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The impact of monetary policy on productivity

A report of the ESCB Expert Group on Productivity, Innovation and Technological Change

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Abstract

This occasional paper extends previous analyses by the WGF Expert Group on Productivity of the impact of monetary policy on productivity by exploring new interactions, particularly the influence of market power and the role of productivity in the transmission of monetary policy through the banking system. Using a consistent definition of monetary policy shocks throughout the report and several large-scale micro distribution exercises across euro area countries, our study examines the short-run procyclical effects of monetary policy shocks on productivity through investment decisions. The results reveal a positive relationship between market power and the transmission of monetary policy to productivity, highlighting the role of heterogeneous markups. Our study confirms the positive impact of expansionary monetary policy on capital reallocation but finds more nuanced results for labour reallocation. It further extends the analysis to the evolution of zombie firms, revealing opposing effects of monetary policy on their entry and exit, while also exploring the interaction between bank characteristics and productivity, though the results remain inconclusive. Overall, the findings suggest that expansionary monetary policy shocks enhance productivity by improving resource allocation. However, they also raise concerns about the potential adverse effects of current contractionary monetary policy shocks on productivity.

Keywords: Monetary policy, productivity growth, resource allocation, monetary policy shocks, markups, capital misallocation, financial frictions

JEL codes: E52, O47, E44, L11, D22

Non-technical summary

This report examines how monetary policy influences productivity in the euro area. While it is widely accepted that monetary policy does not affect productivity in the long run, its short-term effects can be important. By shaping financing conditions, investment decisions and the allocation of resources across firms, monetary policy can influence how efficiently the economy operates.

The analysis is based on a coordinated effort across several euro area countries using comparable firm-level data and a common measure of monetary policy shocks. This approach allows us to identify how unexpected changes in monetary policy can affect productivity through different channels and across countries.

A key finding of the report is that expansionary monetary policy – that is, policy that lowers interest rates or eases financing conditions – tends to support productivity in the short run. This mainly occurs because this kind of policy encourages investment and improves the allocation of resources across firms. When financing becomes more accessible, firms that are more productive but financially constrained are better able to expand, thus making a positive contribution to overall productivity.

The report highlights the important role played by market power in shaping how monetary policy affects productivity. Firms operate in markets with different levels of competition, which influence their pricing behaviour and responsiveness to economic conditions. We find that firms operating in sectors with higher markups – which are often also more productive firms – tend to benefit more from expansionary monetary policy. As demand increases, these firms expand relatively more, leading to a reallocation of resources towards more productive activities. This process can improve overall economic efficiency.

Another important channel is the allocation of capital and labour across firms. In an efficient economy, resources should flow to firms that use them more productively than others, although various frictions, such as financial constraints, can prevent this from happening. This report shows that expansionary monetary policy can reduce these frictions, particularly when it comes to the allocation of capital. As a result, high-productivity firms with limited access to finance are able to increase their investment more than others, thereby improving the allocation of capital in the economy. The effects on labour allocation are less clear, suggesting that labour market dynamics may depend more on structural factors beyond monetary policy.

The report also examines the role of so-called “zombie firms” – firms that struggle to cover their interest payments with profits over extended periods. These firms are often viewed as a potential drag on productivity, as they may tie up resources that could otherwise be used more efficiently. Our findings provide a more nuanced view. While accommodative monetary policy can help such firms survive, it also reduces the number of firms that become distressed in the first place and supports the recovery of some firms back to healthy status. Overall, the net effect of expansionary monetary policy appears to be a reduction in the share of zombie firms present in the economy.

Finally, the report explores how monetary policy interacts with the banking sector, which plays a key role in transmitting policy changes to the real economy. Banks differ in their characteristics, such as their capital levels, funding structures and liquidity positions, all of which can affect how they respond to monetary policy. However, the evidence set out in this report suggests that these characteristics do not have a strong influence on how monetary policy affects the allocation of credit to more productive firms. This indicates that while banks are central to the transmission mechanism, the link between monetary policy and productivity through bank lending may be more complex than previously thought.

Taken together, the findings suggest that expansionary monetary policy can have a positive impact on productivity in the short run, mainly by improving resource allocation and supporting investment. At the same time, the findings reveal important trade-offs and uncertainties. Different channels can operate in opposing directions, and their relative importance may vary across countries and over time.

Overall, the report underscores the importance of considering productivity as part of the broader transmission of monetary policy. It also points to the need for further research to better understand the interaction between monetary policy, financial conditions and the efficient functioning of the economy.

1 Motivation and scope of the report

Although in the long run monetary policy has no real effect on the economy and productivity growth is largely determined by structural factors, in the short run monetary policy can influence productivity growth through a variety of channels. Our analysis focuses on the procyclical effects of monetary policy on interest-sensitive investment, which in turn affects productivity growth. Taking into account all these different channels, the effects of monetary policy on productivity growth are heterogeneous across sectors and countries, and there is also considerable uncertainty surrounding these effects, as shown in ECB (2021).

The most direct channels – lowering financing costs and reducing the profitability threshold – suggest that monetary policy has a positive effect on productivity growth. Therefore, accommodative monetary policy should support investment in productivity-enhancing technologies. Monetary policy can also affect the reallocation of resources by easing financing constraints that arise from asymmetric information or low net worth. This effect is particularly pronounced among young, dynamic firms and highly productive firms with intangible capital.

However, indirect channels introduce ambiguity in the relationship between monetary policy and productivity growth. This is because monetary policy affects resource allocation by affecting the decisions made by both firms and banks. While accommodative monetary policy can ease the financial constraints of productive firms, thus boosting productivity growth, it can also trap financial resources in low-productivity or zombie firms, leading to resource misallocation. This misallocation occurs when vulnerable firms and their banks lack incentives to repair their balance sheets, thereby distorting the "cleansing" mechanism in the economy. Which of these effects dominates remains an empirical question that this report seeks to answer.

Building on previous work, this occasional paper provides a comprehensive analysis of the impact of monetary policy on productivity growth in several euro area countries. The report uses harmonised data across countries through a micro-distributed approach (see Box 1), which involves collecting the same type of data across euro area countries and then running the same specification on the country-level data.

This paper makes a second contribution to the literature by measuring the impact of monetary policy on productivity using the same monetary policy shock across countries in the empirical analysis. This is the unexpected monetary policy shock derived from high-frequency data as in Jarociński and Karadi (2020), aggregated to an annual frequency using a method similar to that of Ottonello and Winberry (2020) (see Box 2 for a description of monetary policy shocks and time aggregation). This allows us to compare the effects of monetary policy not only across different countries, but also across different variables. The latter is important because we are looking at the effects of monetary policy on

productivity growth through different channels, and by using the same shock in all the empirical analyses, we can reliably compare the results.

In the next section, we analyse the role of market power, as measured by the level of markups, in the transmission of monetary policy to the real economy, focusing specifically on productivity. We examine how labour productivity and total factor productivity (TFP) respond to a monetary policy shock based on the degree of market power within a given sector. Our findings indicate a positive relationship between monetary policy, markups and productivity. One possible explanation for this result is that, in the presence of heterogeneous markups, an expansionary monetary policy shock increases productivity by reallocating resources to highly productive firms within sectors that have high markups.

In the third section, we confirm the positive effect of monetary policy on resource allocation, especially among financially constrained firms. This analysis extends the results obtained by Albrizio et al. (2022) and ECB (2021) by incorporating a broader set of countries and applying the same monetary policy shock across them. The analysis shows that there are heterogeneous effects across countries and factors of production, carrying important implications for economic modelling and also the evaluation of policy decisions. The evidence supports the notion that such policies have a positive impact on resource allocation by allowing financially constrained firms to increase their investment. However, the impact on the reallocation of labour is more nuanced and the results are less conclusive, suggesting that job creation and destruction may be less responsive to monetary policy.

We extend the analysis of zombie firm dynamics in ECB (2021) and Nurmi et al. (2022) by applying the same unexpected monetary policy shocks used in other parts of this report, expanding the number of countries analysed and refining the definition of zombie firms. Our study confirms previous findings using a larger sample of countries, showing that changes in the share of zombie firms over time are mainly driven by firms entering zombie status rather than exiting it. By refining the definition of zombie firms, we find that many firms exiting zombie status subsequently recover, rather than exiting the market altogether. Accommodative monetary policy has two opposing effects: it increases the survival rate of zombies while simultaneously lowering the rate at which firms become zombies. However, the effect of such policy on the entry margin dominates, leading to a net reduction in the overall share of zombies in the economy following an accommodative monetary policy shock.

Finally, the last section examines the effect of monetary policy on the allocation of credit by the banking sector to more productive firms. In this part of the report, the data used are extended to include loan-level data and bank characteristics, which are then matched to firm-level data. The novelty of this exercise lies in the fact that we use the unexpected monetary policy shock to understand how monetary policy interacts with the level of firm productivity in the bank's decision on whether to lend. Contrary to the findings of previous theoretical and empirical studies, we do not find a significant interaction between monetary policy and bank characteristics, as is usually found to exist when studying the

transmission of monetary policy. Nor do we find significant effects when monetary policy and bank characteristics are interacted with productivity, although we do find some significant effects when we measure risk-taking among banks. This could suggest that firm productivity is very important for macroeconomic developments but not for lending decisions, for which risk appears to be more relevant. What this means for aggregate productivity growth is unclear, as not all risky firms are more productive. The results set out in this section are less consistent and significant than those contained in the previous sections, suggesting that there are several channels warranting closer attention in further research.

To sum up, we have analysed various channels through which monetary policy affects productivity growth, focusing on the role of market power, the allocation of resources and the banking system. Our results are encouraging for two reasons: first, they alleviate concerns that the prolonged period of low interest rates may have harmed productivity growth; second, they reveal promising avenues for future research. Furthermore, if the results of the analysis are assumed to be symmetric, an assumption that could not be tested at the time of writing due to insufficient data, the recent period of monetary policy tightening could have had a negative impact on aggregate productivity growth.

Box 1
Micro-distributed approach to data analysis

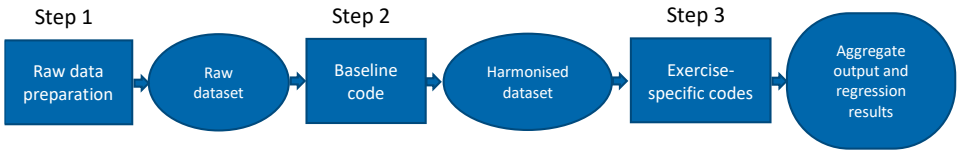
Prepared by Tibor Lalinsky (Národná banka Slovenska)

The results of the various analyses based on firm-level data presented in this report were obtained using a micro-distributed approach applied to country-specific, and frequently confidential, individual data. Common code was distributed to representatives of national central banks, who directly or indirectly ran it on their respective national firm-level datasets. This method ensured broad coverage and cross-country comparability while meeting confidentiality requirements.

The approach was inspired by the established CompNet (The Competitiveness Research Network) infrastructure, and the code drew largely on the experience gained from micro-distributed exercises used for regular updates of the CompNet Dataset of micro-aggregated indicators (mostly the code for the 8th vintage of the dataset).

The process of data collection and analysis was divided into three main steps. In the first step, data providers from contributing countries prepared their data in line with the agreed variable definitions.

Figure A
Steps of the micro-distributed approach



In the second step, the baseline code was run on the raw firm-level datasets. It first read the available data, verified whether the data had the expected properties and renamed all variables using a common key across countries. The code then eliminated false observations and outliers and created various ratios, growth rates and various non-parametric variables, such as labour and financial indicators. Lastly, the code calculated several types of productivity measures and related parametric indicators and completed the preparation of the harmonised firm-level dataset that served as input for the various exercises.

In the third step, the data providers ran the exercise-specific modules on their harmonised datasets and shared the aggregate results and regression outputs with the participants that had prepared the exercises – partial analyses. The expert team ran a total of eight separate exercises, with the number of participating countries varying depending on the availability of the required data. The results of seven exercises that produced reasonable results for a sufficient number of countries provided crucial inputs for the reports of the WGF Expert Group on Productivity: three for this report, three for the report of the workstream on COVID-19 and productivity (Lalinsky et al., 2024) and one for the report of the workstream on digitalisation and productivity (Anghel et al., 2024) (see Table A).

Table A

Micro-distributed exercises

Report	Exercise	Countries
The impact of the COVID-19 pandemic and policy support on productivity	Intensive productivity growth and productivity-enhancing reallocation	12
	Distribution of pandemic subsidies and guaranteed loans across firms	7
	Pandemic support, indebtedness and zombification	10
The impact of monetary policy on productivity	Role of market power on the transmission of monetary policy to productivity	8
	Effects of monetary policy on the allocation of input factors	8
	Effects of monetary policy on zombie margins	8
	The transmission channels of monetary policy and productivity	4
Digitalisation and productivity	The impact of digital uptake of firms on their productivity	2

Box 2
Construction and aggregation of the monetary policy shock

Prepared by Dmitry Khametshin

This box explains how the monetary policy shocks employed throughout the report are constructed. To measure changes in monetary policy stance, we use the high-frequency monetary policy shock identification method developed by Jarociński and Karadi (2020). Using this approach, monetary policy surprises are inferred from changes in prices of financial assets that take place when the ECB announces its monetary policy decisions. Since asset prices react to news almost immediately, we can isolate the effects of monetary policy news from other shocks by narrowing the time window around the policy announcements. Assuming that asset prices reflected all publicly available information before the announcements were made, a change in prices during the announcement window represents the unexpected component of a monetary policy shock. The unexpected nature of the shocks is crucial for econometric identification.

To identify monetary policy surprises, Jarociński and Karadi (2020) use changes in the yield curve and a stock market index. The information on interest rates is represented by the first principal component of changes in the risk-free rates in OIS swaps. The stock market index, in turn, is used to disentangle discount rate shocks from central bank information shocks that emerge during the ECB's announcements. To separate the two, the authors use sign restrictions whereby a tightening of monetary policy increases interest rates and reduces stock prices, while an unanticipated release of positive information increases both.

Note that the high frequency of the data is needed to identify the shock, even though the firm-level data used in the different exercises present an annual frequency. Hence, to align the frequency of the shocks with that of the firm-level data, we aggregate the monthly series of monetary policy shocks from Jarociński and Karadi (2020) to an annual frequency. We rely on the time aggregation scheme used by Ottonello and Winberry (2020) in the context of monthly-to-quarterly aggregation. When applied at an annual frequency, this approach assumes that a monthly shock enters the annual surprise for both the year in which it occurred (the "current" year) and the following year. Furthermore, the allocation of the monthly shock to the current and the following year depends on when it occurred within the current year. For instance, a high-frequency surprise occurring in January of a given year is entirely allocated to that year, while one occurring in December is mainly attributed to the annual shock for the following year. More broadly, the share of the shock that is attributed to the current year decreases linearly with the month of the year. Albrizio et al. (2023) show that one can derive this aggregation scheme under certain assumptions about the effects at a higher frequency – see Albrizio et al. (2023) for further details.

In all exercises, we use a different aggregation scheme to assess the robustness of our results and address potential endogeneity concerns stemming from the autocorrelation of the aggregated shocks. Under this scheme, an annual shock includes only those high-frequency shocks that occurred during that year, thus eliminating the overlap between monthly shocks across two consecutive years that occurs under the baseline aggregation scheme. When constructing this annual series, we weight monthly shocks using weights that decrease with the month of the year. The results discussed in the main part are robust to this aggregation scheme. Note that these shocks are not suitable for analysing long term trends, but rather for capturing surprise changes in interest rates.

Sources & Notes

2 Role of market power in the transmission of monetary policy to productivity[1]

2.1 Motivation

Prepared by Annalisa Ferrando and Orchi Modhurima

Monetary policy influences productivity through various channels, with firm heterogeneity being a crucial factor in the pass-through mechanism. The literature includes several studies documenting, both theoretically and empirically, the significant effects of monetary policy on productivity (see Comin and Gertler, 2006; Moran and Queralto, 2018; Garga and Singh, 2021), as well as the persistence of these effects over time (Jordà, Singh and Taylor, 2020). One key channel involves the impact of monetary policy on resource (mis)allocation across firms, driven by their responses to changes in business conditions. In this chapter, we explore the role played by market power in resource allocation, which is important for understanding the transmission of monetary policy to the real economy.

Relatively little is known about the role of firms' heterogenous market power in influencing the pass-through of monetary policy to productivity. While there is a growing body of literature showing that firms with more market power exhibit slower pass-through from marginal costs to prices and, consequently, respond less to policy shocks in terms of investment and sales (see Ferrando et al., 2021; Duval et al., 2021), the impact of market power on the pass-through of monetary policy to productivity remains largely unexplored. Baqaee et al. (2022) provide empirical evidence of a reallocation process that leads to procyclical productivity growth following an expansionary monetary policy shock. They find that an accommodative monetary policy shock causes high markup firms, which also tend to be highly productive, to grow more than low-markup firms. Meier and Reinelt (2022) show that the dispersion of markups across firms (within industries) increases significantly following a contractionary monetary policy shock in the presence of price rigidities. This has negative implications for the allocative efficiency of inputs and, consequently, aggregate productivity.

In this section we examine the effects of monetary policy on productivity in the context of heterogeneous sectoral markups, using euro area data. Our contribution is twofold. First, we document how firms' productivity across selected euro area countries varies depending on the degree of sectoral market power. Second, we analyse how firms' responses to a monetary policy shock depend on the degree of sectoral market power. The empirical analysis employs the same monetary policy shock as that described in Box 2. The empirical specification is provided in Box 3. Our chapter also includes Box 4 by Colciago and Silvestrini

[1] We acknowledge the research assistance of Elias Kastritis (ECB).

(2022), which focuses on the role of market concentration in the transmission of monetary policy to productivity in the United States.

Quantifying market power has proven to be a challenge in the literature, as there are no perfect measures of market power. For example, concentration ratios such as the Herfindahl-Hirschman Index (HHI) can be sensitive to market definitions (see De Loecker, Eeckhout and Unger, 2020). In our analysis, we use sectoral markups as a measure of market power to mitigate measurement issues, including endogeneity concerns. We follow the production function approach proposed by De Loecker and Warzynski (2012), whereby markups are calculated using the inputs' expenditure shares in revenue, together with their output elasticity.

We find that a monetary policy shock has a positive and immediate effect on average productivity growth, potentially through the reallocation of inputs. In the presence of heterogeneous markups, expansionary monetary policy shocks are expected to raise aggregate productivity by increasing the output of firms in high-markup sectors relatively more than that of other firms, thereby reallocating inputs to these sectors. While the immediate response is similar across all countries, the longer-term impact is more heterogeneous. This finding alleviates concerns that an expansionary monetary policy shock might contribute to a slowdown of aggregate productivity. More importantly, we confirm that average firm-level productivity increases more in high-markup sectors than in low-markup sectors following an expansionary monetary policy shock. This highlights the relevance of markup heterogeneity for the transmission mechanism of monetary policy.

