of firms in the transmission of international spillovers. Another avenue of research would be to look at the role of banks i.e. to examine the role of credit supply in firm's investment decisions.

## References

ALPANDA, S. AND S. KABACA (2020): "International Spillovers of Large-Scale Asset Purchases." Journal of the European Economic Association, 18(1), 342–391.

ALTAVILLA, C., L. BURLON, M. GIANNETTI, AND S. HOLTON (2022): "Is There a Zero Lower Bound? The Effects of Negative Policy Rates on Banks and Firms." Journal of Financial Economics, 144(3), 885–907.

ALTAVILLA, C., L. BRUGNOLINI, R. GÜRKAYNAK, R. MOTTO, AND G. RAGUSA (2019): "Measuring Euro Area Monetary Policy." *Journal of Monetary Economics*, 108, 162–179.

ARBATLI-SAXEGAARD, E., M. FIRAT, D. FURCERI, AND J. VERRIER (2025): "U.S. Monetary Policy Shock Spillovers: Evidence from Firm-Level Data." *Journal of International Money and Finance*, 158.

AUDZEI, V., J. BRŮHA, AND I. SUTÓRIS (2025): "Does Firms' Financing in Foreign Currency Matter for Monetary Policy?" *CNB Working Paper* 10/2025.

BABECKÁ KUCHARČUKOVÁ, O., P. CL AEYS, AND B. VAŠÍČEK (2016): "Spillover of the ECB's Monetary Policy Outside the Euro Area: How Different is Conventional from Unconventional Policy?" *Journal of Policy Modeling*, 38(2), 199–225.

BERNANKE, B. S., M. GERTLER, AND S. GILCHRIST (1999): "The Financial Accelerator in a Quantitative Business Cycle Framework." In: J. B. TAYLOR & M. WOODFORD (ED.), *Handbook of Macroeconomics*, Edition 1, Volume 1, Chapter 21, 1341–1393, Elsevier.

BLUWSTEIN, K. AND F. CANOVA (2016): "Beggar-Thy-Neighbor? The International Effects of ECB Unconventional Monetary Policy Measures." *International Journal of Central Banking*, 12(3), 69–120.

BORIO, C. AND L. GAMBACORTA (2017): "Monetary Policy and Bank Lending in a Low Interest Rate Environment: Diminishing Effectiveness?" *Journal of Macroeconomics*, 54(PB), 217–231.

CA' ZORZI, M., L. DEDOLA, G. GEORGIADIS, M. JAROCIŃSKI, L. STRACCA, AND G. STRASER (2020): "Monetary Policy and Its Transmission in a Globalised World," *ECB Working Paper* 2407.

CLOYNE, J., C. FERREIRA, M. FROEMEL, AND P. SURICO (2023): "Monetary Policy, Corporate Finance, and Investment." *Journal of European Economic Association*, 21(6), 2586–2634.

DEDOLA, L., G. RIVOLTA, AND L. STRACCA (2017): "If the Fed Sneezes, Who Catches a Cold?" *Journal of International Economics*, 108(1), S23–S41.

DI GIOVANNI, J. AND J. ROGERS (2024): "The Impact of U.S. Monetary Policy on Foreign Firms." *IMF Economic Review*, 72, 58–115.

DÖTTLING, R. AND L. RATNOVSKI (2023): "Monetary Policy and Intangible Investment." *Journal of Monetary Economics*, 134, 53–72.

DURANTE, E., A. FERRANDO, AND P. VERMEULEN (2022): "Monetary Policy, Investment and Firm Heterogeneity." *European Economic Review*, 148, 104251.

EGGERTSSON, G. B., R. E. JUELSRUD, L. H. SUMMERS, AND E. GETZ (2024): "Negative Nominal Interest Rates and the Bank Lending Channel." *Review of Economic Studies*, 91(4), 2201–2275.

ENGLER, P., G. FERRUCCI, P. ZABCZYK, AND Z. TIANXIAO (2024): "ECB Spillovers to Emerging Europe: The Past and Current Experience." *IMF Working Paper* 170.

FERRANDO, A. AND K. MULIER (2015): "Firms' Financing Constraint: Do Perceptions Match the Actual Situation?" *The Economic and Social Review*, 46(1), 87–117.

FUNGÁČOVÁ, Z., E. KEROLA, AND O.-M. LAINE (2023): "Monetary Policy Transmission Below Zero." *Bank of Finland Research Discussion Papers* 11/2023.

GEORGIADIS, G. AND M. JAROCIŃSKI (2025): "Global Spillovers from Multi-Dimensional US Monetary Policy." *Journal of International Economics*, 158, 104169.

