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THE EFFECTS OF MONETARY POLICY ON GROSS DOMESTIC PRODUCT, INVESTMENT AND INFLATION: AN ANALYSIS OF ITALIAN REGIONAL HETEROGENEITY

by Sara Cecchetti*, Valter Di Giacinto†, Francesco Montaruli‡ and Alessandro Montino§

Abstract

This paper analyzes the impact of the ECB's monetary policy on Italian regional economies and seeks to identify and explain the heterogeneous effects across regions by focusing on gross domestic product, investment, and inflation. The approach is empirical and involves two stages. First, we estimate impulse response functions at regional level and test for the presence of heterogeneity. Second, we explore the underlying drivers of heterogeneity using synthetic indicators that capture the key structural characteristics of local industrial and banking systems. The analysis uncovers statistically significant heterogeneity. Furthermore, a substantial share of the variance in the responses is explained by differences in the strength of regional industrial structures. The financial fragility of firms and the share of small banks in local credit systems also contribute to explaining the observed heterogeneity, albeit to a lesser extent.

JEL Classification: C22, C58, G12, E31, E44.

Keywords: monetary policy shocks, regional heterogeneity, GDP, investment, inflation, local projections.

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1 Introduction

Empirical evidence shows that the effects of monetary policy can vary significantly across countries and even within the same country, depending on the local structural characteristics. For instance, Carlino and DeFina (1998) examine the magnitude of local GDP responses to monetary policy shocks in the USA, given state-specific structural factors, such as the share of manufacturing in the gross product and the concentration of small firms. In the same vein, the FED note by Datasenko and Fleck (2024), shows that the impact of the ECB monetary policy is stronger in euro area countries with a higher weight of manufacturing.

The well-known heterogeneity of local economies motivated us to conduct a similar analysis for Italy, with the aim of providing evidence of regional differences in the response to monetary policy shocks. Our empirical strategy is twofold: (i) first, we estimate impulse response functions (IRFs) at regional level and test for heterogeneity; (ii) second, we explain the regional variation of IRFs by relating it to a set of structural indicators.

Our analysis is based on quarterly data covering the period from 1999 to 2023. In the first part of the paper we use monetary policy shocks in a local projections (LPs) framework,[1] to estimate the monetary policy transmission on real GDP, investment and prices.

As the official ISTAT data on regional GDP and investment are only released with annual frequency, we use the quarterly indicator of regional economic activity (ITER)[2] estimated by the Bank of Italy, coupled with our estimates of quarterly series of regional investment and the ISTAT regional CPI series. We obtain monetary policy shocks using the high-frequency identification (HFI) based on financial markets intraday data.[3] To separate this kind of shocks from the so-called information shocks we employ the simplified method by Jarociński and Karadi (2020), known as *poor man's sign restrictions.*

Our results on the effects of monetary policy on the real economy in Italian regions are broadly in line with those found in the literature.[4] In particular, following a monetary policy tightening, both real GDP and investment decline within the first

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[1]See Jordà (2005) and Jordà (2023).

[2]See Di Giacinto et al. (2019) for details and Section 3 for a brief description.

[3]See *e.g.* Gertler and Karadi (2015), Andrade and Ferroni (2021), Jarociński and Karadi (2020)

[4]See, in particular, Ramey (2016), Jarociński and Karadi (2020), Deb et al. (2023), and Datasenko and Fleck (2024).

year. The effect on prices requires more time to fully materialize. As expected, we find evidence of significant heterogeneity in the regional IRFs.

In the second part of the paper, we investigate the drivers of such heterogeneity by constructing three synthetic indicators of the local productive and financial structures. These indicators can be interpreted as proxies for (i) the strength and maturity of the regional industrial structure, (ii) the fragility of firms' financial structures, and (iii) the characteristics of local banking systems. We then employ those indicators in a state-dependent LP equation and study their interaction with monetary policy shocks.

First, in line with Carlino and DeFina (1998) and Datasenko and Fleck (2024), we find that the effects of monetary policy shocks are stronger in more industrialized regions. Second, we observe that financial vulnerability slightly enhances the impact on inflation. Finally, a higher proportion of small and medium-sized banks mitigates the impact on GDP.