2.2 Markup and productivity trends across euro area countries: some descriptive statistics

Markup and productivity trends vary across euro area countries, with greater heterogeneity observed in markup dynamics. Using firm-level data from five euro area countries, we document the trend in markups and productivity (both labour productivity and total factor productivity (TFP)) between 2006 and 2020.[2] Chart 1 below illustrates these dynamics for Italy, France, Portugal, the Netherlands and Spain.[3] As shown, average markup dynamics differ across countries. While markups in Italy remained stable over the period under consideration, those in France declined significantly (by around 10 bp). Markups in Portugal were fairly volatile, showing a decline until 2014, followed by an increase until 2019. The sharp drop observed in Portugal's markups in the last year of the sample likely relates to the COVID-19 pandemic and ensuing temporary business closures, especially in high-markup sectors such as export industries (see Fernandes et al., 2021). In contrast, both the Netherlands and Spain saw a slight drop in their aggregate markups (2-4

[2] Detailed definitions of markup and productivity are included in the data annex. We calculate absolute sector-level markups using sectoral factor elasticities. The two measures of productivity are: (1) labour productivity (revenue/number of employees) and (2) total factor productivity (TFP), which is calculated using firm revenues, factors of production and the input elasticities of output using an OLS Cobb-Douglas production function.

[3] In this chapter we present the results for those countries with sectoral markup data covering the largest number of sectors. The data appendix contains the results for the remaining countries.

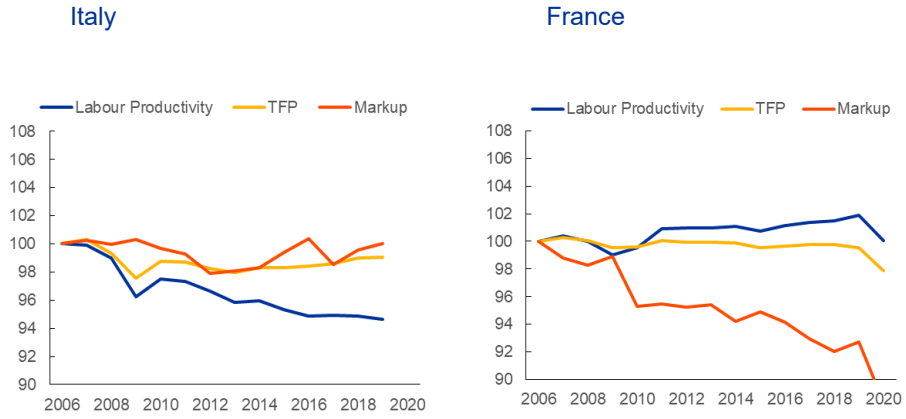
bp) during this period. These results align with other studies that find evidence of stable or decreasing markups in the euro area (see Kouvavas et al., 2021; McAdam et al., 2019).

Cross-country heterogeneity is also evident in TFP and labour productivity dynamics. In our sample, TFP has either increased slightly (in Portugal, the Netherlands and Spain) or remained broadly stable over time (in France and Italy). However, labour productivity trends differ significantly. Labour productivity has steadily declined in Italy and Portugal, but increased slightly in France, the Netherlands and Spain. Generally, we find that both TFP and labour productivity are either stagnant or declining in our sample, which is supported by other research (see Fernald and Inklaar, 2020).

Overall, there appears to be a positive correlation between aggregate markup and productivity trends at the country level. While comparisons at this level of aggregation are challenging, a positive association between markup and productivity developments can be observed within each country, except for France.[4] Battiati et al. (2021) find similar results using national accounts in their analysis.

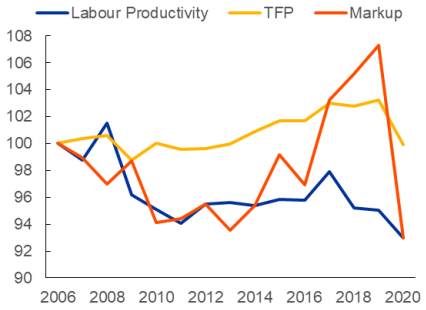
Chart 1

Aggregate markup and productivity trends in selected countries (2006=100) (basis points)

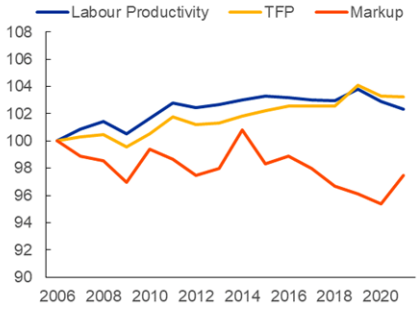


[4] France has a small negative correlation coefficient between its labour productivity and markup. All other correlation coefficients (between TFP and markups in all countries and between labour productivity and markups in Italy, Portugal, the Netherlands and Spain) are positive.

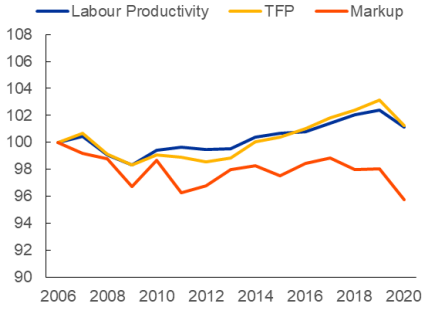
Portugal



Netherlands



Spain



Sources: MDE firm-level national sources and ESCB calculations.
Notes: The figure reports labour productivity, total factor productivity and markups for each country (averaged using each country's sectoral productivity shares and markups). For definitions of labour productivity, TFP and markups, see footnote 1 or the data annex.

Industrial sectors share similar markups across countries. To analyse the markup distribution across sectors in the euro area, we first calculate the average markup for each sector (at NACE 2 level) in each country by pooling together all years.[5] We then categorise these sectors into three buckets. The first bucket includes all sectors with low markups (the first tertile – bucket 1); the second bucket consists of sectors with medium markups (the second tertile – bucket 2); and the third bucket comprises sectors with high markups (the third tertile – bucket 3). Chart 2 below displays the sectoral distribution across the three buckets for selected countries in 2018.[6] The vertical axis indicates the sectors, while the horizontal axis reports the number of sectors included in the analysis. Several general stylised facts can be identified. First, despite significant heterogeneity across countries due to differing industrial structures, sectors such as construction, wholesale and retail trade, and transport and storage typically fall into the low markup group in most

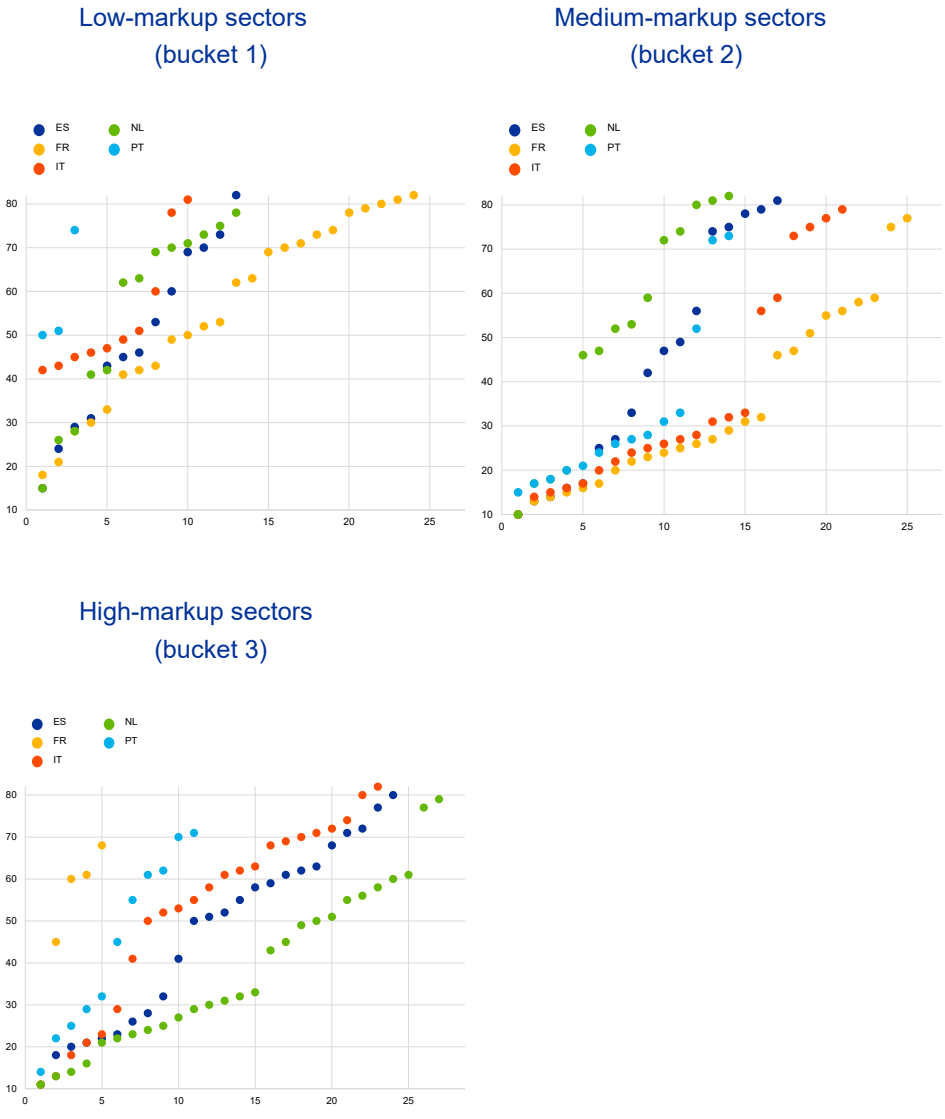
5 We run OLS Cobb-Douglas production functions to calculate firm-level markups, which are then aggregated to measure sectoral-level markups. We also use a generalised method of moments (GMM) estimator, which is asymptotically more efficient than OLS (Arellano and Bover, 1995), to run the same exercise as a robustness check. We find the overall results to be similar but less significant.

6 The reference year does not affect the overall distribution of sectors in the three buckets.

countries, with the exception of Portugal. In France and the Netherlands, business sectors that support companies (professional, technical and administrative support) are also classified as low-markup sectors. Meanwhile, most traditional manufacturing sectors are included in the medium markup bucket, along with accommodation and food services and certain business sectors related to information and communication. Finally, the high-markup bucket can be divided broadly into two blocs: in Italy and Spain, high-markup sectors are mostly concentrated in construction, wholesale and trade, transport and storage, and services related to professional and technical activities. In contrast, Dutch firms in specific manufacturing sectors (pharmaceuticals, machinery, plastics and glass) report the highest markups.

Chart 2

Sectors included in low, medium and high-markup buckets in selected countries in 2018



Source: Own calculations on MDE firm-level data obtained from national sources.

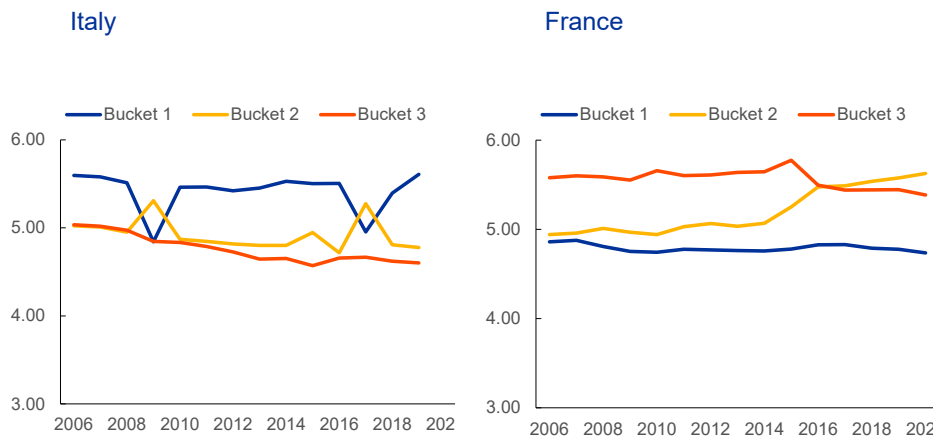
Notes: The figure reports, for each bucket, the sectors across countries for the year 2018. The horizontal axis shows the number of sectors in each bucket, while the vertical axis shows the sectors according to NACE Rev. 2 classification, as follows: Manufacturing, 10-33 ; Construction, 41-43; Wholesale and retail trade; repair of motor vehicles and motorcycles, 45-47; Transportation and storage, 49-53; Accommodation and food service activities, 55-56; Information and communication, 58-63; Real estate activities, 68; Professional, scientific and technical activities, 69-75; Administrative and support service activities, 77-82.

More productive firms tend to operate in industries with higher markups. Chart 3 below presents the average labour productivity for each of the three buckets in each country. Except for Italy and Portugal, firms operating in sectors with high and medium markups tend to be more productive. This observation is consistent with stylised facts documented in studies based on more harmonised databases. For instance, Battiati et al. (2021) show that industries with higher productivity tend to have higher markups and that those with faster productivity growth tend to increase their markups more rapidly. In the case of Italian firms, the drop in productivity within service sectors is primarily due to entry and exit barriers, particularly affecting sectors such as professional services and information and communication, which have high profit margins (and fall within the high markup bucket) (see Belhocine and Garcia-Macia, 2020). This trend diverges from that observed in other European countries and may explain why Italian firms in the low-markup bucket exhibit higher productivity. In Portugal, firms with the highest markups are typically less productive. One possible reason could be greater resource misallocation in certain high-markup service sectors in Portugal.[7]

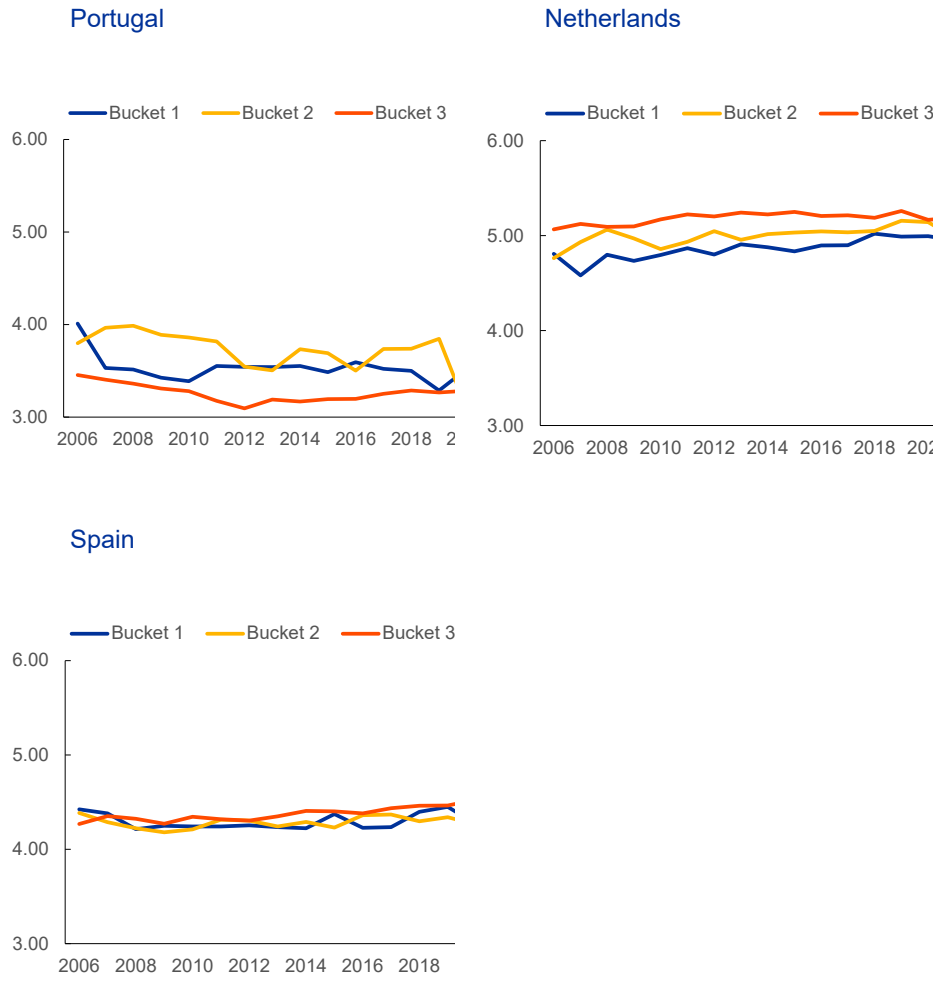
High market power or high-markup sectors do not necessarily contribute to the productivity slowdown in these five European economies. Looking at the aggregate charts, we find that, while aggregate country-level markups do not closely mirror aggregate productivity trends, there is a positive correlation between them. Additionally, firms in high-markup sectors tend to be more productive, thereby contributing to the overall productivity gains in these countries.

Chart 3

Labour productivity across the three markup buckets in selected countries (in logs)



7 See Dias, Marques and Richmond (2016), who find evidence of greater resource misallocation in certain service sectors than in manufacturing sectors in Portugal.



Sources: National sources and ESCB calculations.
Note: The figure reports average productivity for each bucket in each country.

2.3 Empirical evidence on the impact of markups on productivity in the euro area

In this section we analyse the heterogeneous response of average productivity to monetary policy shocks depending on the level of sectoral markups. Our empirical analysis is based on the local projection method introduced by Jordà (2005). As detailed in Box 3, we quantify the response of firm-level productivity to an exogenous monetary policy shock (see Box 2) by focusing on average firm-level productivity and allowing it to vary across the three groups of sectoral markups described in the previous section.

Box 3
Econometric specification

Prepared by Annalisa Ferrando and Orchi Modhurima

The econometric specification used to analyse the impact of monetary policy on productivity is based on the local projection framework (Jordà, 2005). The change in productivity is regressed on the contemporaneous monetary policy shock and on its interaction with the different groups of sectoral markups, according to the following specification:

$$\Delta_h Y_{i,t+h} = \sum_{g=1}^{G} \alpha_g^h * Z_{i,t-1}^g + \sum_{g=1}^{G} \beta_g^h * Z_{i,t-1}^g * \epsilon_t^{MP} + \Gamma^h * \Delta X_{i,t-1} + \mu_{i,t+h},$$

where $Y_{i,t+h}$ is the productivity of firm i, expressed as the logarithm of either labour productivity or TFP, and ϵ_t^{MP} is the monetary policy shock as defined in Box 2. Z refers to the defining characteristic we used to divide the firms into groups, the main one being the three high, medium and low-markup groups (g = 1,2,3). Here, Z_i^g is the sectoral markup of firm i, which places this firm in group g.

We have calculated the markups using three different specifications for the sectoral factor elasticities of output (constant shares, an OLS Cobb-Douglas production function and a GMM Cobb-Douglas production function). Factor elasticities are estimated at the sectoral level using each of these production functions. We use sectoral elasticities, sectoral revenue, labour costs and other input costs to calculate sectoral markups at the NACE 2 level.[8] Labour productivity is calculated by dividing firm revenue by the number of employees in each firm. TFP is calculated using the same sectoral factor elasticities. In this exercise, TFP is the difference between output in terms of revenue and the sum of factor elasticity of output multiplied by expenditure on each factor of production.