GRIC, Z., J. JANKŮ, AND S. MALOVANÁ (2025): "Corporate Lending in Face of Domestic and Foreign Monetary Policy: Insights from AnaCredit." Presented at the Second Annual Czech National Bank Conference, Prague, September 25–26, 2025.

GROSSMANN, J., R. PAŠALIČOVÁ, AND Z. PIKHART (2025): "The Czech Housing Market in the Upward Phase of the Cycle." *Czech National Bank Monetary Policy Report*, Summer 2025.

HASHMI, A. R. AND D. NSAFOAH (2024): "International Spillovers of Conventional Versus New Monetary Policy." *Economic Modelling*, 139, 106812.

JAROCIŃSKI, M. AND P. KARADI (2020): "Deconstructing Monetary Policy Surprises—The Role of Information Shocks." *American Economic Journal: Macroeconomics*, 12(2), 1–43.

JORDÀ, O. (2005): "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review*, 95, 161–182.

KOLASA, M. AND G. WESOŁOWSKI (2020): "International Spillovers of Quantitative Easing." *Journal of International Economics*, 126, 103330.

LAINE, O.-M. AND M. PIHLAJAMAA (2024): "Pushing And Pulling On A String? Inflationary Effects of Expansionary and Contractionary Monetary Policies When Rates Are Negative." *Economic Modelling*, 131(C).

MCQUADE, P., M. FALAGIARDA, AND M. TIRPÁK (2015): "Spillovers From The ECB's Non-Standard Monetary Policies On Non-Euro Area EU Countries: Evidence From An Event-Study Analysis," *ECB Working Paper* 1869.

MIRANDA-AGRIPPINO, S. AND T. NENOVA (2022): "A Tale of Two Global Monetary Policies." *Journal of International Economics*, 136, 103606.

MODER, I. (2023): "The Transmission Of Euro Area Monetary Policy To Financially Euroized Countries." *Economics and Politics*, 35(3), 718–751.

MODER, I. (2019): "Spillovers from the ECB's Non-standard Monetary Policy Measures on Southeastern Europe." *International Journal of Central Banking*, 15(4), 127–163.

PEERSMAN, G. AND F. SMETS (2005): "The Industry Effects of Monetary Policy in the Euro Area." *Economic Journal*, 115(503), 319–342.

POTJAGAILO, G. (2017): "Spillover Effects from Euro Area Monetary Policy Across Europe: A Factor-Augmented VAR Approach." *Journal of International Money and Finance*, 172, 127–147.

REY, H. (2015): "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence." *NBER Working Paper* 21162.

HOHBERGER, S., M. RATTO, AND L. VOGEL (2023): "The Macroeconomic Effects of Unconventional Monetary Policy: Comparing Euro Area and US Models with Shadow Rates." *Economic Modelling*, 127, 106438.

ULATE, M. (2021): "Going Negative at the Zero Lower Bound: The Effects of Negative Nominal Interest Rates." *American Economic Review*, 111(1), 1–40.

WALERYCH, M. AND G. WESOŁOWSKI (2021): "Fed and ECB Monetary Policy Spillovers to Emerging Market Economies." *Journal of Macroeconomics*, 70, 103345.

# Appendix A: Data

## A.1 Definition of Sectors

Sector: Manufacturing (C)

| Industry | NACE code |
|---|---|
| *Durable industries:* | |
| manufacture of wood and products of wood and cork | 16 |
| manufacture of other non-metallic mineral products | 23 |
| manufacture of basic metals | 24 |
| manufacture of fabricated metal products | 25 |
| manufacture of computer and electronic products | 26 |
| manufacture of electrical equipment | 27 |
| manufacture of machinery and equipment | 28 |
| manufacture of motor vehicles and trailers | 29 |
| manufacture of other transport equipment | 30 |
| manufacture of furniture | 31 |
| *Nondurable industries:* | |
| manufacture of food products | 10 |
| manufacture of beverages | 11 |
| manufacture of tobacco products | 12 |
| manufacture of textiles | 13 |
| manufacture of wearing apparel | 14 |
| manufacture of leather | 15 |
| manufacture of paper and paper products | 17 |
| printing and reproduction | 18 |
| manufacture of coke and refined petroleum products | 19 |
| manufacture of chemicals and chemical products | 20 |
| manufacture of basic pharmaceutical products | 21 |
| manufacture of rubber and plastic products | 22 |
| repair and installation | 33 |