The paper is structured as follows. Section 2 provides a brief review of the literature and Section 3 describes the data. Section 4 illustrates our analysis of IRFs. Section 5 investigates the main drivers of the differences in regional responses to monetary policy shocks. Section 6 concludes.

2 Literature review

There is an extensive literature on the heterogeneity of monetary policy effects. Dominguez-Torres and Hierro (2019) provide a comprehensive survey of the empirical works on the regional effects of monetary policy on economic activity. They highlight various sources of regional heterogeneity, examine different types of econometric models, and discuss approaches to identifying monetary shocks.

Regional heterogeneity is linked to differences in local productive structures. For this reason, it is interesting to look at studies that use granular data to examine responses at the firm level. These studies suggest that firm-level responses depend on factors such as firm size (Gertler and Gilchrist, 1994), liquidity structure (Jeenas, 2023), and firm age, which directly influences corporate financial behavior (Cloyne et al., 2023a). Ottonello and Winberry (2020) argue that firms with low default risk are the most responsive to monetary policy, as they have better access to funding for investment in the presence of financial frictions. De Groot et al. (2020) examine the impact of monetary policy on regional inequality using granular data on economic activity at the city and county levels in Europe, documenting significant heterogeneity in regional patterns of monetary policy transmission. Similarly, Durante et al. (2020) analyze how annual investment by firms in Germany, Spain, France, and Italy responded to monetary policy shocks between 2000 and 2016. Their findings confirm that firms' responses can vary depending on factors such as age and sectoral industrial affiliation. Pietrunti and Signoretti (2017) relate the heterogeneity in the intensity and speed of the response to monetary policy shocks to the prevalence of fixed- versus variable-rate interest contracts, showing that countries characterized by a higher prevalence of variable-rate debt tend to exhibit a stronger reaction to conventional monetary policy shocks. This heightened sensitivity arises because variable interest payments adjust more swiftly to changes in policy rates, amplifying the transmission of monetary policy through the interest rate channel. Lastly, Auer et al. (2021) study the relationship between corporate leverage and the sensitivity of industrial production to monetary policy shocks within the euro-area manufacturing sector; they find that more indebted industries adjust more broadly their output after a monetary policy shock.

Another interesting line of research is the study of how monetary policy impacts differently on different sectors of the economy. For instance, Bernanke and Gertler (1995) show that interest rates hikes tend to have a stronger impact on activity in the manufacturing than in the service sector. Carlino and DeFina (1998) show that, in the USA, the states with a high manufacturing share are more responsive to changes in monetary policy shocks than the states with a more diversified industrial base. Interestingly, recent work by Datasenko and Fleck (2024) provides evidence of a similar effect for the euro area: the response to monetary policy shocks is stronger in manufacturing-intensive countries.

Obviously, the study of heterogeneity is intertwined with the study of transmission channels. Among the seminal contributions to the monetary policy transmission literature, Bernanke and Blinder (1988) and Kashyap et al. (1993) explore the significance of firms' dependence on bank credit. Later, Kashyap and Stein (1995) focus on banks' ability to adjust their balance sheets. Carlino and DeFina (1998) argue that the higher degree of responsiveness of the manufacturing sector is related to a local interest rate channel. They also show that regions with a relatively higher concentration of small firms tend to be more responsive to monetary policy shocks compared to regions with fewer small firms, offering evidence for the so-called broad credit channel. Durante et al. (2022) show that the reaction of corporate investment to a monetary policy shock depends on the firms' age and sector of activity. These two dimensions are related to the credit channel and the interest rate channel, respectively.

Regarding the relationship between the transmission of monetary policy and the prevailing banking structure, Ehrmann et al. (2001) show that a monetary restriction leads to a more limited contraction of bank loans in countries where banks typically have closer relationships with their clients and therefore tend to mitigate the effects of changes in monetary conditions on credit supply. Holm-Hadulla et al. (2022) study the relation between the transmission of monetary policy shocks and the debt financing structure of euro area firms.