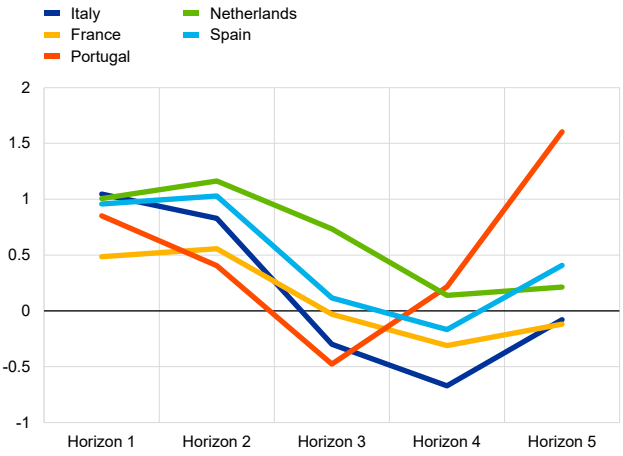
Sectoral markups are used to divide the sectors into three groups. To account for endogeneity, all these variables are lagged by one period. $X_{i,t-1}$ includes a set of lagged firm-level control variables: cash ratio, leverage and sales growth. Estimation errors are clustered by time. Following the convention in the literature, the dependent variable is defined in terms of changes from t − 1. We consider five periods (h = 0-4), with the response in period 0 referring to the same year as the monetary policy shock. The coefficient of interest is β_g^h, which measures the impact of monetary policy shocks on firms' productivity across the three sectoral markup groups. When plotting the impulse response functions of productivity, the magnitude is based on the standardised monetary policy shock, so that an increase in one unit of the standard deviation of the shock implies a change in productivity measured in percentage points.

[8] A measure of market concentration is also computed as an alternative measure of market power, using the share of total sales of the top 10 firms in each sector. The results obtained using this alternative measure are not reported but show findings very similar to those obtained using the original measure of sectoral markup.

We find that an expansionary monetary policy shock has a positive effect on average productivity across countries. In Chart 4, we show the impact of an expansionary monetary shock on labour productivity (TFP is shown in Chart A.1 in the appendix) for all firms over time.[9] In all five countries, average labour productivity increases immediately and remains positive in the following year. By the end of the fourth year, the impact remains positive but small in three of the five countries. Therefore, the average impact of expansionary monetary policy shocks on country-level productivity is positive both in the immediate aftermath of the shock for all countries and over the long run for the majority of them. This outcome can be explained through the potential reallocation of resources from low to high-markup sectors.

Chart 4

Country-average impulse response function of labour productivity to an expansionary monetary policy shock



Sources: National sources and ESCB calculations.
Note: The figure reports the average impulse responses for the five selected countries over a five-period horizon following a one-standard-deviation expansionary monetary policy shock.

With heterogeneity in markups and pass-through, expansionary monetary policy shocks are expected to raise aggregate productivity by increasing the output of high-markup firms relatively more than that of other firms. Battiati et al. (2021) show that high-markup firms tend also to be highly productive. Additionally, Baqaee and Farhi (2020) note that such firms tend to underproduce relative to low-markup firms.[10] Hence, the presence of heterogeneous markups might have the effect of lowering aggregate output and/or productivity due to the misallocation of production resources. According to the theoretical mechanism outlined in Baqaee and Fahri (2022), firms with high markups also tend to exhibit low

9 The impact is calculated as a weighted average of firm-level response functions across the three markup buckets, using the share of firms in each bucket as the weight.

10 In the presence of heterogeneous desired markups and a non-constant elasticity of demand, the steady-state equilibrium is generally inefficient, with highly productive firms using less than the optimal amount of labour and producing less than the optimal level of output.

pass-through of monetary policy shocks. Specifically, high-markup firms pass a smaller portion of increased marginal costs (e.g. intermediate costs and labour costs) on to prices than low-markup firms.[11] Therefore, an expansionary monetary policy shock increases demand for the products of high-markup firms, as low-markup firms experience larger price increases. This shift in demand prompts high-markup firms to expand production and increase their demand for labour and other inputs relative to low-markup firms. This reallocation helps to reduce resource misallocation and enhance aggregate productivity by expanding the output of more productive firms.

Despite some degree of heterogeneity, an expansionary monetary policy shock generally increases labour productivity across all buckets in most countries. Chart 5 below reports the estimated coefficients of a one-standard-deviation monetary policy shock interacted with high, medium and low sectoral markups. In most countries, the immediate response is an increase in firm-level labour productivity across all buckets. More specifically, starting with the first panel on the left-hand side, the figure shows that the average labour productivity of firms in Italy increases immediately across all buckets, but turns negative after two periods. By the end of the fourth year, the impact becomes positive again but only for firms in the medium-markup bucket. A similar pattern emerges for firms in France, though with a larger initial effect, which is also more pronounced than in the other countries. Conversely, the initial response in Portugal is somewhat muted but becomes large and positive after four years. In the Netherlands, the impulse response functions (IRFs) remain positive throughout the time periods for the high and medium-markup buckets, while in Spain, this is true only for the medium-markup bucket.

Firms operating in sectors with higher markups (high and medium-markup buckets) are likely to show a greater labour productivity response to monetary policy shocks. The bold dots in Chart 5 show the points on the IRFs that are significant at the 5% level. These points suggest that the increase in average labour productivity is greater for the high and medium-markup buckets (except in Spain) than for the low-markup bucket. However, based on the current results, we cannot confirm whether the impact on the productivity of firms operating in higher-markup sectors is significantly different from that of firms operating in lower-markup sectors.

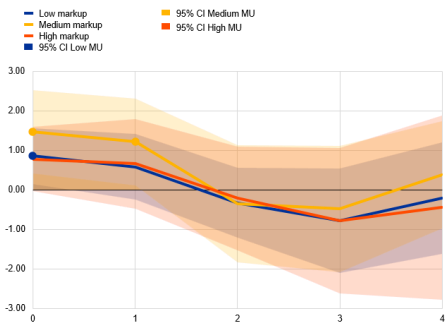
Reallocation of resources from low to high-markup sectors could reconcile the theoretical channel with our empirical findings (see Charts 4 and 5). One possible explanation for these results is that, following a monetary policy shock, resources are reallocated from low to high-markup sectors, thus contributing to the overall increase in productivity. However, it is not possible to confirm that this reallocation takes place, given our limited data.

[11] Unlike the CES demand system, which assumes that the price elasticity of demand is constant both over the time series and across firms, Baqaee and Farhi (2022) allow the price elasticity facing a firm to vary both with the firm's type θ and its position on the demand curve.

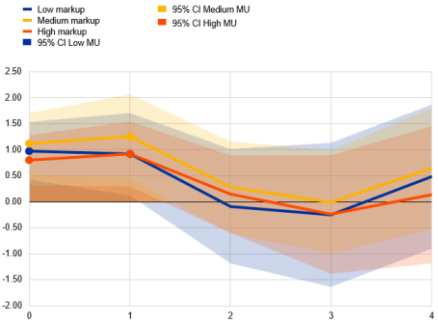
Chart 5

Firm-level IRFs based on labour productivity for selected countries (percentage points)

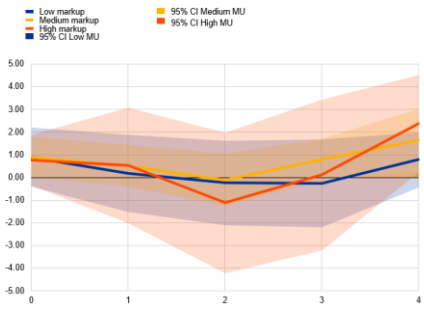
Italy



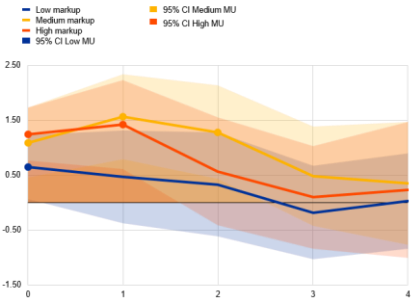
France



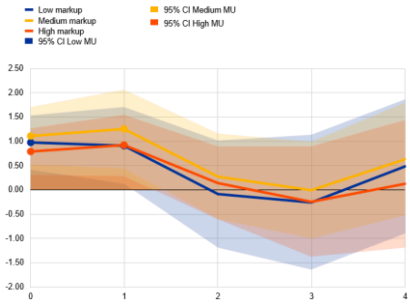
Portugal



Netherlands



Spain



Sources: National sources and ESCB calculations.
Note: The figure reports impulse responses across each bucket for the five selected countries over a five-period horizon following a one-standard-deviation monetary policy shock. Statistically significant coefficients at a 95% confidence level are indicated with a dot.

2.4 Concluding remarks on market power and productivity

Market power, as indicated by high sectoral markups, has not been found to contribute to the productivity slowdown in Europe. As it happens, productivity and markup trends at the country level are positively correlated. Firms in high-markup sectors also tend to be highly productive and more likely to contribute to aggregate productivity gains.

In the presence of heterogeneous markups, one possible channel through which expansionary monetary policy shocks can increase productivity is by facilitating the reallocation of resources to highly productive firms operating in high-markup sectors. This is observed not only for firms in the euro area but also for those operating in the US market. Therefore, by boosting demand and reducing misallocation, expansionary monetary policy can be effective in increasing productivity both immediately and in the long term.

Box 4

Monetary policy, productivity and market concentration in the United States

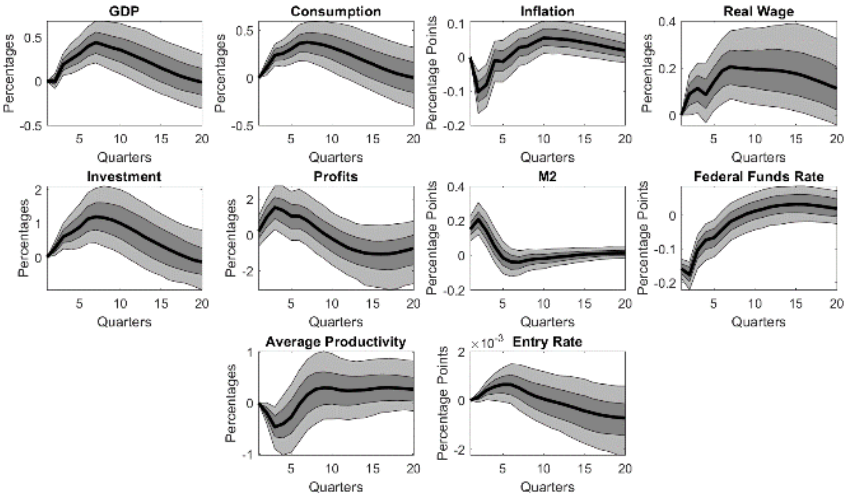
Prepared by Andrea Colciago

Colciago and Silvestrini (2022) show that, by affecting aggregate demand and borrowing costs, a monetary policy shock alters the composition of the pool of firms that are active in a market. The adjustment along the extensive margin affects productivity. Further, the strength of the mechanism depends on the initial degree of sales concentration in the final goods market.

Chart A

IRFs to an expansionary monetary policy shock

(percentages)



Source: Colciago and Silvestrini (2022).

The effects of monetary policy shocks on average productivity across firms and firm entry are identified in a VAR(4) model, where the sample period is 1966:Q1-2014:Q4 in all specifications. Firm-level data refer to the United States and come from Compustat. Chart A displays IRFs to an unexpected one-standard-deviation reduction in the federal funds rate. We report the median and 68% (darker areas) and 95% (lighter areas) confidence intervals computed using bootstrap. We identify two key findings. The first is that average productivity across firms displays a non-monotonic response to a monetary expansion. It initially declines for a few quarters and then overshoots its long-run level for several periods before reverting to the baseline. The second finding is that the entry rate shows the opposite dynamics with respect to average productivity: entry initially increases in response to the shock, while, after a few periods, it persistently undershoots its long-run level.

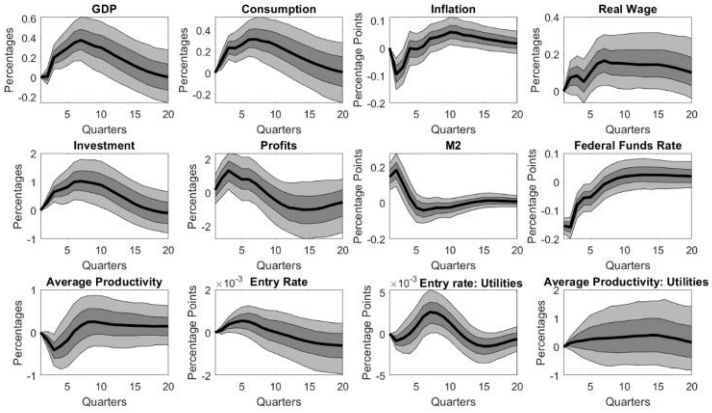
To investigate whether the monetary transmission mechanism is affected by the initial degree of market concentration, we first rank sectors according to the Herfindahl-Hirschman Index (HHI). We then augment the baseline VAR with the average productivity and entry rate in the NAICS-2 Utilities sector. This sector, with an HHI equal to 0.013, is the least concentrated sector in our sample. We construct quarterly series for sectoral productivity and entry using the same approach as for the economy-wide variables. Chart B reports the results for the baseline VAR specification augmented with the average productivity and entry rate in the Utilities sector. After an initial non-significant

decrease, the response of the sectoral entry rate is larger than that of the economy-wide entry rate. Indeed, the point estimate for the peak is twice as large.

Chart B

IRFs to an expansionary monetary policy shock (includes sectoral evidence)

(percenatges)



Source: Colciago and Silvestrini (2022).

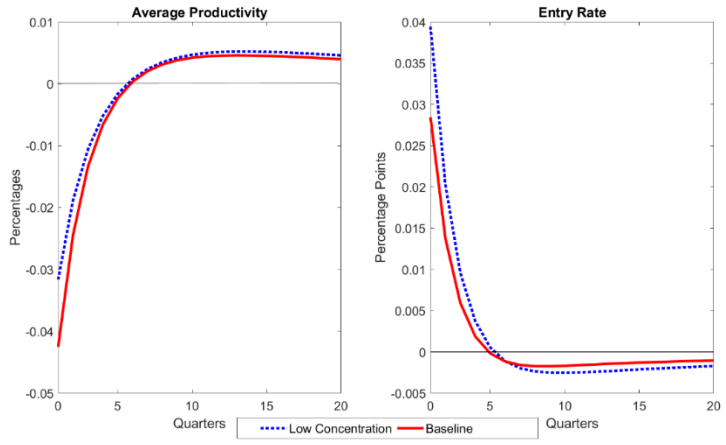
We interpret the results using a New Keynesian industry dynamics model. The model has the following features. First, we allow for both endogenous entry and endogenous exit dynamics, such that the monetary transmission mechanism rests on both margins of adjustment. Second, we allow firms to display heterogeneous productivity levels. As a result, we can study how average productivity within a sector, and its aggregate counterpart, respond endogenously to a monetary shock that alters the composition of the pool of active firms, and how the propagation mechanism depends on the degree of market concentration. Third, we assume that firms must borrow working capital to finance their wage bill. When producing, firms face fixed production costs. In this setting, given aggregate conditions, only a subset of firms can break even on production costs and continue production. Firms with an idiosyncratic productivity level below a specific threshold are forced to discontinue production and remain inactive until production becomes profitable again. Chart C displays the IRFs of productivity and entry in response to a one-standard-deviation decrease in the nominal interest rate. Solid lines represent the IRFs under the benchmark calibration of the model, while blue dotted lines represent those under an alternative calibration meant to represent a highly competitive market such as the US utilities sector. The units on the vertical axis are deviations from the steady state. Entry rates are given in percentage points, while average productivity is shown in percentages. The dynamics are qualitatively consistent with the empirical results. A competitive market is populated by many firms exhibiting similar levels of productivity. Thus, a change in the productivity threshold needed to survive affects many incumbents and potential new entrants. As a result, a monetary policy shock that affects the productivity threshold leads to more sizeable entry and exit flows than in a more concentrated market. For the same reason, in a market characterised by low levels of concentration, average productivity among operative firms and the threshold level of productivity are relatively close to each other. Thus, the idiosyncratic productivity of new entrants does not differ significantly from that of the average incumbent. Consequently, we observe a muted response of productivity to the shock, particularly on impact. By contrast, in concentrated markets with relatively few large firms, entry and exit occur only in response to large swings in the threshold

productivity level and involve relatively few firms. The entry or exit of a smaller number of large firms can, however, have a stronger effect on productivity than in the former case.

Chart C

IRFs to a monetary policy shock – Model dynamics

(percentages, deviations from the steady state



Source: Colciago and Silvestrini (2022).

3 Effects of monetary policy on the allocation of input factors

Prepared by Dmitry Khametshin and Beatriz González

In this section, we provide empirical evidence showing that monetary policy affects the allocation of input factors.[12] In theory, monetary policy matters when it comes to the allocation of production inputs if it affects the wedges between factor prices and firms' marginal products. In this context, financial constraints represent a natural example of a factor wedge that may be affected by monetary conditions and, in turn, affects factor allocation. For example, if monetary policy easing relaxes the financial frictions faced by constrained but productive firms, it may reduce factor misallocation and increase aggregate productivity. The opposite effect may occur in response to monetary policy tightening. In this section, we present empirical evidence supporting this mechanism. Since the shocks in our framework are symmetric, our results can be interpreted from the perspective of an unexpected episode of monetary policy tightening simply by changing their sign.

3.1 Empirical evidence for the euro area

At the industry level, the effect of monetary policy on misallocation is likely to manifest itself as a change in the dispersion of the marginal products of inputs following a monetary policy shock. Theoretically, in the absence of frictions, marginal products should be equalised across firms within sectors. It follows then that the dispersion of marginal products can be used as a good proxy for factor misallocation (Hsieh and Klenow, 2009). Accordingly, we measure the misallocation of capital and labour using the within-industry variance of their marginal products. We approximate a firm's marginal product of capital (MRPK) and labour (MRPL) by the ratio of its value added to tangible capital and to the average number of employees during a year, respectively. We then estimate the effect of monetary policy on factor misallocation using local projections (Jordà, 2005). Specifically, following Albrizio et al. (2023), we estimate the regression coefficients of the following equations:

$$VAR(x_i)_{j,t+h} - VAR(x_i)_{j,t-1} = \beta^h \epsilon_t^{MP} + \psi \mathbb{Z}_{j,t-1} + \gamma_j^h + u_{j,t}^h,$$

where $VAR(x_i)_{j,t}$ is the logarithm of the variance of firms' MRPK or MRPL in industry j in year t, ϵ_t^{MP} is the monetary policy shock measured as described in Box 2, $\mathbb{Z}_{j,t}$ is a vector of aggregate and sector-level controls, and $h = 0, 1, \ldots, 4$ is the horizon over which the effect is measured, in years. The latter includes the

[12] Note that this report focuses on monetary policy surprises, rather than secular changes in interest rates.

aggregate unemployment and inflation rates, as well as sector-level sales growth. We also include sector-level fixed effects, γ_j, to account for time-invariant industry characteristics that may affect misallocation trends. We sign ϵ_t^{MP} such that positive values indicate monetary policy easing. Our main object of interest is the set of coefficients β^h, which represent the dynamic response of misallocation to monetary policy shocks over the h time horizons. Negative values of β^h provide evidence in favour of the above mechanism, whereby monetary policy easing decreases within-sector dispersion of marginal products and, thus, factor misallocation, while monetary tightening increases it.