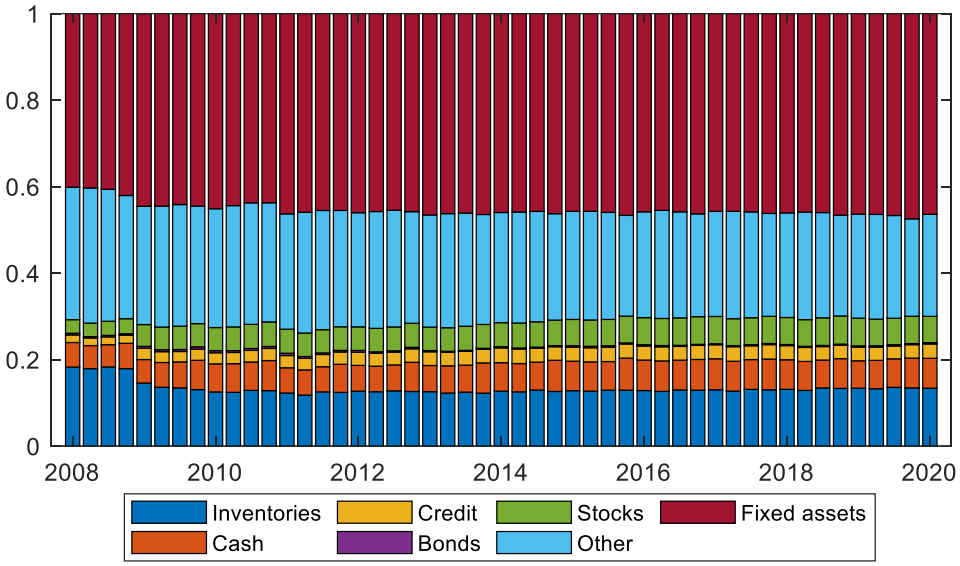
Sector: Construction (F)

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

accommodation and food services (I)
information, communication, and R&D (J and M)
administrative and support service activities (N)
transportation and storage (H)
wholesale retail and trade (G)