A handful of papers have addressed the issue of territorial heterogeneity at the intra-national level. Arnold and Vrugt (2002) examine differences in the impact of monetary policy shocks on regional and sectoral output in the Netherlands for the period 1973 to 1993. In a subsequent paper, the same authors apply a similar approach to the German Länder (Arnold and Vrugt, 2004). Anagnostou and Papadamou (2016) investigate the heterogeneous impact of monetary policy on regional and sectoral output in Greek regions. Finally, Capasso et al. (2021) test the effectiveness of monetary policy on the real economy in Italian regions from 2000 to 2016. In all these papers, monetary policy shocks are identified within VAR models and substantial territorial differences in responses to monetary policy shocks are found.

Building on this literature, we exploit recent advances in econometric techniques. Specifically, we use high-frequency identification to detect exogenous monetary policy shocks and local projections to estimate impulse responses. With respect to Capasso et al. (2021), we extend the time frame to account for the effects of the restrictive monetary policy measures adopted by the European Central Bank in response to the recent, abrupt and substantial inflationary pressures. In addition, we offer a detailed analysis of the local factors underlying the heterogeneous responses across Italian regions.

3 Data

In this work we analyze quarterly data covering the period from 1999 to 2023. Official quarterly estimates of Italian GDP are published by ISTAT. However, corresponding regional data are only available at annual frequency. Therefore, we use Bank of Italy's ITER (Indicatore Trimestrale dell'Economia Regionale), a quarterly indicator that is consistent with the official data on national and regional GDP. Similarly, for regional investment data, we employ quarterly estimates based on the official annual data.[5] Regional quarterly price indexes are based on the historical CPI series published by ISTAT.[6]

Monetary policy shocks are constructed using *poor man's sign restrictions* as in Jarociński and Karadi (2020). This simplified approach yields a decomposition of the series of interest-rate surprises associated to monetary policy announcements into two orthogonal components: a pure monetary policy shock and an information

[5]We obtain quarterly regional investment series by implementing the Chow and Lin (1971) methodology, using the following variables as quarterly indicators: Bank of Italy indicator of World demand, real exchange rate, industrial production indices for the construction and the capital goods sectors, 3-month Euribor rate, regional exports in volume, amount of banks loans to the business sector, new business registrations, business confidence indices, ITER indicator of quarterly regional GDP. The goodness-of-fit statistics for the regional temporal disaggregation models are generally satisfactory. The mean and the median correlation between the quarterly interpolated data and the value predicted by the underlying regression function are both equal to 0.98.

[6]When data where missing we considered the national price level for each of the twelve components of the CPI; we multiplied the price level of each component by its regional weight and finally we obtained the regional CPI as a weighted sum.

shock, also called *odyssean* and *delphic* shocks in Andrade and Ferroni (2021). The former is characterized by a negative comovement between interest rates and stock prices[7], while the latter by a positive comovement. We use data from the Euro Area Monetary Policy Event-Study Database (EAMPD), updated by the authors (Altavilla et al., 2019). We consider surprises of the 3-month Overnight Indexed Swap (OIS) in the time window around the ECB press release, thus focusing on movements of short-term rates. Using the terminology of Altavilla et al. (2019), we limit our attention to the *Policy Target* factor and ignore the *Timing*, *Forward Guidance* and *Quantitative Easing* factors. Our choice is motivated by the intention to focus on the immediate and direct effects of monetary policy in ordinary macroeconomic environment, when the heterogeneity of local responses is not affected by exceptional conditions. Indeed, it is plausible that the structural factors determining the heterogeneous responses to unconventional monetary policy measures may be different from those at play under normal economic conditions and would therefore require specific analysis, which we leave to future research.