At the firm level, monetary policy affects firms differently depending on the levels of their marginal products of capital and labour. Thus, higher levels of a firm's marginal products relative to the industry-wide average may point to elevated factor wedges, such as tighter financial constraints faced by the firm. If financial frictions depend, among other factors, on monetary policy, the factor decisions of firms with higher marginal products are likely to be more sensitive to monetary policy shocks. To test this hypothesis, following González et al. (2023) and, more closely, Albrizio et al. (2023), we run a series of local projections at the firm level to estimate the following equations:

$$y_{i,t+h} - y_{i,t-1} = \beta_1^h \epsilon_t^{MP} + \beta_2^h \epsilon_t^{MP} x_{i,t-1} + \psi \mathbb{Z}_{j,t-1} + \theta Q_{i,t-1} + \gamma_j^h + u_{i,t}^h,$$

where $y_{i,t}$ is the log of tangible capital or the number of employees in firm i in year t, $Q_{i,t-1}$ is a vector of firm-level controls that include financial leverage, cash holdings and firm age, $x_{i,t}$ is the firm's MRPK or MRPL (both demeaned and standardised by sector), and the remaining variables are as described above. As in the sector-level analysis, we include sector-level fixed effects, γ_j, to account for time-invariant industry characteristics that may affect capital and employment growth rates. The coefficient β_1^h measures the direct dynamic effects of monetary policy on firms with average levels of marginal products. Our main coefficient of interest, however, is β_2^h, which represents the heterogeneous dynamic response of firms' usage of the two factors of production to monetary policy shocks. Positive values of β_2^h indicate that firms whose marginal products are high relative to the industry average are more sensitive to monetary policy shocks. This result would be consistent with the hypothesis that monetary policy affects factor wedges by altering the financial frictions faced by firms.[13]

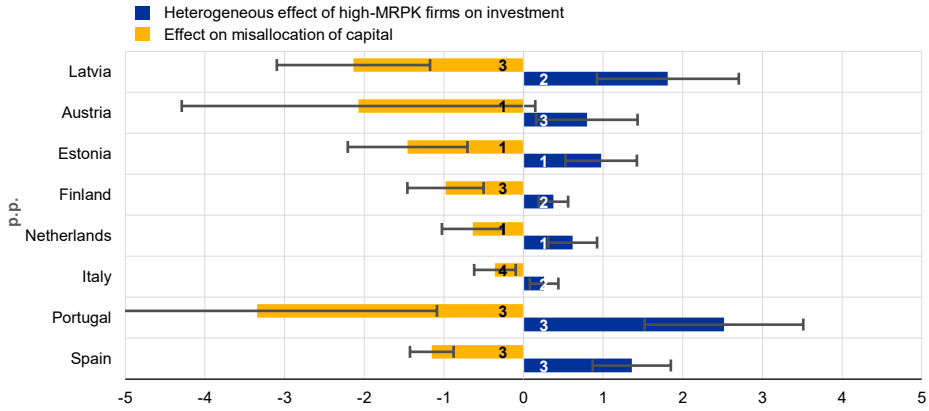
The estimation strategy requires both rich time- and cross-sectional dimensions of the data, somewhat limiting the number of countries included in the analysis. Long sample periods are needed to ensure sufficient variation in the

[13] The firm-level analysis described above focuses on the intensive margin of factor utilisation. However, there may be other channels through which monetary policy affects sector-level misallocation. In particular, monetary policy stance can affect firms' entry and exit decisions. To the extent that the composition of entering or exiting firms in terms of their marginal revenue productivities is sensitive to monetary policy, this can affect misallocation via the extensive channel (see Albrizio et al., 2023).

realised monetary policy shocks.[14] Moreover, sufficiently representative cross-sectional variation is necessary in order to measure the within-industry dispersion of marginal products and a firm's position in the distribution of MRPK and MRPL. These data requirements limit our empirical analysis to a relatively small number of countries, namely Spain, Portugal, Italy, the Netherlands, Finland, Estonia, Austria and Latvia. We present the results in Chart 6 and 7, where we report the peak effects of monetary policy on factor misallocation and factor use by firms with high levels of revenue products for the eight countries included in the sample. We plot the dynamic responses of misallocation and firms' investment and employment in the chart provided in Appendix 7.2.

Chart 6

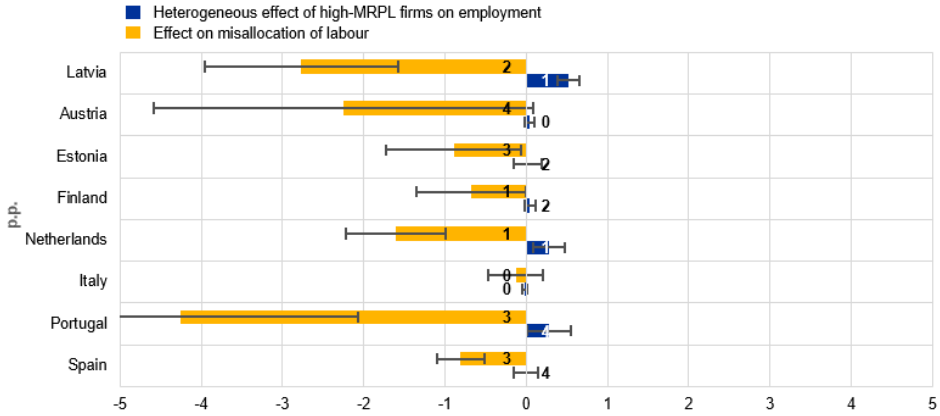
Effects of expansionary monetary policy on capital misallocation



Notes: Effects of a one-standard-deviation expansionary monetary policy shock. The numbers at the base of the bars indicate the year in which the effects peak. Whiskers represent 90% confidence intervals.

Chart 7

Effects of expansionary monetary policy on labour misallocation



[14] The effects of monetary policy on misallocation can be asymmetric, i.e. they may differ between monetary expansions and contractions. However, analysing these asymmetric effects is constrained by the relatively short time dimension and low frequency of the firm-level data.

Notes: Effects of a one-standard-deviation expansionary monetary policy shock. Numbers at the base of the bars indicate the year in which the effects peak. Whiskers represent 90% confidence intervals.

Our results show that monetary policy easing appears to improve the allocation of capital (while monetary policy tightening worsens it). As illustrated in Chart 6, monetary policy easing exerts downward pressure on capital misallocation in all countries included in the sample.[15] Furthermore, the effects of monetary policy on capital misallocation vary across all the countries analysed in terms of both their peak magnitude and timing. For example, capital misallocation in Portugal appears to be strongly affected by the monetary shock, while in Italy it appears to be somewhat less sensitive. In Austria, Estonia and the Netherlands, the effect quickly fades after one year, while in the remaining countries it takes three to four years to reach its peak. The peak effects are statistically significant at the 10% level in all countries, with the sole exception of Austria, for which the sample period is relatively short.

Firms with high marginal productivity of capital relative to the sector average are more sensitive to monetary policy shocks. As illustrated in Chart 6, the pattern of the estimated effects of monetary policy on investment closely mirrors the sector-level effects on capital misallocation. Furthermore, as with the sector-level results, the peak effects on investment among high-MRPK firms are statistically different from zero, being stronger in Portugal and weaker in Italy, and fading more quickly in the Netherlands and Estonia. Overall, the results suggest that firms facing greater capital distortions than their industry peers are more sensitive to monetary policy shocks. This is consistent with the hypothesis that these firms are financially constrained and that monetary policy affects the degree of financial frictions (see Albrizio et al., 2023). For instance, monetary easing can ease financial constraints by increasing the value of collateral available to firms and, hence, the amount of external finance available to them, and also by lowering their debt repayments and increasing profitability. Greater collateral availability or profitability then relaxes financial frictions and allows constrained high-MRPK firms to increase their capital by relatively more than their unconstrained peers.

In contrast, the evidence with respect to labour misallocation is rather mixed. Chart 7 illustrates the effects of monetary policy easing on the variance of MRPL at the sector level for the countries included in the sample. The effects of monetary policy on labour misallocation are statistically significant and show the expected pattern only in a subset of countries (such as the Netherlands and Portugal), while in other countries the effects are either not statistically significant or follow a non-monotone pattern (as in the case of Italy and Latvia, respectively). Furthermore, the greater sensitivity of employment among high-MRPL firms to monetary policy is consistently observed only in the Netherlands and Portugal. In other countries, the firm- and sector-level results indicate either a weak relationship, or no relationship at all, between monetary policy and labour misallocation (Finland, Italy and Austria). This could suggest that labour reallocation is more sensitive to other policies, including fiscal and structural ones, including, for instance, changes in the intensity

[15] The estimated effects are positive for a subset of horizons only in the case of Finland and Estonia; however, these point estimates are not statistically different from zero.

of labour use, which are difficult to measure using firm balance sheet data, or changes in the extensive margin.

3.2 Concluding remarks on input allocation

The results suggest that there is a significant relationship between monetary policy and capital misallocation, while the effect of monetary policy on labour misallocation is less clear. Conceptually, monetary policy is more likely to affect capital price distortions rather than labour price wedges, for instance by altering the degree of financial frictions faced by firms. Furthermore, in the case of labour misallocation, other structural channels may play a greater role. Lastly, firm entry and exit decisions may be sensitive to monetary policy shocks, which could affect sectoral labour misallocation if entering or exiting firms that differ in their marginal productivity of labour respond differently to monetary policy shocks. Other structural characteristics of the countries analysed, such as the proportion of temporary workers or the prevalence of variable versus fixed interest rates in credit contracts, may contribute to heterogeneity in the speed of monetary policy transmission.

4 Effects of monetary policy on zombie margins

Prepared by Paloma Lopez-García and Juuso Vanhala

While concerns over the increase in the share of zombie firms have persisted following the end of the low-interest rate period, the focus of the discussion has shifted. It has been argued that the era of low interest rates following the global financial crisis supported the survival of zombie firms, leading to an increase in their share of the total firm population (known as "zombie incidence"), with possible implications for aggregate productivity. Zombies are unviable firms that are unable to cover their debt servicing costs from current profits over an extended period. As they tend to be low-productivity firms, their survival could dampen productivity growth.[16] In recent years, the rise in interest rates has raised the question of whether these firms kept alive by cheap credit would begin to die off as debt servicing costs rise.

In this section we challenge the claim that European economies are plagued by a secular increase in the incidence and survival of zombie firms, and we scrutinise the role of accommodative monetary policy in "zombification" and "dezombification". Using firm-level data for eight euro area Member States, we first explore the share of zombies in the economy (incidence), its evolution over time, and the entry to and exit from distress, often referred to as "zombie demographics", following Nurmi et al. (2022) and ECB (2021). As in those studies, we separate growing firms from downsizing or stagnant "true zombies" to show that not all firms typically labelled as zombies are truly in distress and that many of them are able to fully recover. We then study the so-called congestion effects, that is, the impact of zombies on healthy firms operating in the same sector.[17] Our analysis extends that of ECB (2021) to cover a larger set of countries and examines the impact of monetary policy shocks, as defined in Box 2, on the different margins.

Our analysis of the effects of monetary policy shocks on zombification encompasses several largely neglected channels arising from zombie demographics. Instead of merely examining the effects of monetary policy on changes in the share (incidence) of zombies, we study the impact on the flows of firms both into and out of zombie status, which underlie fluctuations in zombie incidence. Moreover, we decompose the zombie exit margin into firms exiting the market and firms recovering to healthy status.

Our results suggest that the effects of monetary policy shocks on different adjustment margins operate in opposing directions. On the one hand, accommodative monetary policy may support zombie survival (by reducing zombie exits), thereby reducing the outflow from zombie status and leading to an increase in zombie incidence, as argued in earlier studies (see Banerjee and Hofmann, 2018;

16 See ECB (2021).

17 See Alogoskoufis et al. (2021).

Duval and Obstfeld, 2018; Bindseil and Schaaf, 2020). On the other hand, accommodative monetary policy tends to help firms recover from zombie to healthy status. It also reduces the rate at which firms become zombies in the first place. Of these two effects, the former increases the outflow from zombie status, while the latter reduces the inflow into zombie status, with both therefore contributing to an overall decline in zombie incidence.

The preliminary results presented in this report suggest that the impact of monetary policy on the entry margin dominates its impact on other margins. Thus, accommodative monetary policy is expected to result in a decline in zombie incidence. Symmetrically, our results suggest that monetary policy tightening might increase the entry of firms into "zombieness", thereby increasing the share of zombies in the total firm population.

Box 5
Identifying zombies

Zombie firms are commonly identified using measures of their ability to service their debt costs from current profits, possibly combined with other conditions, over a relatively narrow time frame (see, for example, Adalet McGowan et al., 2018). Nurmi et al. (2022) use a dynamic model of firm entry and exit to show why some firms may, at first glance, appear to be zombies if the interest coverage ratio alone is used to identify them. In a dynamic setting, a firm's exit decision is forward-looking. Its survival not only depends on its current returns, but also on its expected future value. This is a key issue for zombie identification, as the expected future value of a firm determines whether it is likely to recover from losses accumulated during a spell of weak performance. Growing and downsizing firms differ in this respect.

We follow Nurmi et al. (2022) by augmenting the common zombie definition based on the interest coverage ratio (ICR) (see, for example, Adalet McGowan et al., 2018) with a forward-looking element that requires zombies to be non-growing firms. This separates true zombies from growing firms experiencing temporarily weak earnings, which are commonly misidentified as zombies according to conventional definitions.

As in Nurmi et al. (2022), we identify zombie firms based on two conditions:

$$ICR(3) = \frac{EBIT}{interest + financial\ charges} < 1 \quad \text{and} \quad l_t - l_{t-2} \leq 0. \qquad (1)$$

The first condition captures the firm's current weak performance. It is the widely used requirement that the interest coverage ratio (ICR) remain low for three consecutive years, with a direct counterpart in the data. According to this condition, a firm must, in order to meet its interest payments, take new loans or receive other outside funding, as its earnings are insufficient to cover its interest costs.

The second condition differentiates between growing and downsizing firms. It requires that a firm's annual employment growth rate not be positive on average over a two-year period during the low ICR period. This serves as a proxy for expectations about the firm's future value and distinguishes truly distressed firms from viable firms experiencing temporarily weak earnings. As expectations

regarding the future value of a firm are unobservable, they are proxied by firm growth. Nurmi et al. (2022) note that, conceptually, employment growth is a good proxy for expectations about a firm's future value. If a firm decides to grow (employment growth is a decision that a firm controls endogenously), this growth reveals the firm's own private assessment of its expected future profitability.

In Section 4.1 we show the relevance of the non-growth criterion for separating "true zombies" from "false zombies", which are growing firms experiencing temporarily low earnings. This extended zombie definition also offers a conceptually appealing way to distinguish currently unprofitable, but growing, start-ups from zombies without imposing an arbitrary minimum age threshold. By construction, however, the zombie indicator rules out the youngest firms from the data, as the ICR(3) < 1 condition implicitly sets a three-year threshold. Evidence from our data suggests that, within the sample of firms that have been active for more than three years, the age threshold makes little difference to the results (see Chart A.8 in the Appendix).

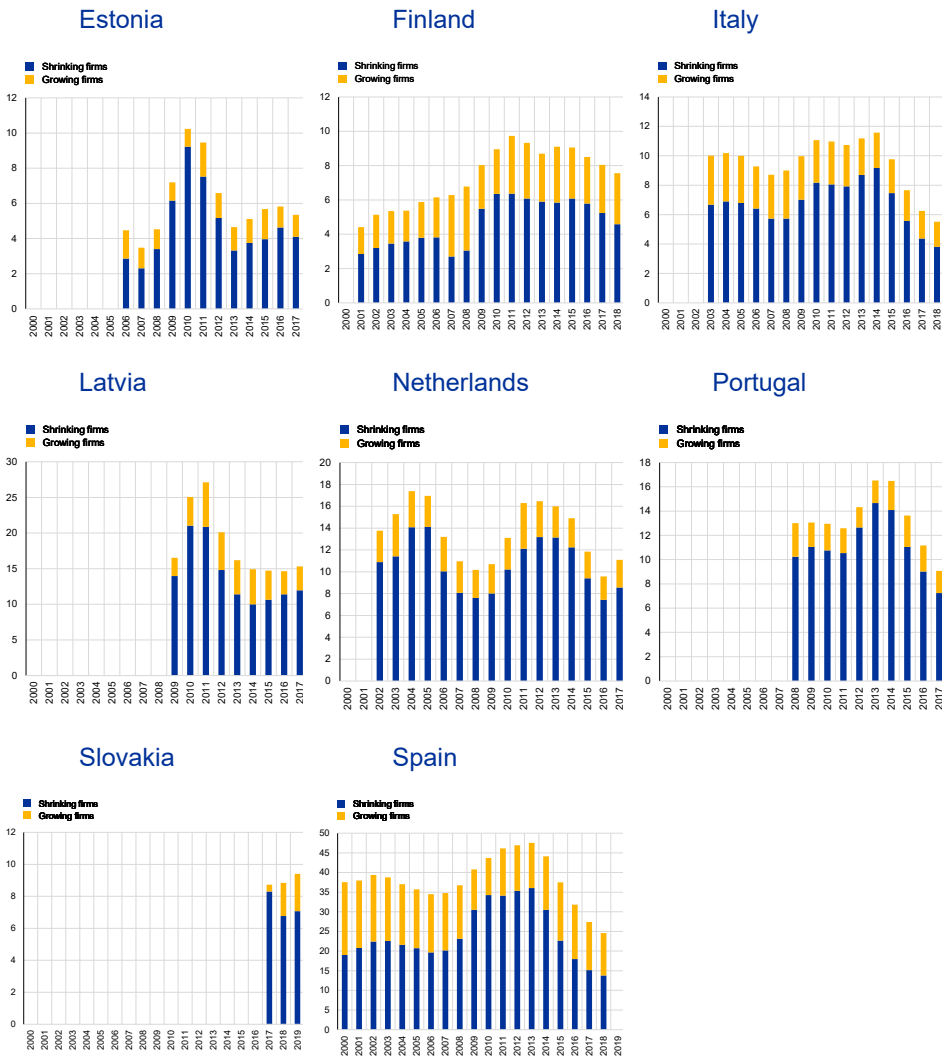
The choice between EBIT (earnings before interest and taxes) and EBITDA (earnings before interest, taxes, depreciation and amortisation) in the interest coverage ratio makes a quantitative difference when analysing distressed firms, since EBIT is affected by depreciation and amortisation. EBIT may be influenced by, for example, strategic accounting practices involving investment and amortisation decisions, whereas EBITDA is not subject to such practices. The analysis presented in this chapter was also conducted using EBITDA and the results are qualitatively similar, although the share of zombie firms is several percentage points lower when using EBITDA (see Figure A.9 in the Appendix).

Sources: Nurmi et al. (2022) and ECB (2021).

4.1 Zombie demographics

Changes in zombie incidence appear less alarming when firms' growth potential is explicitly considered when identifying zombies. Applying the forward-looking or extended zombie definition (see Box 5) to the data suggests that zombie incidence is considerably lower than earlier studies indicate. We find that a large share (up to 40% in some countries) of firms flagged as zombies according to the widely used ICR definition are actually growing in terms of employment (Chart 8). Hence, a low interest coverage ratio could be a temporary product of heavy investment in growth-enhancing activities. While this is perhaps not surprising for start-ups, the same pattern is observed across age groups and firm sizes. For example, in the data for Finland, growing firms account for an average of 36% of all firms with ICR(3) < 1 and 32% of firms that have been active for over 10 years. For Italy, the corresponding figures are 29% and 25%. Indeed, zombie firms, as commonly defined in the literature, are often not so much truly distressed firms but instead growing companies experiencing temporarily weak performance measures.