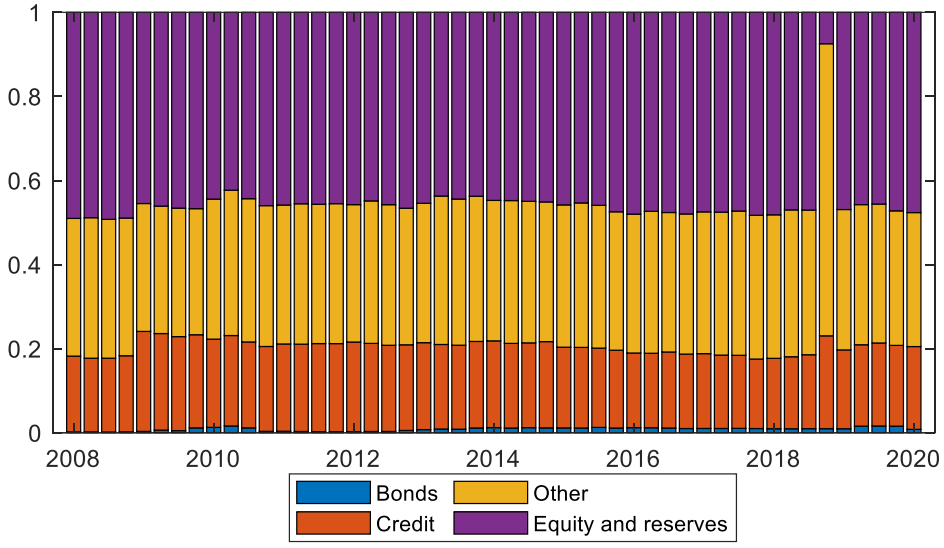
## A.2 Evolution of Balance Sheet Items

***Figure A1. Evolution of Firms' Assets***




***Source:*** Czech Statistical Office

***Figure A2. Evolution of Firms' Liabilities and Equity***

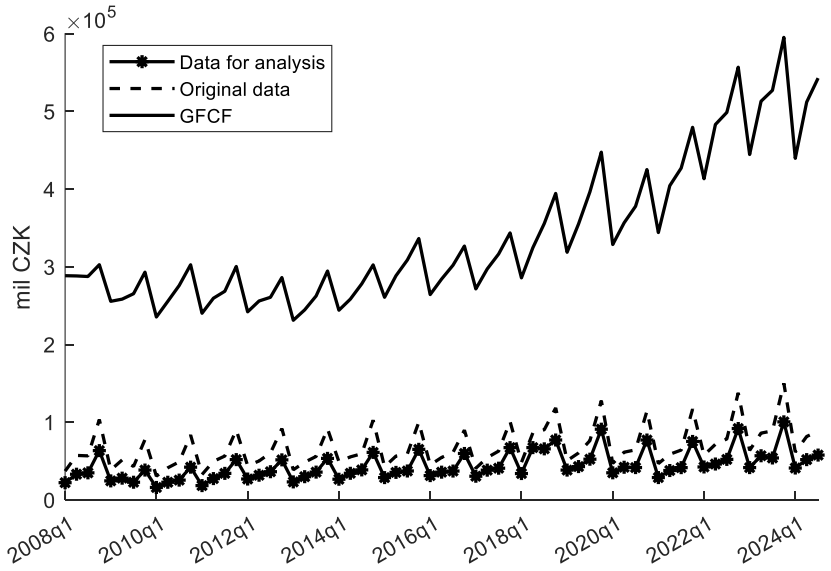



***Source:*** Czech Statistical Office

### A.3 Data Coverage and Representativeness

Gross fixed capital formation (GFCF), net investment in fixed assets of firms for all sectors from the Quarterly Survey of Financial Indicators, and net investment used in the analysis (after cleaning the data and dropping the construction sector) are shown in Figure A.3. GFCF constitutes around a quarter of Czech GDP.

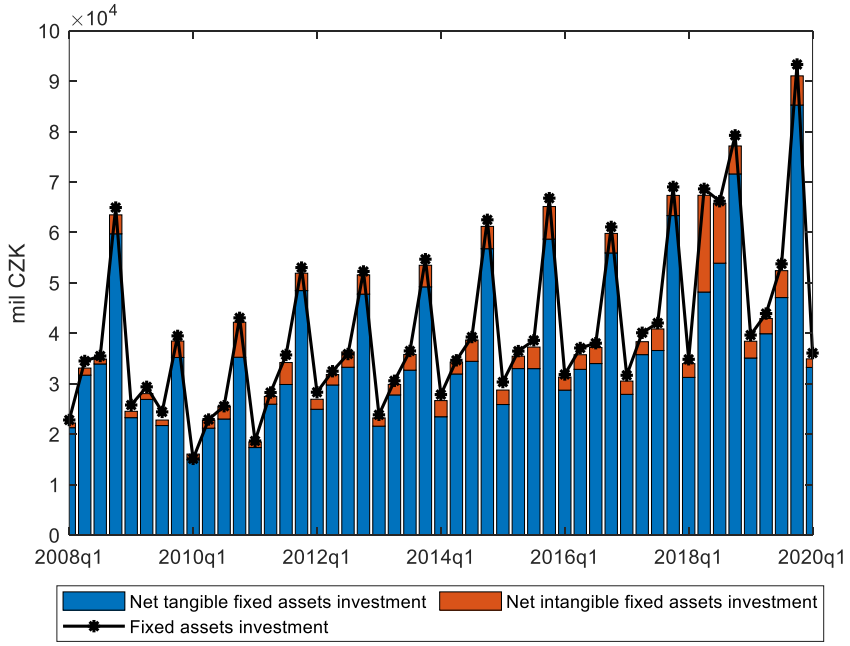
***Figure A3. Aggregate Investment from National Accounts and Quarterly Survey of Financial Indicators***




***Note:*** Data on investment from the national accounts (GFCF—Gross Fixed Capital Formation), investment in fixed assets from the Quarterly Survey of Financial Indicators and (Original data), and data on investment are used for the analysis after dropping Construction and cleaning the dataset.

The observed strong seasonality is an intrinsic characteristic of Czech investment data. Also visible are a decrease in investment in 2009 after the Global Financial Crisis and the European debt crisis, an increase starting in 2014, and a fall around the time of COVID-19 and Russia's invasion of Ukraine.

***Figure A4. Composition of Investment***



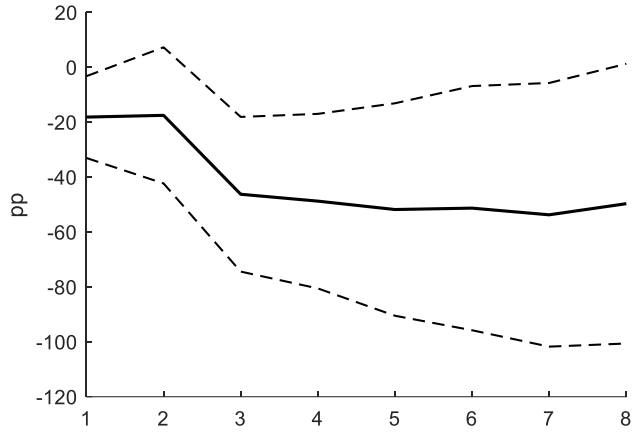

***Source:*** Quarterly Survey of Financial Indicators, Czech Statistical Office.

Some papers distinguish between intangible and tangible fixed assets when defining investment (e.g., Durante et al., 2020). Our dataset does not allow for that. It does not distinguish between the stock of tangible and intangible fixed assets; only flows are available in the two categories. The literature suggests different investment behavior after monetary policy shocks for firms with different shares of tangible and intangible assets (Döttling and Ratnovski, 2023). It turns out that firms with a higher share of intangible assets react less to monetary policy shocks; the credit channel is weaker. However, intangible assets are not a big issue in the Czech case—see Figure A.4.