The daily series of monetary policy shocks needs to be aggregated to quarterly frequency in order to fit in with regional data. To this end, we first aggregate the shocks to monthly frequency using the method described in Gertler and Karadi (2015).[8] This approach takes into account the different timing of ECB Governing Councils within the month. This is relevant because interest-rate surprises occurring at the beginning of the month have a greater impact on monthly economic activity than those at the end of the month. The shock within a quarter is obtained by summing the three corresponding monthly shocks. Finally, to make the results easier to interpret, we normalize the shock so that a unit shock corresponds to a 100 basis points increase of the 3-month OIS rates, following standard practice in the literature.

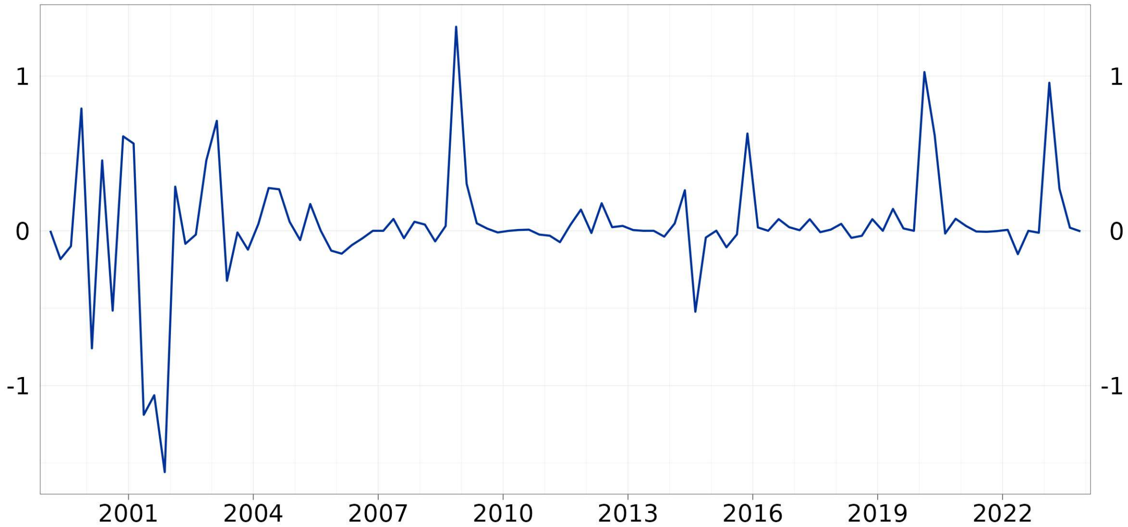
In order to assess the drivers of regional heterogeneity, we collect variables characterizing the regional productive and financial structures. The sources of this set of variables are ISTAT, CERVED and Bank of Italy.[9] The descriptive statistics of the variables used in our analysis are presented in Table 1 of Appendix C.1.

[7]In our case, the Euro Stoxx 50 index. The intuition underlying the classification of the shock is that, in presence of a textbook monetary policy restrictive shock, stock prices should go down both due to a decrease in the expectations about future dividends and to a decrease in the discout factor used to calculate their present value. Thus, interest rates and stock prices should move in opposite directions. When this is not the case, we interpret the event as an information shocks. Namely, the Central Bank's decision has been interpreted by the markets as new information about the state of the economy, leading to a revision of expectations.

[8]See note 11 in the cited paper.

[9]See Section 5.1 for details of the collected variables.

Figure 1: High-frequency ECB monetary policy shocks.



Note: Time series of the monetary policy shocks aggregate to quarterly frequency and normalized so that a positive unit shock corresponds to a one-hundred basis points increase of the 3-month OIS rate.

4 Cross-region heterogeneity in response to monetary policy shocks

The use of LPs for the estimation of IRFs is nowadays standard in the empirical economic literature. The advantages of this method are its simplicity and flexibility. In our case, this econometric tool is suitable to accomodate the panel structure of regional data, a feature which will be particularly useful in the next section, allowing us to investigate the drivers of heterogeneity through state-dependent LPs.