Chart 8
Shares of downsizing and growing firms with ICR(3) < 1



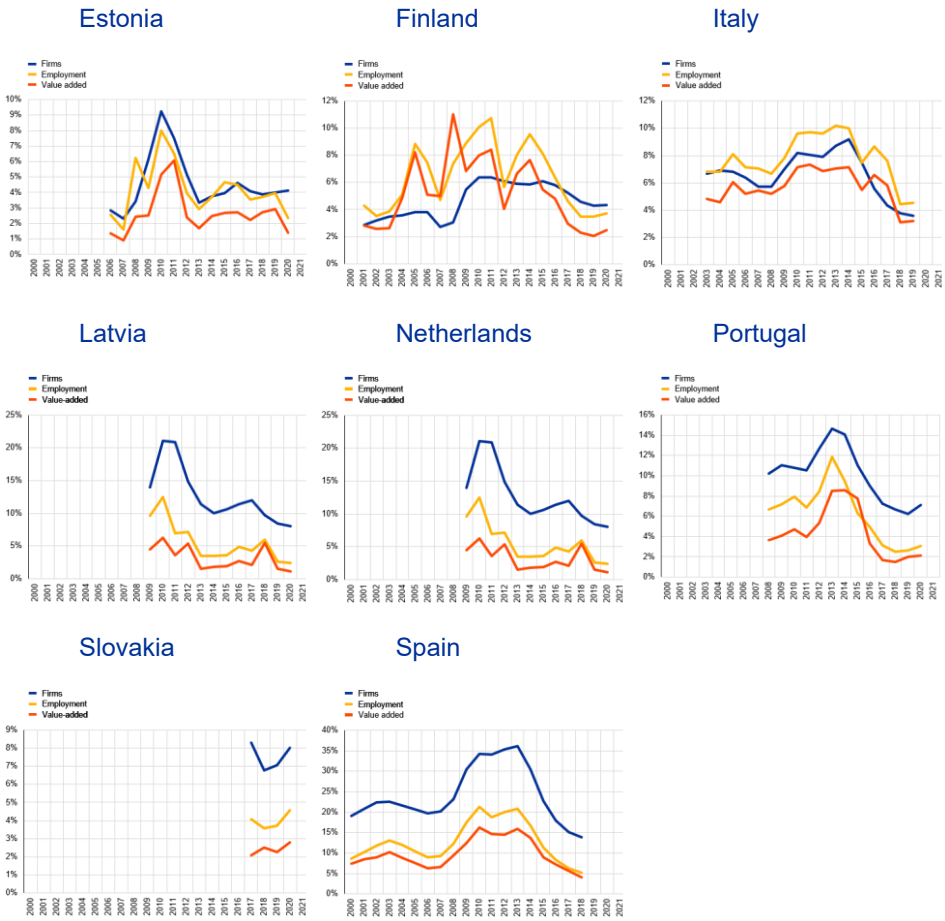
Sources: National sources and ESCB calculations.
Notes: Firms with ICR(3) < 1 are firms whose ratio of earnings before interest and taxes (EBIT) to interest paid plus financial charges is less than one (EBIT/interest < 1) for three consecutive years. A downsizing (growing) firm's annual employment growth rate is not positive (positive) on average over a two-year period within the low ICR period.

The share of zombies (as a proportion of the total number of firms, i.e. zombie incidence) alone may be an imperfect indicator of the macroeconomic implications of this phenomenon. The macroeconomic significance of zombies can also be characterised by weighting firms by the employment or capital (mis)allocated to them, or by their share of total value added. We find clear cross-country differences when using such weightings. For example, in Finland, the employment and value-added shares of zombie firms are larger than their share of the total firm population, reflecting the fact that many large firms are zombies. Hence, in countries with many large firms classified as zombies, the economic importance of zombie firms may be greater than their share of the total firm population would suggest. Moreover, in such countries, a relatively small number of large firms that enter and exit zombie status may cause large fluctuations in the employment or capital allocated to zombie firms. The opposite is true in most other countries, including the Netherlands, Portugal and Spain: the employment and value-added shares are lower than the share of zombie firms to the total firm population,

because zombie firms tend to be small. Italy and Estonia are intermediate cases. These differences may also arise from cross-country sectoral differences in zombie incidence.

Chart 9

Proportion of zombie firms and zombie shares of employment and value added



Sources: National sources and ESCB calculations.
Notes: Zombies are defined as non-growing firms whose ratio of EBIT to interest paid plus financial charges is less than one (EBIT/(interest + financial charges) < 1) for three consecutive years.

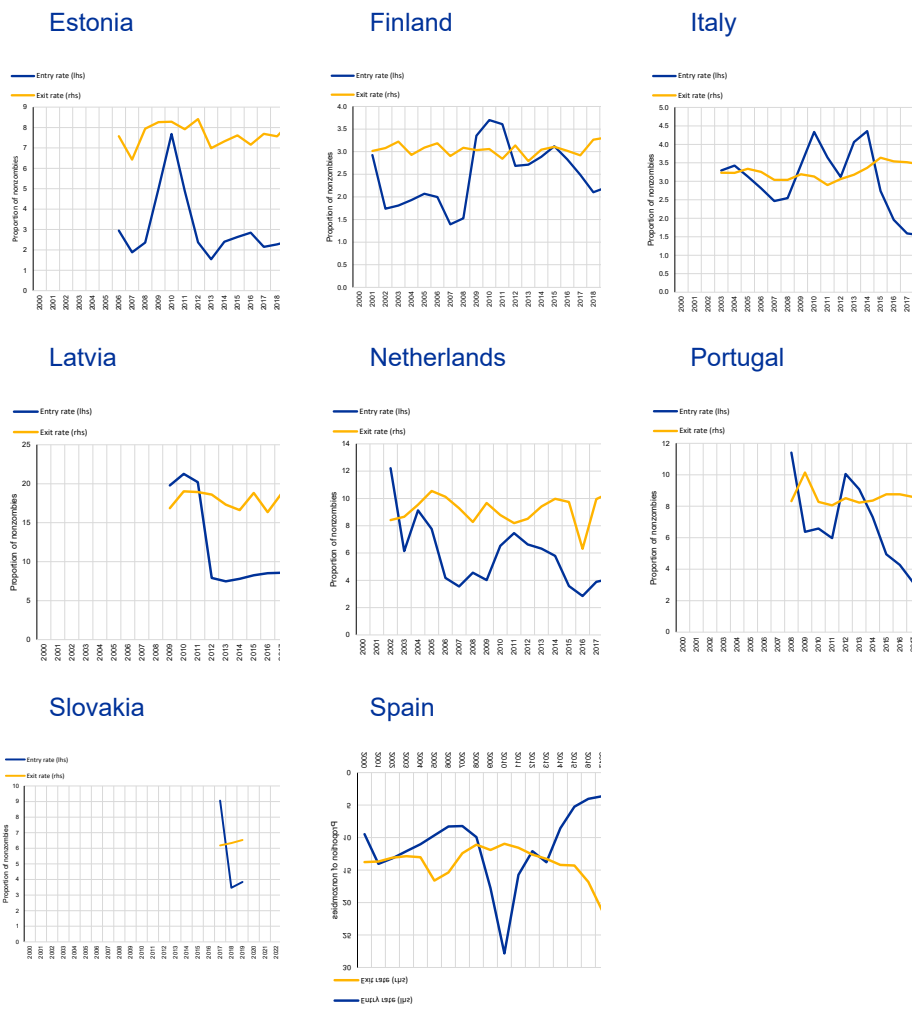
The purported increase in zombie incidence has been linked to increasing survival (declining exits) of zombie firms. Cheap credit and low interest rates have been blamed for these developments in both the literature and policy narratives (see, for example, Adalet McGowan et al., 2018; Banerjee and Hofmann, 2018; Duval and Obstfeld, 2018; Bindseil and Schaaf, 2020; Demertzis and Viegi, 2021).

However, the change in the stock of zombies depends not only on outflows from zombie status (exit), but also on inflows into zombie status (entry). Indeed, Chart 10 shows that zombie entries are the main driver of zombie dynamics: the rise in zombie incidence during the financial crisis resulted from an increase in zombie entries, which remained elevated for several years. Subsequently zombie entries and the stock of zombies declined, reflecting improved cyclical conditions. By

contrast, exits from zombie status remained relatively stable throughout the sample period, implying that, on average, the duration of zombie spells remained stable. In other words, the rise and fall in zombie incidence were driven by the cyclical entry into distress of firms, and not by the more persistent survival of zombies suggested by popular narratives.

Note, however, that a stable zombie exit rate is consistent with both a decline in market exit (firm death) rates and an increase in exits from zombie status as firms become healthy again (recovery), especially in an environment of low and falling interest rates. This will be discussed below.

Chart 10
Zombie entry and exit

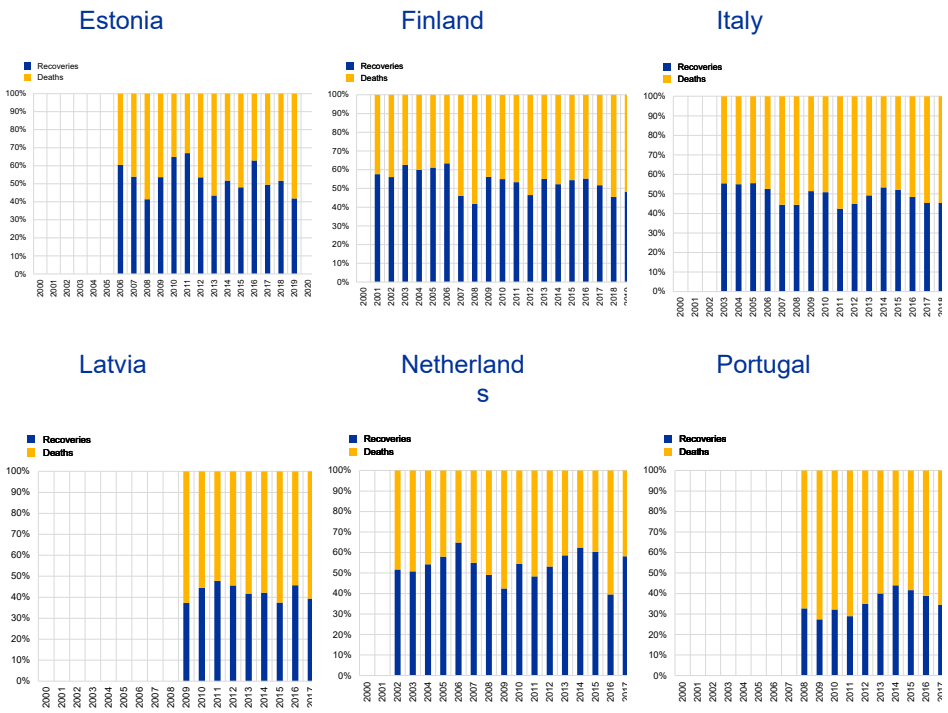


Sources: National sources and ESCB calculations.
Notes: Zombies are defined as non-growing firms whose ratio of EBIT to interest paid plus financial charges is less than one (EBIT/(interest+financial charges) < 1) for three consecutive years.

In the sample of countries and over the period analysed in this section, zombies frequently recover to become healthy firms. A firm may exit zombie status because it leaves the market (firm death) or because it becomes a healthy firm again (recovery). Whether a zombie firm exits through to death or recovery carries policy implications, as providing life support (such as through subsidies or low interest rates) to firms on the brink of death is harder to justify than supporting temporarily unprofitable but recovering firms. Zombie spells frequently end in recovery in our data: recovering firms accounted for 40-70% of zombie exits, while dying zombie firms represented 30-60% across the eight countries included in the sample (Chart 11). The share of recoveries is relatively high and stable among both downsizing firms with ICR(3) < 1 (true zombies) and growing firms with ICR(3) < 1 (false zombies), being higher among the latter. The high recovery rate suggests that some growing firms misclassified as zombies may simply be temporarily unprofitable owing to, for example, restructuring or investment in their future profitability.[18] Meanwhile, the relatively high recovery rate even among true zombies indicates that firms adjust (albeit perhaps sluggishly) in response to negative shocks. Moreover, the recovery of firms from zombie status seems to be persistent. Of the recovered firms that are still active after three years, only a small proportion have fallen back into zombie status, while most remain healthy. This is supported by the fact that most firms experience only one zombie spell during the sample period.[19]

Chart 11

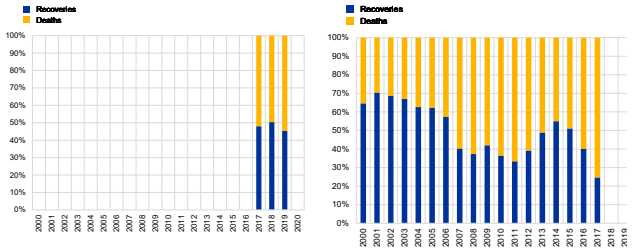
Proportions of zombie exits: recoveries versus deaths



[18] Similar evidence for Austria is reported by Beer et al. (2021).

[19] In the data for Finland, the three-year survival rate is high but somewhat lower for recovered zombies than for the sample as a whole. The three-year survival rate for recovered zombies is about 66%, compared with around 71% for the full sample. Of the surviving firms that have recovered from zombie status, only about 10% return to zombie status within three years, while the remainder remain healthy.

Slovakia Spain



Sources: National sources and ESCB calculations.
Notes: Zombies are defined as non-growing firms whose ratio of EBIT to interest paid plus financial charges is less than one (EBIT/(interest+financial charges) < 1) for three consecutive years.

4.2 Zombie congestion

Zombie firms may congest markets for healthy firms. Zombie firms can drag down productivity growth not only because their own productivity is lower, but also because they can negatively affect the performance of other firms operating in the same sector.[20] This congestion effect arises when zombies compete with healthy firms for the same resources (thus increasing input prices) and operate in the same market (increasing competition and reducing output prices), thus constraining the output, job creation and investment of healthy firms.[21]

The results suggest that resources (mis)allocated to zombies have a negative effect on healthy firms. To evaluate the effects of zombie firms on the performance of non-zombie firms, we follow a methodology similar to that of Caballero et al. (2008) and Adalet McGowan et al. (2018). In those studies, congestion is assessed by regressing various measures of healthy firms' performance against the share of resources (capital and labour) allocated to zombie firms (see Appendix 7.3.2 for the specification). The results indicate that a high concentration of capital in zombie firms within an industry is associated with lower investment among healthy firms, pointing to a congestion effect caused by zombie firms (Table 1).

20 In ECB (2021) we find that, on average, zombies' productivity is about 60% that of healthy firms operating in the same sector and country.

21 In addition, zombie firms may congest financing markets if incumbent zombie firms are able to obtain financing with fewer frictions or at lower costs than, for example, start-ups.

Table 1

Zombie congestion and investment: zombie share of industry capital

	Estonia	Finland	Italy	Latvia	Netherlands	Portugal	Slovakia	Spain
Zombie industry share measure:	**All firms with ICR(3) < 1, capital share**							
Non-zombie dummy	0.026***	0.117***	0.130***	0.215***	0.142***	0.163***	0.174***	0.0957***
	(0.0105)	(0.00377)	(0.00119)	(0.00904)	(0.00196)	(0.00347)	(0.00823)	(0.00124)
Non-zombie dummy * zombie industry share	-0.107***	-0.110***	-0.0891***	-0.0571***	-0.101***	-0.111***	-0.121***	-0.107***
	(0.0393)	(0.0123)	(0.00320)	(0.0216)	(0.00676)	(0.0113)	(0.0439)	(0.00366)
Zombie industry share measure:	**True zombies: Downsizing firms with ICR(3) < 1, capital share**							
Non-zombie dummy	0.275***	0.148***	0.156***	0.247***	0.154***	0.178***	0.191***	0.116***
	(0.0114)	(0.00467)	(0.00135)	(0.00995)	(0.00213)	(0.00374)	(0.00906)	(0.000921)
Non-zombie dummy * zombie industry share	-0.354***	-0.148***	-0.113***	-0.121***	-0.112***	-0.163***	-0.148**	-0.195***
	(0.0467)	(0.0157)	(0.00400)	(0.0260)	(0.00827)	(0.0128)	(0.0619)	(0.00339)
Observations	107,665	467,871	4,198,492	74,674	1,236,657	481,706	95,888	2,617,381

Source: Authors' calculations.
Note: True zombies are defined as non-growing firms whose ratio of EBIT to interest paid plus financial charges is less than one (EBIT/interest paid < 1) for three consecutive years. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3 Monetary policy shocks and zombification

The possible role played by accommodative monetary policy shocks in supporting the survival of zombie firms has received considerable attention in recent research and policy narratives (see Acharya et al., 2020; Banerjee and Hofmann, 2018; Borio, 2018; Duval and Obstfeld, 2018; Bindseil and Schaaf, 2020; Demertzis and Viegi, 2021). In these studies, zombie status has implicitly been assumed to be a terminal state that ultimately leads to the death of a firm. According to these narratives, accommodative monetary policy (low interest rates), in conjunction with lax banking regulation, may have incentivised banks to evergreen loans, thereby postponing the inevitable exit of these poorly performing firms from the market.

However, the net effect of monetary policy shocks on zombie incidence depends also on how they affect the rates at which firms become zombies and recover from zombie status. While a low-interest rate environment may indeed support the survival of non-viable firms, it may also help firms recover from zombie status. Moreover, low interest rates may reduce the share of firms that become zombies in the first place. The policy implications of low interest rates may thus be ambiguous and more complex than popular narratives suggest. It should also be stressed that the monetary policy stance responds to inflation developments and cyclical conditions and affects all firms, not just zombies.

This sub-section analyses the effects of the unexpected monetary policy shocks used throughout the rest of the report on the stock of zombie firms (incidence), as well as on the flows of firms into and out of zombie status. The analysis distinguishes between the impact on both the entry and exit margin from zombie status. The cross-country data available/necessary for this exercise do not allow us to separate the exit margin into recoveries and firm deaths.

The specification follows Banerjee and Hofmann (2018) and regresses the share of zombie firms in a given country-sector-year on the lagged monetary policy shock. We expand the analysis by also studying the impact of monetary policy shocks on the different margins: entry into zombie status and exit through recovery or death. As in Banerjee and Hofmann (2018), identification is achieved using the Rajan and Zingales (1998) sectoral measure of firms' dependence on external finance. The rationale is that firms in sectors more dependent on external finance are more exposed to monetary policy shocks. The sector-specific measure of external dependence indicates the amount of desired investment that cannot be financed through internal cash flows generated by the firm. The measure is computed using data from ORBIS for the four largest euro area countries and averaging the median two-digit sector-level year across all countries. This follows the original approach proposed by Rajan and Zingales (1998), who assumed that sector dependence on external finance was an exogenous sector characteristic. Unlike Banerjee and Hofmann (2018), we do not control for the health of the banking sector, as the authors estimate that it does not significantly help to explain the dependent variable. Instead, we include a full set of country, sector and year fixed effects, as well as controls for the cyclical position of the sector and the country in which the firm operates. We pool the sector entry and exit shares across the eight countries and run a separate panel regression for the share of zombies and for each flow variable (the share of firms entering and exiting the zombie stock).[22]

In contrast to Banerjee and Hofmann (2018), we find that, on average, an accommodative monetary policy shock decreases the overall share of zombies. The estimates are shown in Table 2. The first column shows the results for zombie incidence (the share of zombies in the total firm population), the second reports the impact of the monetary policy shock on the entry margin (the percentage of healthy firms that become zombies), and the third presents the exit margin (the share of firms exiting zombie status through recovery or death). The results show that an accommodative monetary policy shock reduces exits from zombie status or, in other words, increases zombie survival, as found in other related studies. However, it also reduces entry into zombieness and, according to our results, that particular effect dominates. The net impact is therefore a decrease in the zombie incidence rate within the economy (it bears repeating that an increase in the MP indicator signals an accommodative monetary policy shock). These results are robust to different specifications of the indicator of external finance dependence, as well as to the sets of controls.