**Representativeness.** Based on GFCF from the national accounts covering the period 2008Q1–2020Q1, a local projection with quarterly dummies is estimated by OLS:

$$log(GFCF_{t+h}) - log(GFCF_{t-1}) = \alpha^h + \beta^h Shock_t + \delta_t^h + \varepsilon_{i,t+h}.$$

***Figure A5. Response of GFCF after a 1 pp Contractionary EA Monetary Policy Shock***




***Note:*** The dashed lines indicate the 95 percent confidence interval.

The usual profile of a temporary fall in the investment rate after a contractionary monetary policy shock is estimated (Figure A.5), similarly to the response of the average firm presented in Section 5.1. The difference in magnitudes is due to the fact that we work with investment, not with the investment rate as in the case of firm-level data. In addition, GFCF includes the construction sector, which is excluded for firm-level data.

# Appendix B: Additional Results

## B.1 Full Results for the Average Effect

Table B1 provides the full estimation results of model (2) estimated on the sample 2008Q1–2020Q1. The results are discussed in Section 5.1.

***Table B1: Estimation Results Based on Subsample 2008Q1–2020Q1***

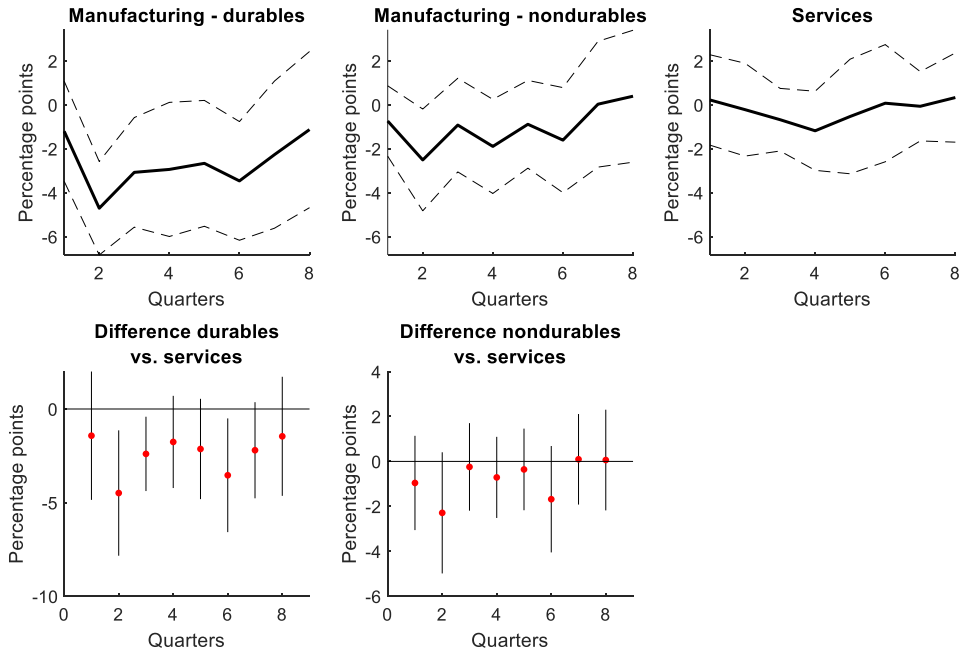
| Horizon (Q): | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $Shock_t$ | -0.76 | -2.82*** | -2** | -2.28** | -1.81 | -2.27* | -1.36 | -0.51 |
| | (0.63) | (0.9) | (0.99) | (1.1) | (1.13) | (1.25) | (1.26) | (1.24) |
| $\delta_1^h$ | 0.66*** | 1.71*** | -1.03*** | 0.9*** | 0.74*** | 1.75*** | -1.06*** | 0.95*** |
| | (0.09) | (0.1) | (0.09) | (0.1) | (0.12) | (0.14) | (0.12) | (0.12) |
| $\delta_2^h$ | 1.56*** | -0.22** | -0.88*** | 0.83*** | 1.67*** | -0.18* | -0.89*** | 0.85*** |
| | (0.1) | (0.09) | (0.07) | (0.08) | (0.13) | (0.11) | (0.1) | (0.11) |
| $\delta_3^h$ | -0.8*** | -0.45*** | -1.3*** | 1.33*** | -0.64*** | -0.38*** | -1.34*** | 1.38*** |
| | (0.1) | (0.1) | (0.09) | (0.1) | (0.11) | (0.12) | (0.11) | (0.12) |
| $Shock_{t-1}$ | -2.21** | -1.81 | -2.84*** | -2.42*** | -2.93*** | -2.54** | -1.9* | -1.23 |
| | (0.88) | (1.16) | (0.95) | (0.74) | (1.09) | (1.09) | (1.04) | (0.95) |
| $\Delta I_{i,t-2}$ | -0.45*** | -0.46*** | -0.53*** | -0.44*** | -0.5*** | -0.48*** | -0.53*** | -0.46*** |
| | (0.02) | (0.02) | (0.01) | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| $CZMP_t$ | -0.03 | -0.11** | -0.24*** | -0.28*** | -0.31*** | -0.32*** | -0.36*** | -0.36*** |
| | (0.03) | (0.05) | (0.04) | (0.05) | (0.06) | (0.06) | (0.07) | (0.07) |