4.1 Methodology

The endogenous variables in our LPs are $Y^{\text{GDP}} = 100 \cdot \log(\text{GDP})$, $Y^{\text{INV}} = 100 \cdot \log(\text{Investment})$, and $Y^{\text{CPI}} = 100 \cdot \log(\text{CPI})$. For each each of these variables, we implement the following regressions:

$$Y_{i,t+h} - Y_{i,t-1} = \alpha_{i,h} + \gamma_{i,h} S_t + \sum_{Z \in C} \sum_{j=1}^{m} \beta_{i,j}^{Z} L^j Z_t + \sum_{k=0}^{h+2} \zeta_{i,k} D_t^{t^*-k} + \epsilon_{i,t}^{h} \quad \text{for } h = 0, 1, \ldots, H \tag{1}$$

where i is an index denoting the region, S is the shock and $\gamma_{i,\cdot}$ is the IRF. C is a set of controls which contains the first differences of the endogenous variables, L denotes the lag operator and m is the number of lags included. Here t^* corresponds to the third quarter of 2020 and D^{t^*-k} is a dummy variable with value 1 for $t = t^* - k$ and 0 elsewhere; we include these dummies in order to take into account the anomalous values observed during the first three quarters of 2020 due to the Covid-19 pandemic and subsequent lockdowns.[10] We compute the responses up to 12 quarters following the shock, namely $H = 12$. We include four lags of the controls ($m = 4$). This is standard practice in the economic literature, since it is the number of lags necessary to cover one full year of dynamics.[11]

4.2 Impulse response functions

The IRFs we obtain by estimating γ in equation (1) are coherent with literature and economic theory. Figure 2 shows the responses for Italy, figure 3 for macro-areas, while the responses for regions and autonomous provinces are displayed in appendix B.1.

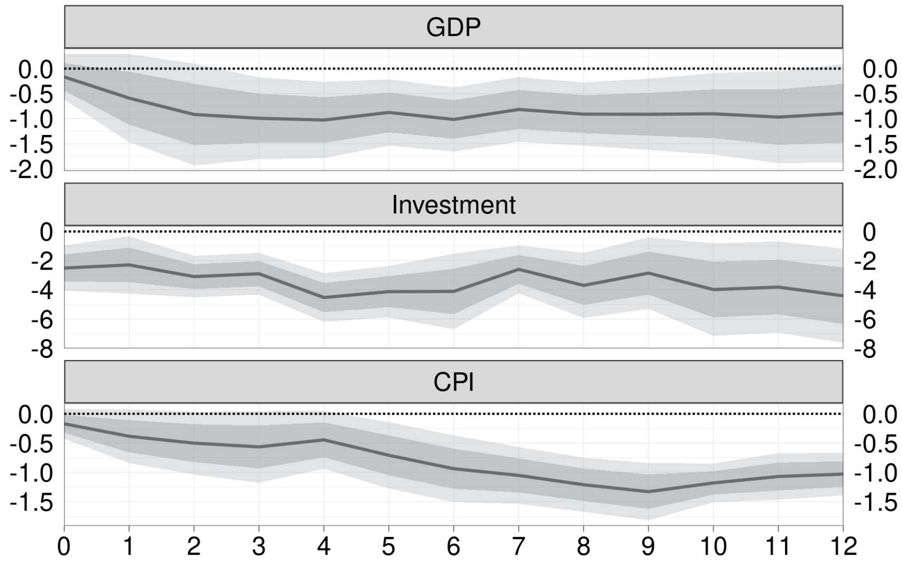
Qualitatively, a monetary policy tightening is followed by a sizeable and persistent decline in real GDP, investment and inflation. Furthermore, a significant degree of heterogeneity can be observed in the shape and magnitude of the IRFs of different regions and macro-areas. As for the magnitude of the effect, our results are broadly in line with those found in the literature.[12] Responses and confidence bands at longer horizons should be interpreted with caution because, as h increases, a range of different shocks affects the response and is incorporated into the regression residuals. Therefore, LPs tend to become less efficient and it is not uncommon to observe effects that are borderline significant at the 90 percent level (see Jordà (2005) and Stock and Watson (2018)).