[22] As in the rest of the section, the shares are defined as a percentage of the pool of origin, i.e. the total number of healthy (non-zombie) firms for the entry margin and the pool or stock of zombies for the exit margin.

Table 2

Impact of an accommodative monetary policy shock on zombie incidence and on zombie entry and exit

VARIABLE	(1) Share	(2) Entry	(3) Exit
External finance dependence	0.00531***	0.00257***	0.000486
	(0.00110)	(0.000668)	(0.000531)
Lagged mon. policy shock	-0.100***	-0.0805***	-0.0329***
	(0.0147)	(0.00893)	(0.00710)
External finance dependence × Lagged mon. policy shock	0.00749	0.00557	0.00191
	(0.00729)	(0.00442)	(0.00352)
Sectoral value added growth	0.00010	0.00400*	-0.00335*
	(0.00397)	(0.00240)	(0.00191)
Real GDP growth	-0.00130***	-0.000391**	-0.00176***
	(0.000289)	(0.000175)	(0.000139)
Observations	4,099	4,099	4,099
Adjusted R-squared	0.549	0.265	0.391
Sector FE	YES	YES	YES
Country FE	YES	YES	YES

Source: Authors' calculations.
Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

The estimation results reported in Table 2 suggest that focusing only on zombie survival or market exit may give an incomplete picture of the effects of monetary policy on zombification. The relationship between monetary policy shocks and zombification involves several channels that operate in opposing directions. Therefore, the effect of monetary policy shocks on zombification is not obvious a priori. Our results for the share of zombie firms suggest that the overall effect on zombification is negative in our data. That is, accommodative monetary policy shocks tend to reduce the share of zombie firms in the total firm population.

4.4 Concluding remarks on zombie firms

The change in the share of zombies in the economy depends on inflows into (entry) and outflows from (exit) zombie status. Despite the extensive body of literature on zombie incidence, the focus has mostly been on zombie deaths (firms exiting the market), whereas exits through recovery and entry into zombie status have been largely neglected. Our results show that entry and recovery flows are important for determining zombie incidence and that they may operate in the opposite direction to the zombie death rate.

Furthermore, zombie dynamics appear considerably less alarming when firms' growth potential is explicitly considered. We separate growing firms from downsizing or stagnant "true zombies" to show that not all firms typically flagged as zombies are genuinely in distress and that many can fully recover. Our firm-level data for eight EU countries suggest that a large share of firms labelled as zombies, as commonly defined in the literature, should not be considered as weakly performing: almost one-third of these supposedly distressed firms happen to be growing companies and around half recover from zombie status to become healthy firms again.

Our results on zombie flows indicate that the relationship between monetary policy shocks and zombification involves several channels that operate in opposing directions. Therefore, the effect of monetary policy on zombification is not obvious a priori. Our results for the share of zombie firms suggest that the overall effect is negative in our data, that is, accommodative monetary policy shocks tend to reduce the share of zombie firms in the total firm population. More broadly, our results reveal that the relationship between zombification and accommodative policies may be more complex than commonly thought.

5 The transmission channels of monetary policy and productivity

Prepared by Diana Bonfim

5.1 The transmission of monetary policy and productivity

In this chapter we analyse how different monetary policy transmission channels operate through the banking sector, using credit register and bank-level data for certain euro area countries. We first examine how traditional channels operate within this sample and then extend our analysis to consider their interaction with firm productivity.

Banks and, more broadly, all economic agents that interact with them play a crucial role in the transmission of monetary policy to the economy. However, there is one group that deserves special attention: corporate borrowers. Much of the empirical literature on monetary policy transmission through banks has focused on this segment of banking activity, partly due to data availability. Perhaps more importantly, investment among non-financial corporations is a core component of aggregate demand and a driver of productivity growth. When firms borrow, the price and quantity of the credit they obtain shape both aggregate investment (Rocheteau et al., 2018) and employment (Bernanke and Blinder, 1992; Kashyap and Stein, 1994, 2000). Thus, credit supply shocks can lead to changes in aggregate productivity, both through the reallocation of resources (Linarello et al., 2022) and through within-firm adjustments (Doerr et al., 2018; Manaresi and Pierri, 2019). If these shocks interact with the allocation of input factors in the economy, the market power of economic agents and the incidence of zombie firms, they may further complicate the monetary policy transmission mechanism, as discussed in the previous sections. In the presence of financial frictions, the sensitivity of productivity growth to the use of external finance is expected to increase (Levine and Warusawitharana, 2021). Moreover, financial frictions amplify productivity and output losses in the aftermath of crises (Queralto, 2020), although monetary policy can help stimulate growth and productivity during such periods (Ikeda and Kurozumi, 2019).

Most of the existing literature on monetary policy transmission to the real economy relies on credit register data, which provide detailed information about firm-bank relationships in credit markets (see Jiménez et al., 2012, 2014; Ioannidou et al., 2015; Morais et al., 2018). In this section, we use a dataset resulting from a collaboration between four national central banks (NCBs). The dataset combines granular loan-level data spanning several years with bank and firm characteristics. Unlike most studies on this topic, we do not focus on a single country but rather explore the cross-country heterogeneity. Using these data, we re-examine some of the most well-known channels of monetary policy transmission through

banks. The aim of the analysis is to better understand how the transmission of monetary policy through these channels can affect productivity.

5.1.1 Revisiting the transmission channels of monetary policy

As a first step, we consider how different bank characteristics can affect the transmission of monetary policy to non-financial corporations. The aim is to establish a unified framework to empirically examine the transmission of an unexpected monetary policy shock through banks.

Bank capital is the first such characteristic we examine. When monetary policy tightens, banks with lower levels of capital are expected to tighten their credit supply to a greater extent (Kishan and Opiela, 2000; Van den Heuvel, 2002; Peek and Rosengren, 1995; Gambacorta and Mistrulli, 2004). Weakly capitalised banks are further away from meeting their economic or regulatory capital targets and do not have the same margin as well-capitalised banks to absorb further shocks. As such, these banks may have to constrain the supply of credit more sharply, thus strengthening the transmission of monetary policy.

In recent years, it has become clear that banks' funding structure, notably their reliance on deposits, also matters for the transmission of monetary policy. Drechsler et al. (2017) show that a monetary policy tightening widens the spreads that banks charge on their deposits, leading to deposit outflows from the banking system. They show that this deposit channel of monetary policy operates through banks' market power in deposit markets. Heider et al. (2019) show that banks' funding structure may be especially relevant in the low interest rate environment that characterised the past decade in the euro area. In this environment, banks were reluctant (or unable) to pass on negative rates to depositors. This reduces the net worth of banks that rely more heavily on deposit funding, making them less willing (or able) to lend.

Finally, banks' liquidity position also strongly interacts with monetary policy transmission (Adrian and Shin, 2009; Kiyotaki and Moore, 2019). When monetary policy tightens, less liquid banks are expected to contract their supply of credit more sharply (Stein, 1998; Kashyap and Stein, 2000).

All these bank characteristics may influence not only the amount of credit granted, but also which borrowers ultimately receive such financing. For instance, the literature on the risk-taking channel of monetary policy shows that, in low interest rate environments, banks are more likely to finance riskier firms (Jiménez et al., 2014; Ioannidou et al., 2015; Dell'Ariccia et al., 2017). The (immediate) costs of doing so are small and, at the same time, riskier lending helps mitigate the pressure on net interest margins that banks experience when interest rates are low. Bank characteristics, such as those discussed above, also play a role in this transmission channel. For instance, banks with lower levels of capital and with large liquidity buffers may take on more risk when interest rates are low, owing to poor managerial incentives that encourage risk-shifting strategies (Bonfim and Soares, 2018).

5.2 Data and empirical strategy

Empirically analysing the transmission of monetary policy through banks requires more granular data than those described in Box 1 and used in the other parts of this Occasional Paper. First, data on banks are needed to capture the heterogeneity that may shape the transmission mechanism. Specifically, data on banks' capital ratios, deposit ratios and liquidity ratios are needed. Bank capital ratios refer to Core Tier 1 capital as a share of risk-weighted assets, this being one of the standard regulatory capital ratios. Deposit ratios are defined as in Heider et al. (2019), i.e. total deposit liabilities as a share of total assets. Finally, liquidity ratios are measured as the ratio of liquid assets (the sum of cash, interbank deposits and government bonds) to total assets.

Second, most of the existing literature on the monetary policy transmission channel relies on granular lending information. Using bank-level data allows us to understand how much each bank is lending, but not to whom. More importantly, such data reflect both loan supply and loan demand, raising serious endogeneity concerns. As such, we follow standard practice in the most recent literature on this topic and match the firm-level data used in other parts of this Occasional Paper with data from national credit registries. This allows us to match firms and banks (borrowers and lenders), thus helping to disentangle the roles of demand and supply, as well as to characterise heterogeneity in lending decisions. From these data sources, we include information on how much each firm borrows from each bank in a given period. We also include information on how much of that credit, if any, is overdue. Our sample includes four countries for which the required information is available: Portugal, Slovakia, Slovenia and Spain.

The unit of observation used in our analysis is a firm-bank pair in a given period. Before delving into the link between monetary policy and productivity, the first step in the analysis is to revisit the transmission channels discussed above. To understand how monetary policy shocks affect bank lending depending on bank characteristics, we estimate the following specification:

$$\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$$

The dependent variable is the log of credit outstanding granted by bank j to firm i in period t. We then consider three channels (or bank characteristics) to capture the transmission mechanisms discussed above. As such, the variable Channel can refer to (1) bank capital, (2) the deposit ratio, or (3) the liquidity ratio. Coefficient β_1 captures how these characteristics influence bank lending. Coefficient β_2 captures how these characteristics interact with monetary policy shocks, as defined in Box 2, thereby shaping the transmission of monetary policy. The

estimations are saturated with fixed effects to capture, to the extent possible, unobserved firm, bank and time dimensions that could help to explain lending outcomes. In most regressions, we include α_{nlst}, which refers to industry (n) × location (l) × size group (s) × time (t) fixed effects (Degryse et al., 2019). Whenever possible, we also report results with a tighter set of fixed effects, following the approach of Khwaja and Mian (2008). In this case, we use firm (i) × time (t) fixed effects, thereby restricting the sample to firms that borrow simultaneously from at least two banks. We also control for bank (α_j), firm (α_i) and time (α_t) fixed effects.

To establish a link between all these well-documented channels of monetary policy transmission through banks and productivity, we need to adapt this empirical specification. We estimate the following:

$$\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \beta_3 \text{Channel}_{jt-1} \times \text{MP shock}_t \times \text{TFP}_{it-1} + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$$

In this specification, we introduce a triple interaction to examine banks' lending allocation decisions towards firms with different levels of productivity (TFP). Coefficient β_3 captures how banks with different characteristics (captured by Channel) adjust their lending decisions in the aftermath of a monetary policy shock, depending on how productive the borrower firms are. The idea is to capture banks' allocation decisions based on differences in borrower productivity.

We also adapt this specification to consider the role of risk, rather than productivity, in banks' allocation decisions. This allows us to empirically test the risk-taking channel of monetary policy in this setting and to understand whether banks respond similarly when financing risky and productive firms following a monetary policy shock, and how these allocation decisions affect lending to corporate borrowers.

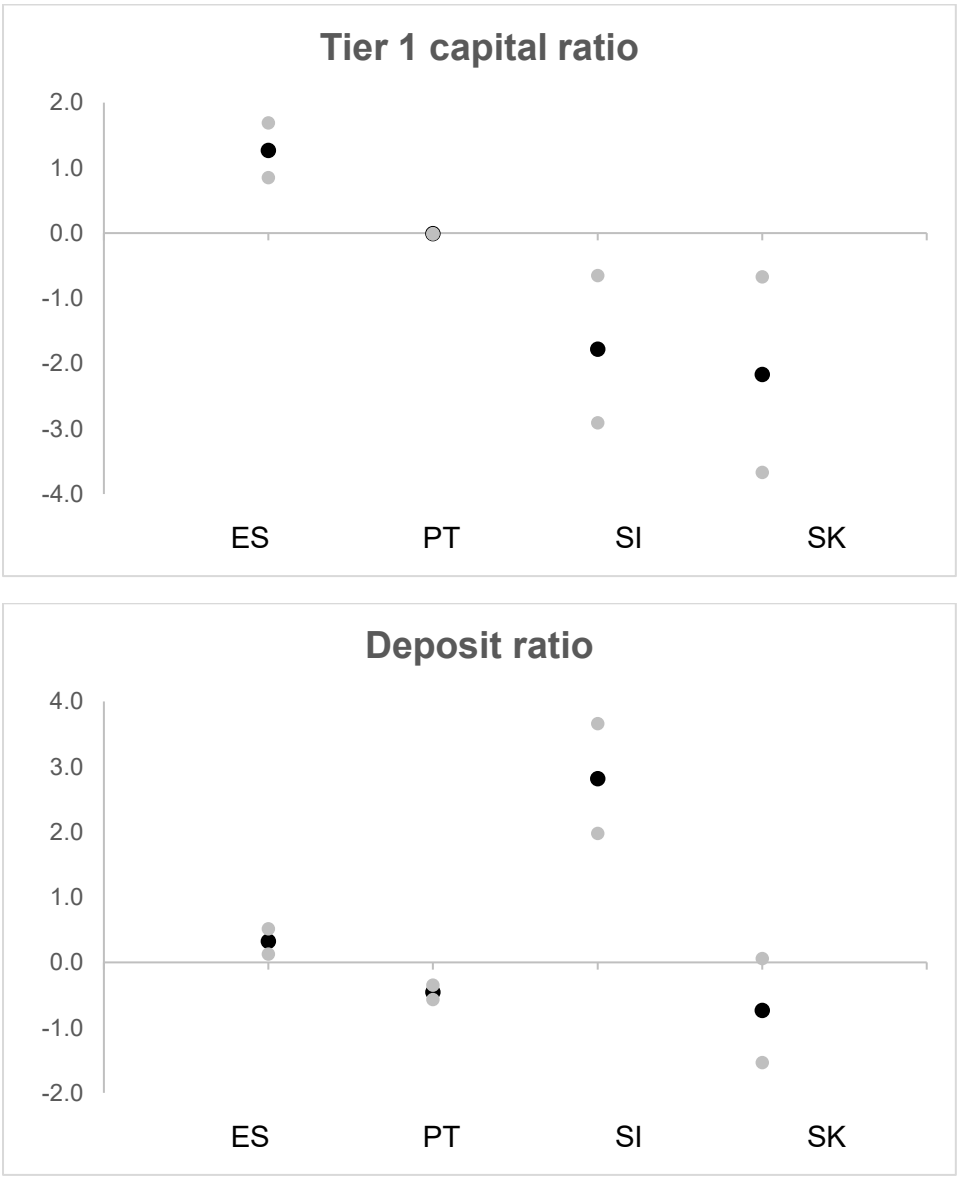
5.3 Empirical evidence

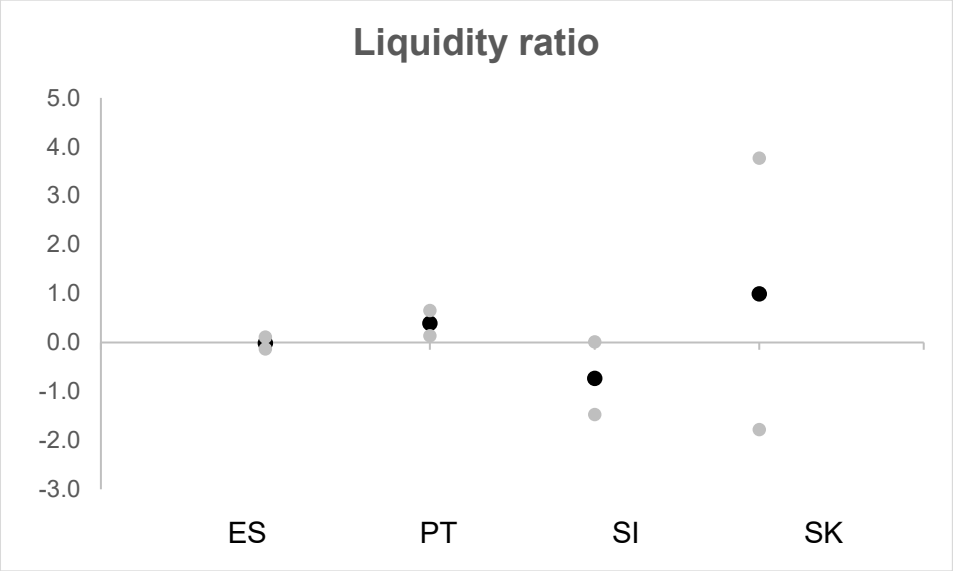
5.3.1 Bank characteristics and monetary policy transmission

We obtain mixed results when looking at the role of bank capital. Chart 12 reports the coefficients and confidence intervals (at a 90% level) for each bank characteristic considered in our first estimation. We find that better-capitalised banks lend more in Spain, while the opposite is true in Slovakia and Slovenia. In Portugal, bank capital does not have a statistically significant effect on lending. The results for the deposit ratio are also mixed across countries. Spanish and Slovenian banks that rely more on deposit funding tend to lend more, as expected, while in Portugal banks that rely more on other types of funding tend to lend more to firms. The deposit ratio does not seem to be relevant in explaining the lending decisions of Slovak banks.

When it comes to the liquidity ratio, the results are generally less statistically significant. It seems to matter only in Portugal, with higher liquidity ratios being associated with more lending following a positive monetary policy shock.