***Note:*** Standard errors in parentheses. *$p < 0.10$,**$p < 0.05$,***$p < 0.01$.

## B.2 Results for Manufacturing and Services

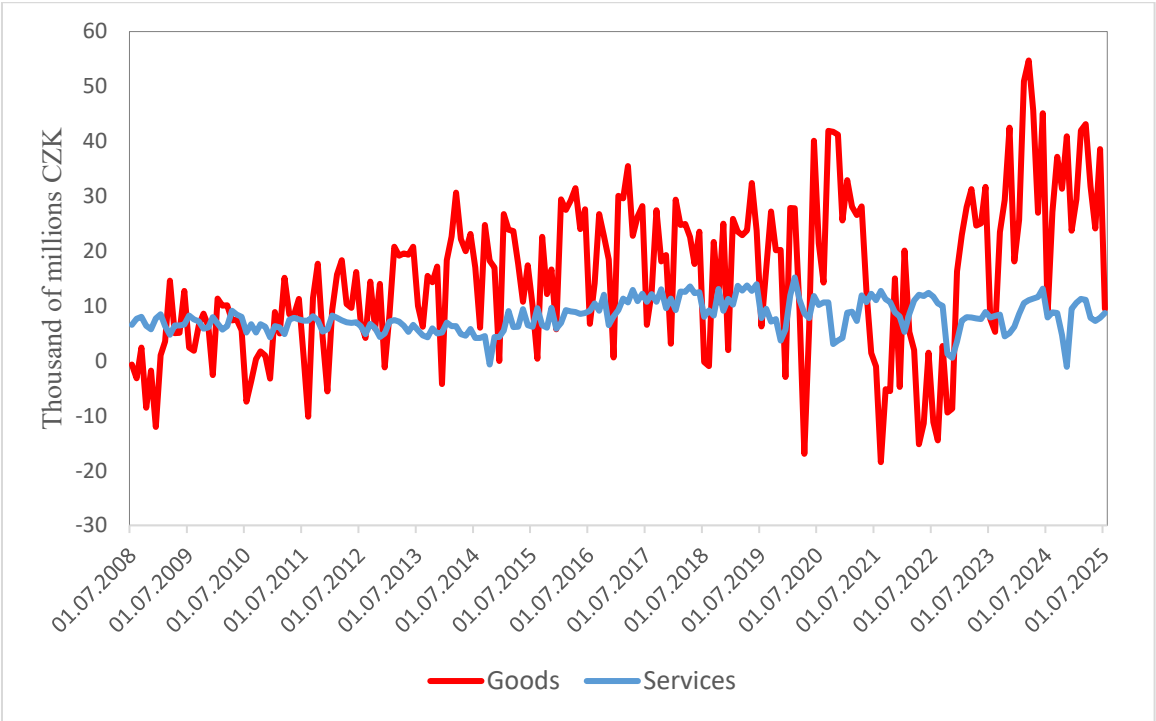
In the main text, we compare the investment behavior of firms producing durables and nondurables. We extend the sample for firms in services in Figure B1. The interest rate sensitivity of demand for services is lower than that for durables, similarly to the case of nondurables vs. durables. The response of services to an EA monetary policy shock is insignificant and the response of investment in both manufacturing sectors is significantly different from that in services. The difference in both manufacturing sectors versus services is consistent with the lower exposure of services to foreign trade, as illustrated in Figure B2.

***Figure B1. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Firms Producing Durables and Nondurables and Firms in Services***




**Note:** The top panels show the response of the investment rate, while the bottom panels show the difference between the responses. The dashed lines in the top panels indicate the 95 percent confidence interval. The vertical lines in the bottom panels indicate the 95 percent confidence intervals.

***Figure B2. Balance of Payments: Net Transactions in Goods and Services***

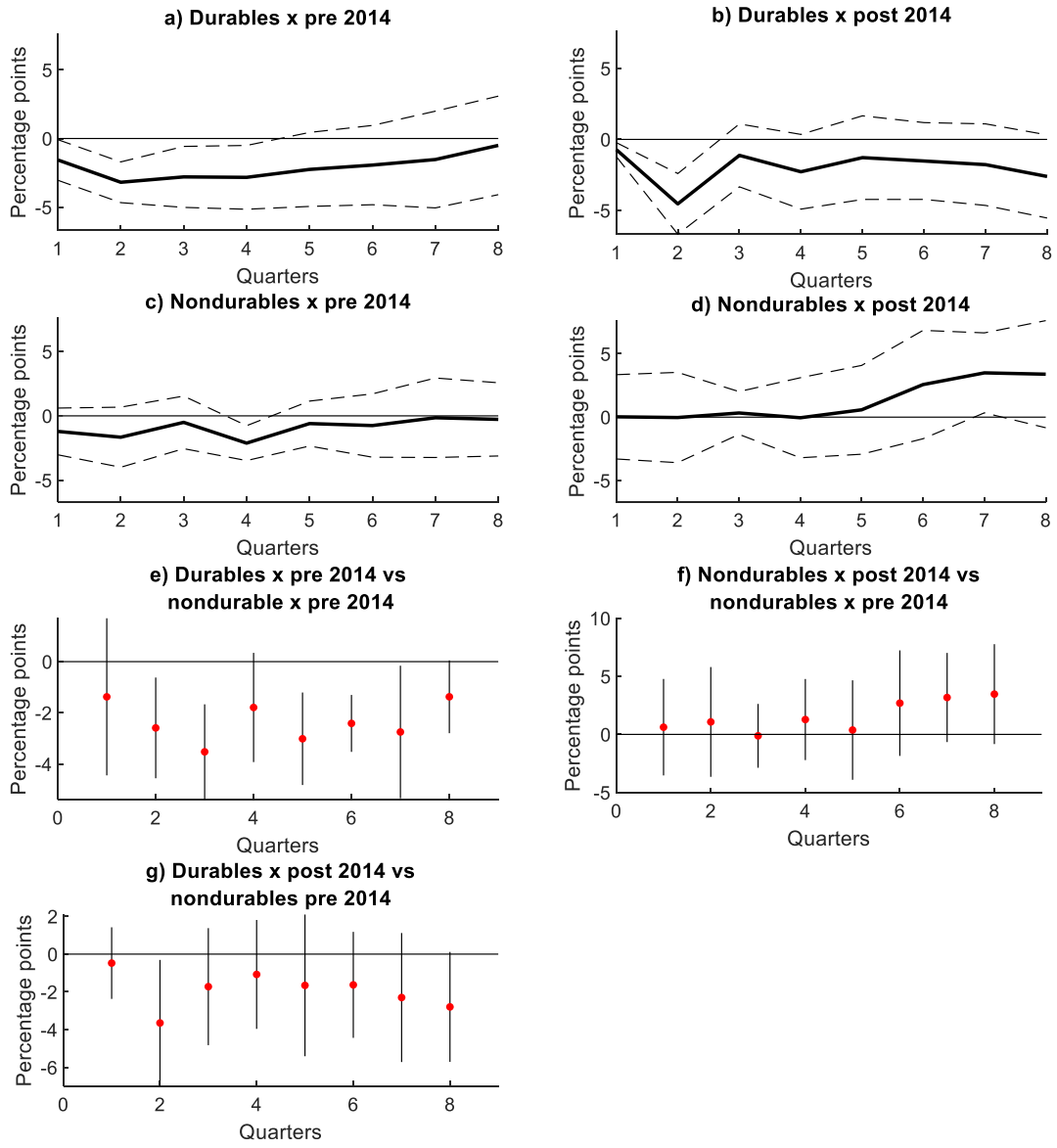



***Source:*** ARAD, balance of payments, current account.

## B.3 Change in the Trade Channel over Time

We examine the statistical significance of the difference in investment responses for subsamples split by 2014Q1 in the specification with pre-2014 and post-2014 dummies. More precisely, the interaction term of the dummy indicating firms producing durables (nondurables) and the shock is extended for pre-2014 and post-2014 dummies, i.e., we work with triple interaction terms. The resulting responses are presented in Figure B3. It follows that the investment of firms producing durables after 2014 responds less strongly than the investment of firms producing nondurables before 2014. This difference in responses is statistically significant (panel g). As firms producing nondurables after 2014 exhibit an even less strong response, statistical significance of the difference for nondurables before and after 2014 follows.