Chart 12
Lending and bank characteristics



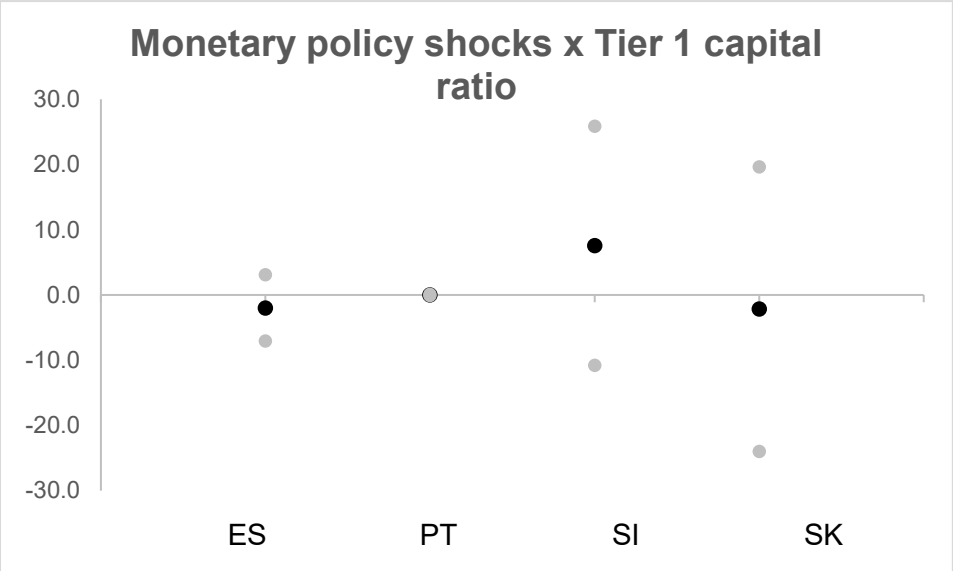


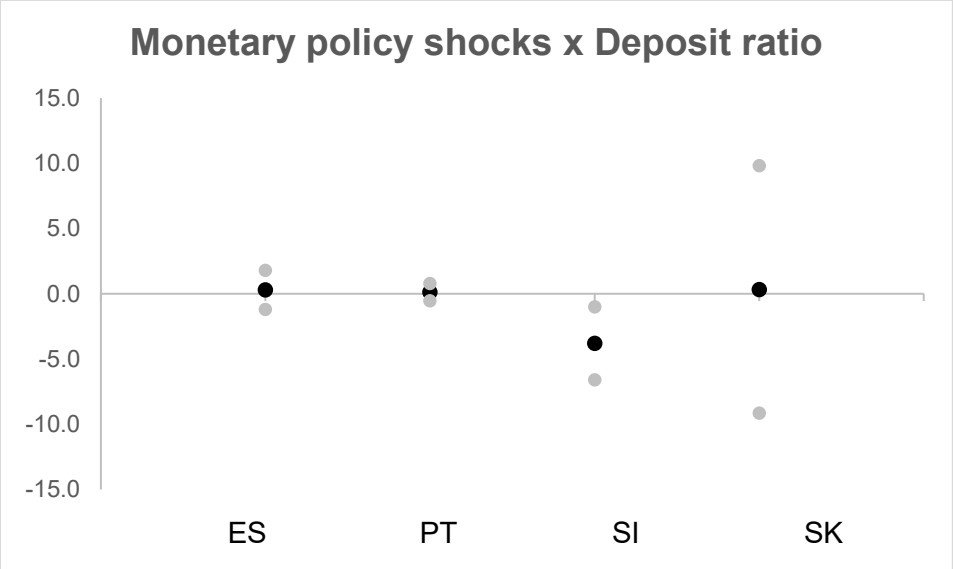
Note: The charts depict the coefficients and 90% confidence intervals for β_1 in the specification $\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$.

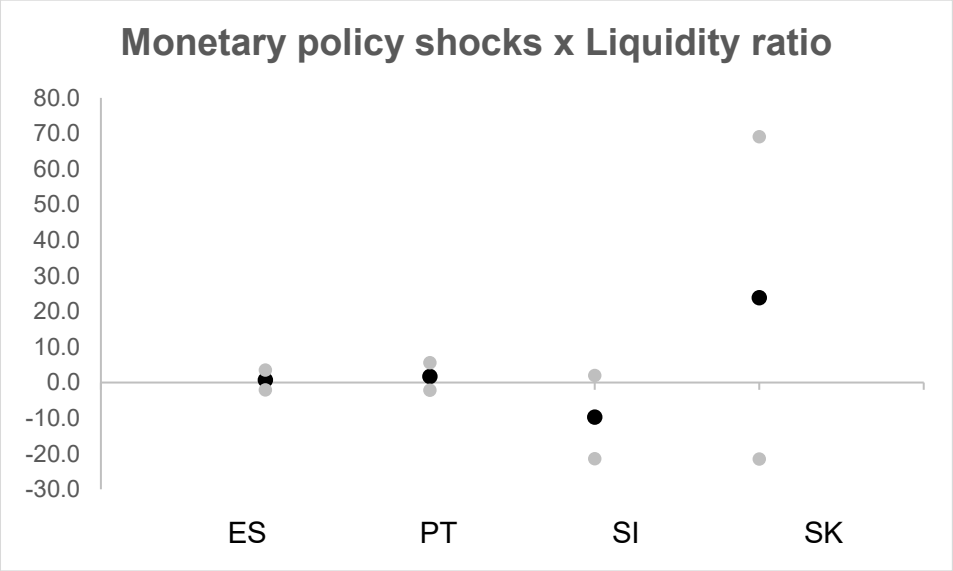
The main focus of the analysis is the interaction between bank characteristics and monetary policy shocks. The coefficients for this interaction are reported in Chart 13, together with their respective 90% confidence intervals. Overall, the results for the four countries analysed suggest that monetary policy shocks do not play a significant role in shaping the relationship between bank characteristics and lending. None of the coefficients relating to capital ratios or liquidity ratios are statistically significant. The only statistically significant coefficient refers to the interaction between monetary policy shocks and the deposit ratio in Slovenia. Following an expansionary monetary policy shock, banks that finance themselves more through deposits tend to lend less. The general lack of statistical significance in these results implies that the transmission of monetary policy shocks through bank lending is neither amplified nor mitigated by bank characteristics.

Chart 13

Lending and the interaction between bank characteristics and monetary policy shocks







Note: The charts depict the coefficients and 90% confidence intervals for β_2 in the specification $\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$.

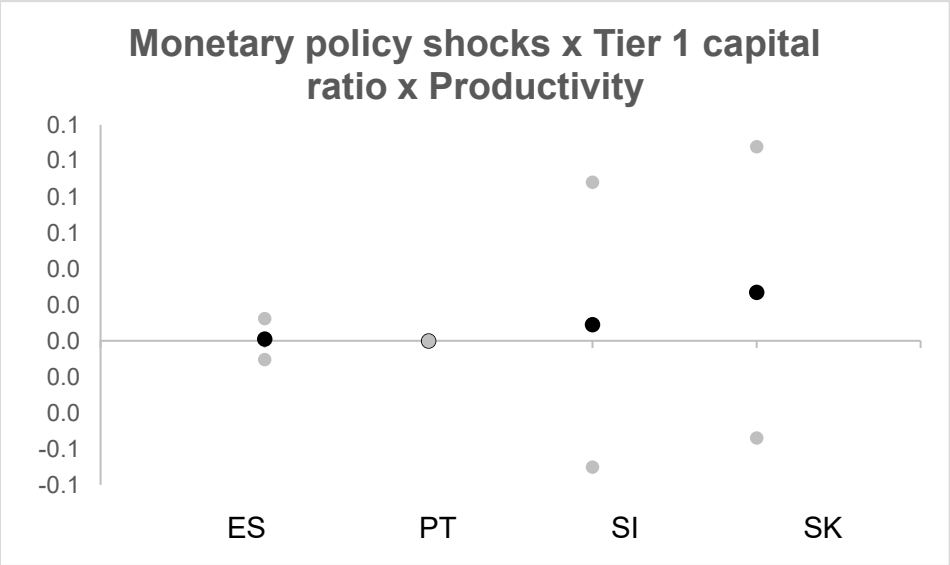
5.3.2 Allocation decisions

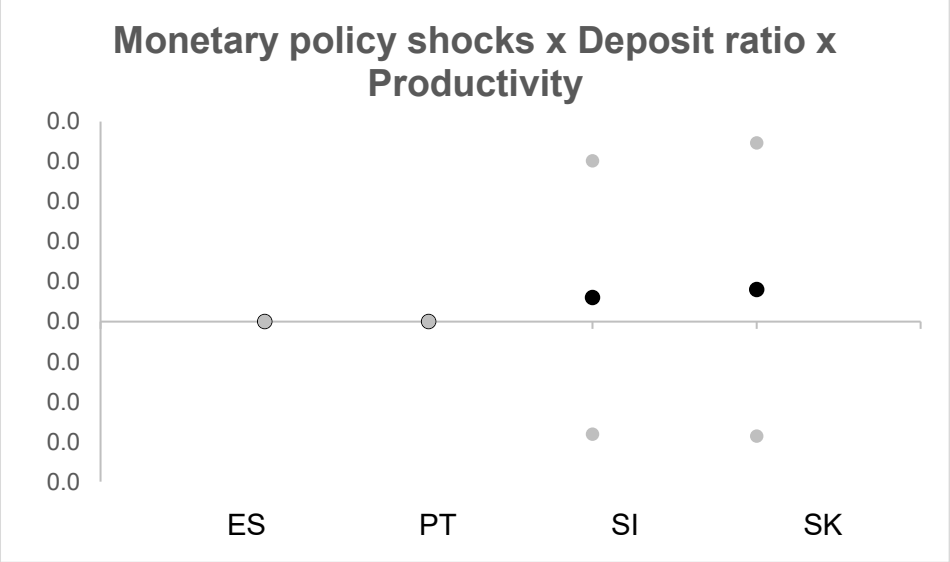
The results reported in the previous subsection aim to validate existing evidence on the transmission of monetary policy. However, the main goal of the analysis is to examine how monetary policy and productivity interact. To this end, we estimate the second equation described earlier in Section 5.2. Chart 14 below reports the coefficients (and confidence intervals) for the interaction between monetary policy shocks, bank characteristics and firm productivity. The idea is to assess whether monetary policy affects banks' allocation decisions. Banks with different characteristics may choose to allocate credit differently across firms with different productivity levels when faced with monetary policy shocks.

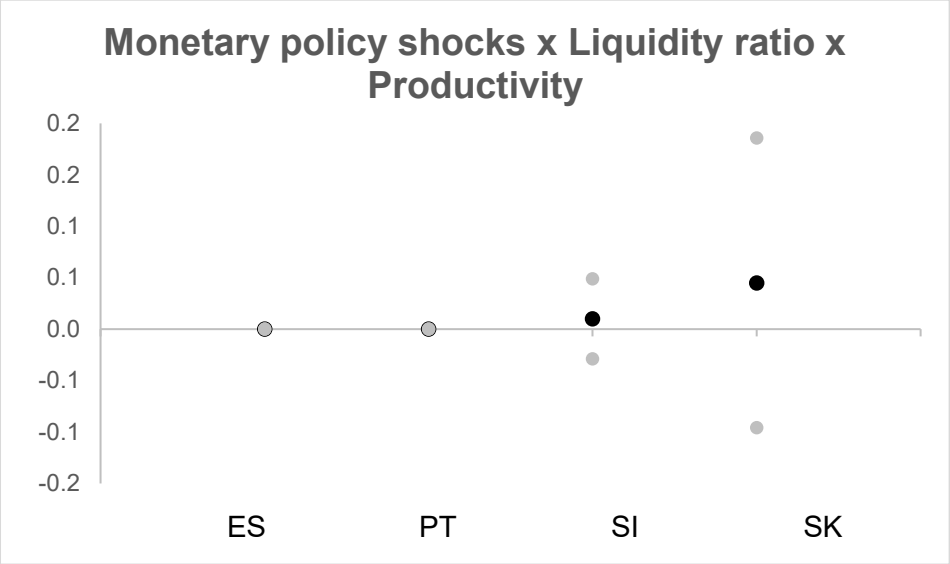
As in the previous set of results, this coefficient is not statistically significant in most estimations. The only exception is Portugal, where the coefficient is always negative and statistically significant, albeit small in magnitude. We find that an expansionary monetary policy shock leads to a decrease in lending to more productive firms by banks with higher levels of capital, deposits and liquidity. However, the economic significance of the coefficients is small.

Chart 14

Lending and the interaction between bank characteristics, firm productivity and monetary policy shocks





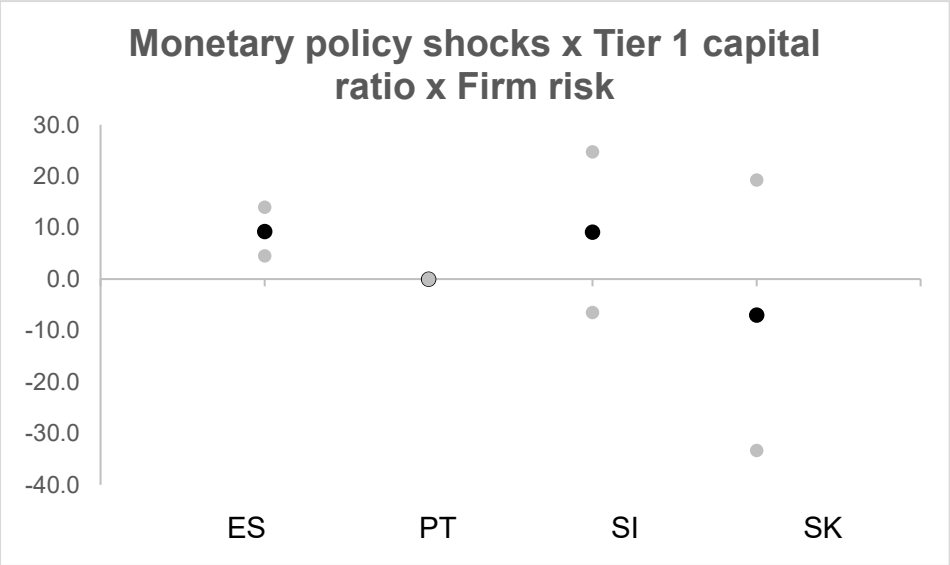


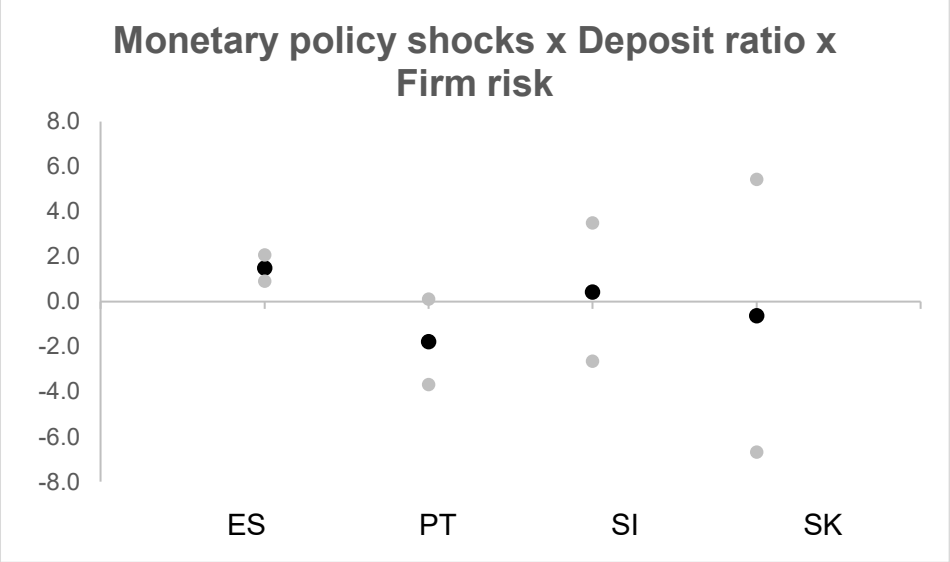
Notes: The charts depict the coefficients and 90% confidence intervals for β_3 in the specification $\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \beta_3 \text{Channel}_{jt-1} \times \text{MP shock}_t \times \text{TFP}_{it-1} + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$.

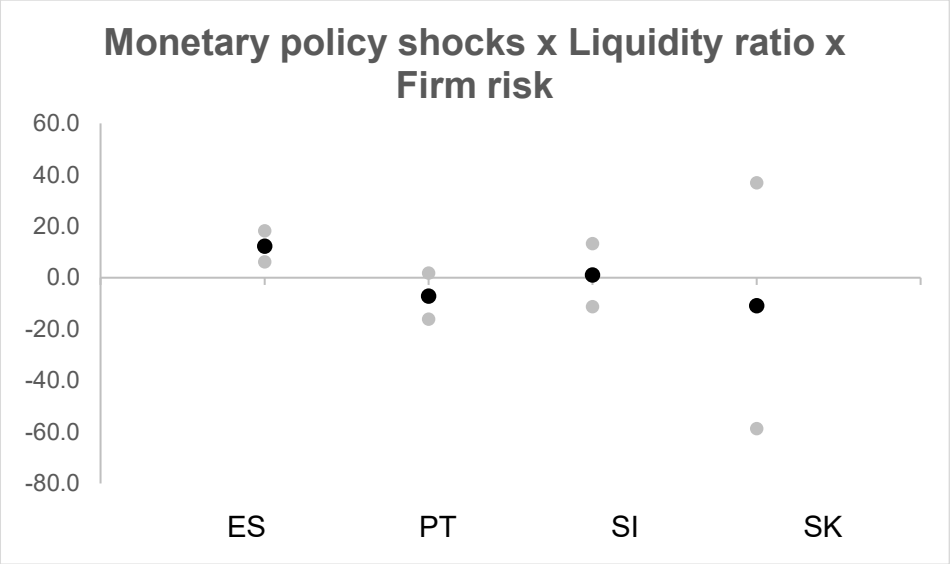
Another allocation effect within the economy could arise where banks channel more credit to risky firms. Although the risk-taking channel is well documented, the consequent impact on aggregate productivity is ambiguous, as there is no one-to-one relationship between riskiness and productivity. Thus, in this section, we estimate the risk-taking channel of monetary policy using this dataset. We follow the same approach as before, but now consider lending to risky firms (i.e. those in default) instead of firms with different levels of productivity. We find that the interaction between bank characteristics, monetary policy shocks and firm risk is statistically significant only in Spain (Chart 15). In this case, we find that an expansionary monetary policy shock leads to an increase in lending to riskier firms by those banks with more capital, deposits and liquidity. This result is somewhat at odds with the evidence on the risk-taking channel, which would suggest that risk-taking increases primarily in response to monetary easing.

Chart 15

Lending and the interaction between bank characteristics, firm risk and monetary policy shocks







Notes: The charts depict the coefficients and 90% confidence intervals for β_3 in the specification $\ln(\text{Credit})_{ijt} = \beta_1 \text{Channel}_{jt-1} + \beta_2 \text{Channel}_{jt-1} \times \text{MP shock}_t + \beta_3 \text{Channel}_{jt-1} \times \text{MP shock}_t \times \text{risky}_{it-1} + \alpha_{nlst} + \alpha_j + \alpha_i + \alpha_t + \varepsilon_{ijt}$.

5.4 Concluding remarks

Banks play a crucial role in the transmission of monetary policy. In this section, we examine how bank characteristics interact with monetary policy shocks and, ultimately, with firms' productivity. Overall, the results on the interaction between bank characteristics and monetary policy are not as strong or consistent as those reported in the existing literature, for several possible reasons. First, part of the literature focuses on monetary policy rates rather than shocks. In an unreported analysis, we estimate the same specifications using a shadow rate instead of monetary policy shocks. In this case, the results are closer to what has already been documented in the literature. Second, our analysis covers a period of ample liquidity and accommodative monetary policy. Third, the cross-country comparison using the same empirical method sheds light on the external validity of existing findings. It might be that the results reported in the literature are valid only for specific economic and institutional settings and do not hold more generally. All these reasons call for further research on this topic.

As regards the interaction between monetary policy and productivity, our results do not point to a strong link between monetary policy transmission channels through banks and the financing of more productive firms. While there is no evidence in the literature against which to benchmark the method used to analyse this question, more research is surely needed to better understand this interaction.

6 Conclusions

In this report, we examine the effects of monetary policy on productivity through various channels. The theoretical underpinning of this relationship is that productivity is, at least partially, driven by investment, which, in turn, is influenced not only by the business cycle but also by the exogenous component of monetary policy.