***Figure B3. Responses of the Investment Rate after a 1 pp Contractionary EA Monetary Policy Shock for Firms Producing Durables and Nondurables and for Sample 2008Q1–2013Q4 and 2014Q1–2020Q1***




***Note:*** Panels a)–d) show the response of the investment rate, while panels e)–g) show the difference between the responses. The dashed lines in panels a)–d) indicate the 95 percent confidence interval. The vertical lines in panels e)–g) indicate the 95 percent confidence intervals.

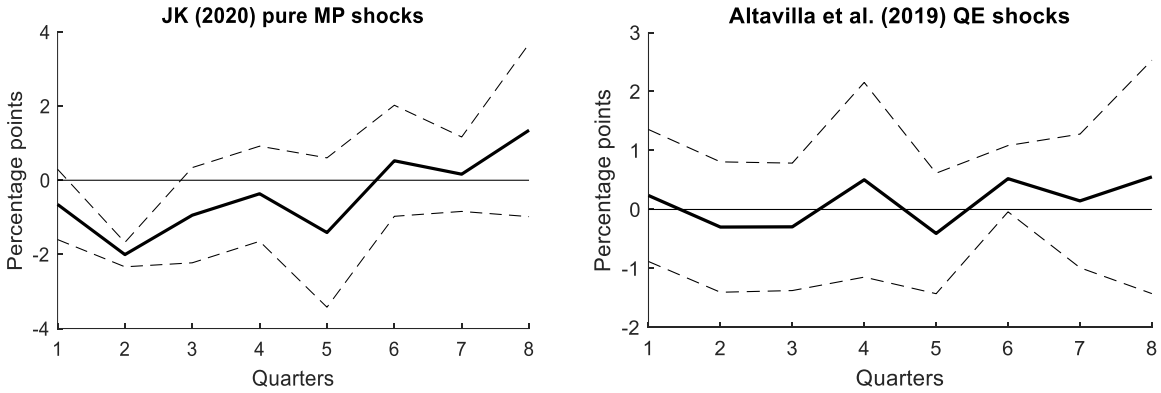
## B.4 Different monetary policy shocks

The version of shocks taken from Jarociński and Karadi (2020) is based on poor's man sign restriction identification.[16] As a robustness check, we estimated specifications with the series of monetary policy shocks based on usual sign restrictions approach available from the same source. Results of the robustness check are very similar and are not presented for brevity.

Employing pure monetary policy shocks from Jarocinski and Karadi (2020) can raise a question how much quantitative easing is represented by those shocks. The reason is that shocks from Jarocinski and Karadi (2020) are based on three-month EONIA swap surprises and thus need not capture total effect of QE measures. Therefore, as a robustness check, we estimate the average effect for the subsample 2014Q1-2020Q1 using QE shocks from Altavilla et al. (2019), who extract factors from a large set of interest rates surprises (changes of rates over a short window around ECB press conferences) to represent different dimensions of unconventional monetary policy.[17]

The effect of QE shocks on the investment of Czech firms is similar to the effect estimated for shocks from Jarocinski and Karadi (2020) – see Figure B4. The responses are not statistically significant for the two series of shocks (except second quarter in the case of shocks from Jarocinski and Karadi, 2020). The size of the responses reflects the fact that Jarociński and Karadi's shocks represent the movement in three-month EONIA swap, while Altavilla et al. (2019) shocks are normalized to have unit effect on 10-year yields.

***Figure B4. Average Firm Response of the Investment Rate to a Contractionary EA Monetary Policy Shock of Size 1 pp after 2014***




***Note:*** The dashed lines indicate the 95 percent confidence interval. Model estimated on subsample 2014Q1–2020Q1, for pure monetary policy shocks from Jarociński and Karadi (2020) – panel a) and QE shocks from Altavilla et al. (2019) – panel b).

[16] Updated series can be found at https://marekjarocinski.github.io/jkshocks/jkshocks.html.
[17] The series can be found at gragusa.org

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CZECH NATIONAL BANK
Na Příkopě 28
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Czech Republic

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