First, we look at the role of market power as measured by sectoral markups and find that high sectoral markups do not appear to be a factor contributing to the productivity slowdown in Europe, as there is a positive correlation between productivity and markup trends at the country level. Firms operating in sectors with high markups often exhibit high levels of productivity, which may contribute to overall productivity gains. Our analysis suggests that expansionary monetary policy shocks could raise productivity by supporting the reallocation of resources towards, and the expansion of, highly productive firms within high-markup sectors, thereby reducing misallocation and raising aggregate productivity, at least in the short run.

Second, we look at the effect of monetary policy on within-sector resource allocation and find a positive and significant effect. This is driven by the positive effect that a monetary policy shock has on the level of investment among financially constrained firms with high marginal productivity of capital. We find that monetary policy has a significant impact on the allocation of capital, and this finding holds true across all countries analysed, while the impact on the allocation of labour is less evident. Monetary policy is more likely to affect capital price distortions than labour price wedges by altering the financial frictions faced by firms.

Third, we examine the impact of monetary policy shocks on the so-called "zombie incidence". Our analysis shows that changes in the share of zombie firms in the economy depend on both entry into and exit from zombie status. The research shows that accounting for firms' growth potential mitigates concerns about the incidence of zombies, revealing that a significant proportion of firms labelled as zombies are actually growing, or are able to fully recover. The results suggest a nuanced relationship between monetary policy shocks and zombification, with different channels working in opposite directions and, overall, with accommodative monetary policy shocks reducing the share of zombie firms in the population.

Finally, we examine the interaction between monetary policy shocks and firm productivity through standard transmission channels in the banking sector. Our results suggest that the interaction between bank characteristics and monetary policy shocks in relation to firm productivity is not as strong or consistent as indicated in the existing literature. This discrepancy may be due to the focus on monetary policy rates rather than shocks, and to the fact that our analysis covers a period of ample liquidity and accommodative monetary policy. Moreover, the results do not indicate a strong link between the transmission of monetary policy through banks and the financing of more productive firms. This may be because factors such as

bank profitability, the availability of collateral and risk considerations – which play a crucial role in lending decisions – are not always directly correlated with productivity.

The results of this analysis consistently point to a positive relationship between monetary policy shocks and productivity growth. The observed positive impact of an expansionary monetary policy shock on productivity growth across the countries and time periods studied supports the notion that such shocks contribute to productivity growth through multiple channels. These compelling results not only confirm the existing link between monetary policy and productivity, but also highlight the need for further research into the intricate mechanisms through which monetary policy influences and supports productivity. At the same time, this positive relationship raises concerns about the potential adverse effects of monetary tightening on productivity. Specifically, tighter monetary policy could increase borrowing costs, dampen investment in innovation, and hinder the reallocation of resources to more productive firms, ultimately slowing economic growth and efficiency.

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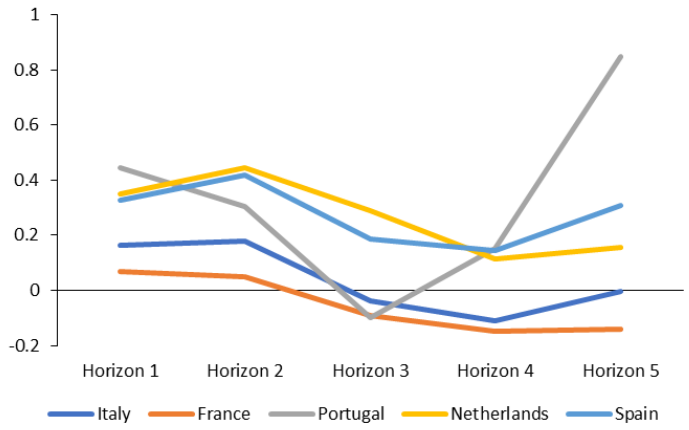
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7.1 Appendix to Section 2

Chart A.1

Aggregated impulse response functions based on TFP across selected countries (percentage points)

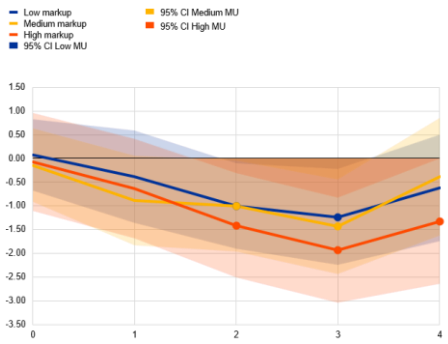


Sources: National sources and ESCB calculations.
Notes: The figure reports aggregate impulse response (TFP) for the five selected countries over a five-period horizon following a one-standard-deviation monetary policy easing shock. The aggregate impulse response is calculated as a weighted average of the firm-level response functions across the three markup buckets, with the share of firms in each bucket used as the weights.

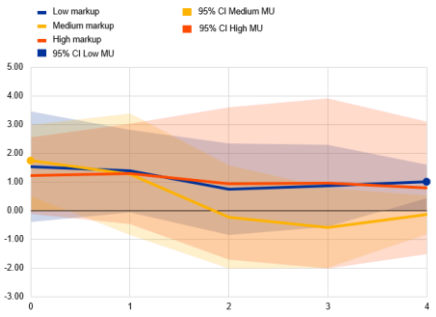
Chart A.2

Firm-level IRFs based on labour productivity for Finland, Estonia and Austria (percentage points)

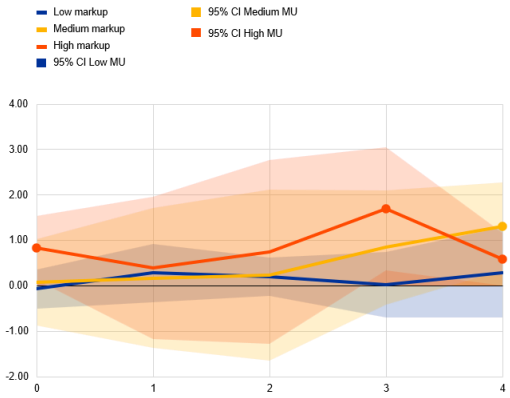
Finland



Estonia



Austria

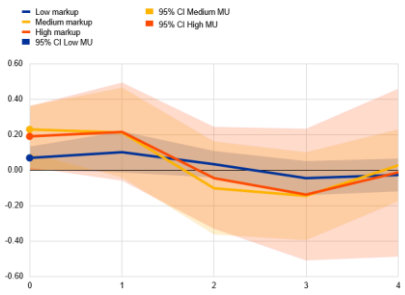


Sources: National sources and ESCB calculations.
Note: The figure reports impulse responses for each bucket for the three selected countries over a five-period horizon following a one-standard-deviation monetary policy easing shock. Statistically significant coefficients at a 95% confidence level are indicated with a dot.

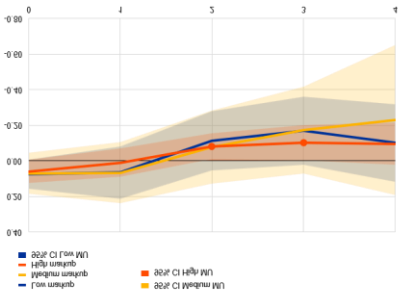
Chart A.3

Firm-level IRFs based on TFP for selected countries (percentage points)

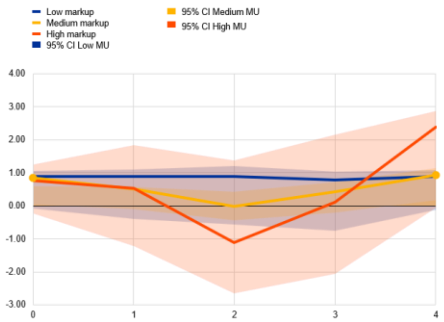
Italy



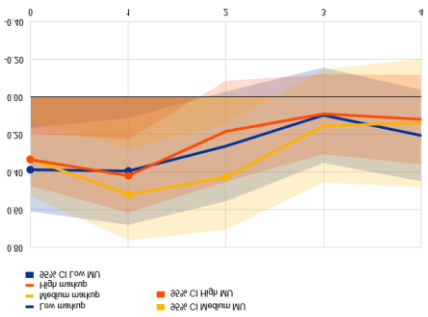
France



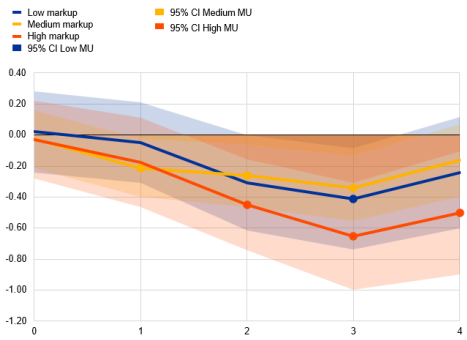
Portugal



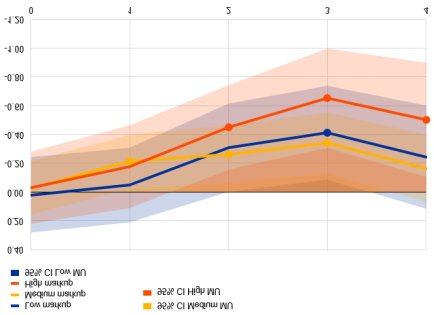
Netherlands



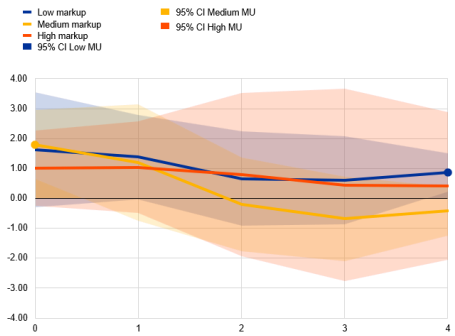
Spain



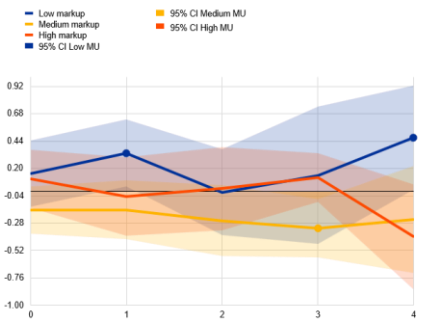
Finland



Estonia



Austria



Sources: National sources and ESCB calculations.
Note: The figure reports impulse responses for each bucket for the eight selected countries over a five-period horizon following a one-standard-deviation monetary policy easing shock. Statistically significant coefficients at a 95% confidence level are indicated with a dot.

7.2 Appendix to Section 3

Figure 1 – The dynamic effects of monetary policy easing on capital misallocation

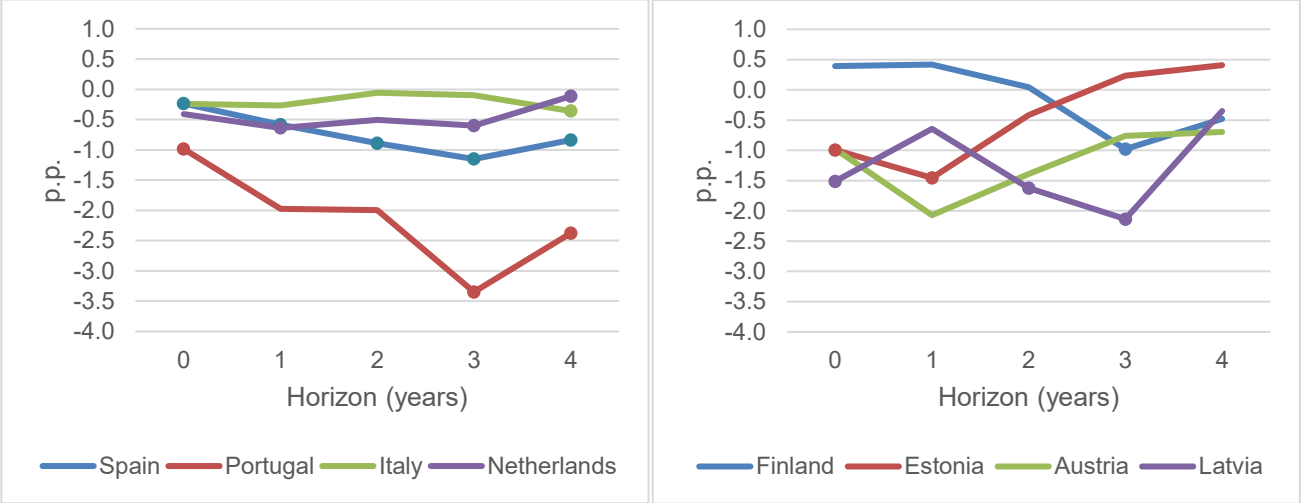


Figure 2 – The dynamic effects of monetary policy on investment by firms with high levels of MRPK

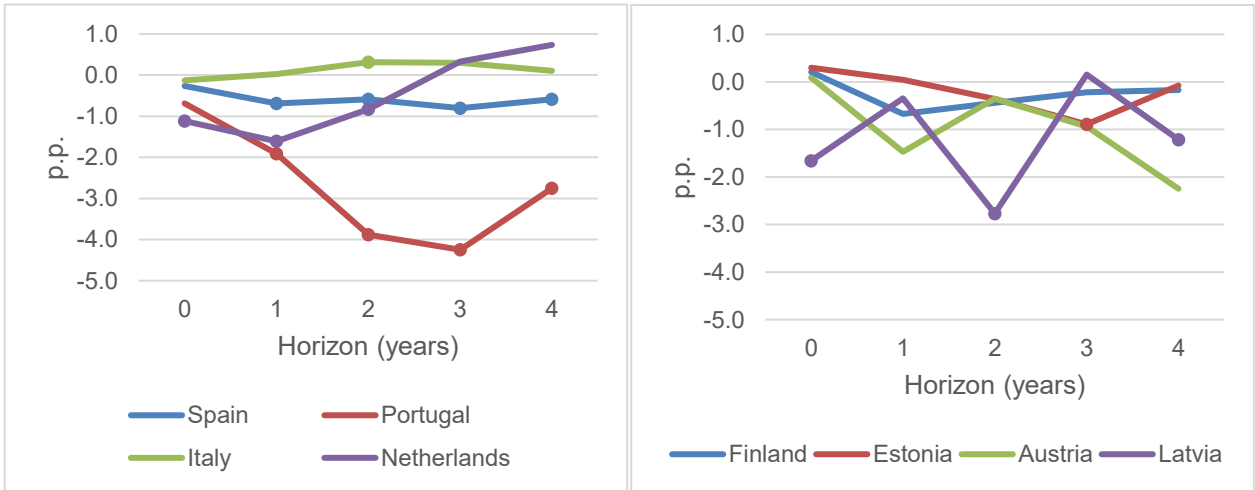


Figure 3 – The dynamic effects of monetary policy easing on labor misallocation

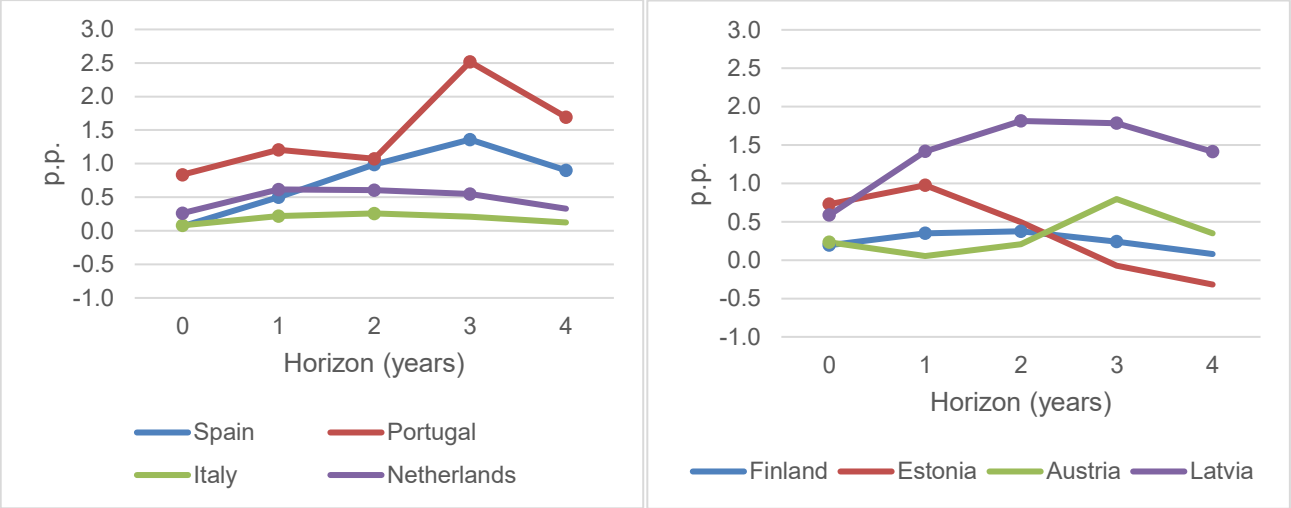
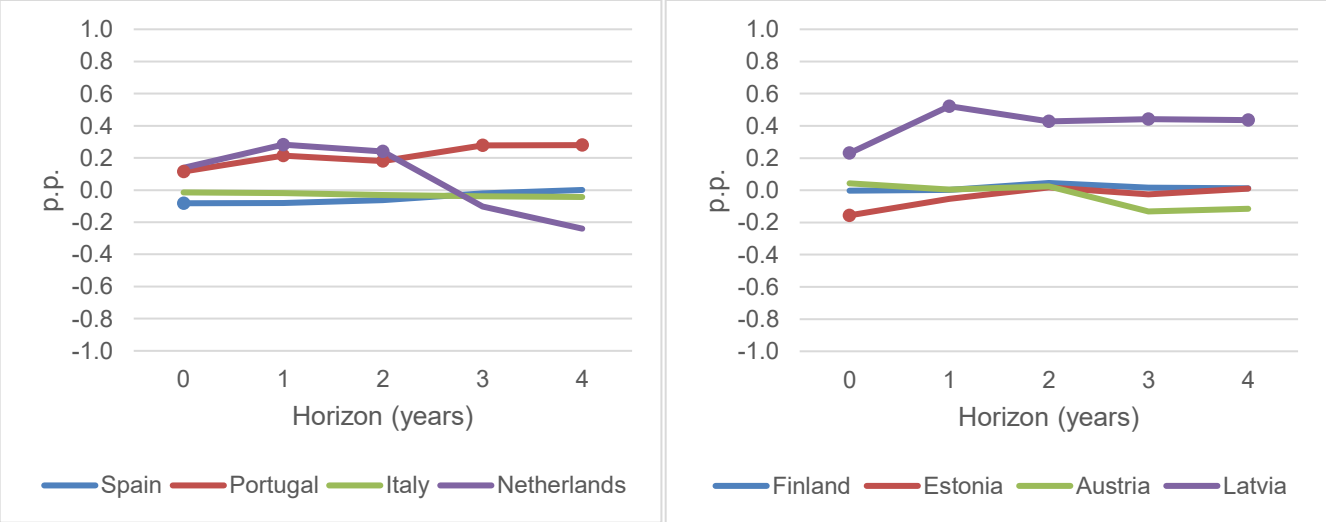


Figure 4 – The dynamic effects of monetary policy on employment among firms with high levels of MRPL



Acknowledgements
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