[10] If t^* denotes the quarter with anomalous data, when estimating IRFs at horizon h we include a binary dummy for each quarter in the time span between $t^* - h$ and t^*, since all the h-step cumulative differences in this time range will include the exceptional spike recorded in t^*. We considered all three of the first quarters of 2020 to be anomalous, as they showed exceptionally volatile fluctuations in the response variables, due to the introduction and subsequent easing of restrictions on people's mobility.

[11] The choice $m = 4$ is also supported by the results of statistical tests. See Appendix A for details.

[12] See Section 3 in Ramey (2016) for a review of results on the impact of monetary policy shocks.

Figure 2: Monetary policy transmission to Italian real GDP, investment and CPI.



Note: IRFs of Italian GDP, investment and CPI following a monetary policy shock corresponding to a 100 basis points increase of the three-month OIS rate. The shaded areas are the 68 and 90 percent confidence intervals obtained using Newey-West HAC standard errors.

As shown in figure 2, Italian real GDP registers a 1 percent decline by the second quarter, which persists until the end of the considered period (three years). Investment experiences an immediate decline, peaking at a 4 percent reduction after one year, and then remains broadly stable, subject to minor fluctuations, throughout the subsequent quarters. The effect on CPI requires more time to reach its maximum impact, corresponding to a decrease of almost 1.5 per cent, which is reached after nine quarters; although somewhat attenuated, the negative effect persists throughout the remaining quarters.

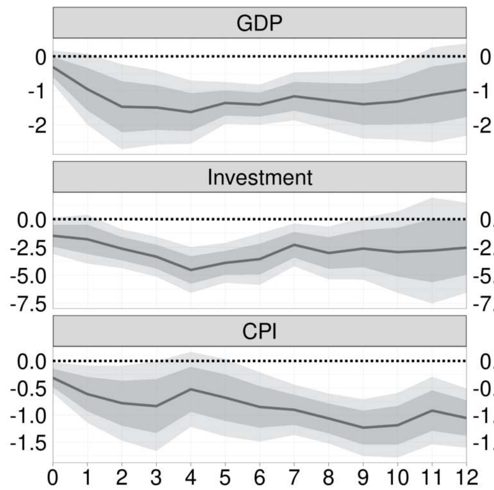
The macro-areas' responses are shown in figure 3. We observe that GDP in the Northwest reaches a peak of almost -2 percent, a response which is stronger compared to those of other macro-areas and of Italy as a whole. The GDP response at peak for the other macro-areas is -1.5 percent for Northeast, -0.6 for Center, -0.5 for South.

The largest fall in investments is instead in the Northeast, where the decline exceeds 5 percent after 1 year, while the South again records the smallest impact, equal to around -2 percent, after 6 quarters. The corresponding responses at peak are -3.5 percent for Center and -4.5 percent for Northwest.

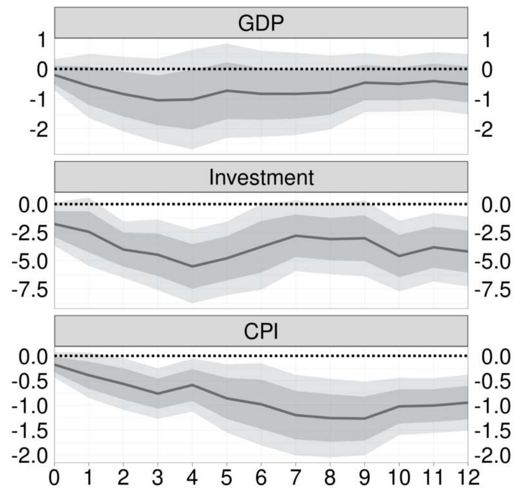
As far as prices are concerned, the response is more significant and comparable in magnitude across the two northern macro-areas, where the maximum effect is registered after nine quarters and approximately equal to -1.25 percent; the central regions, by contrast, record the mildest impact, at aproximmately −0.5 percent after two years; finally, for the southern regions, the peak effect is observed 10 quarters after the shock, and corresponds to a 0.8 percent decrease of the price index.

Figure 3: Monetary policy transmission to real GDP, investment and CPI in the Italian macro-areas.

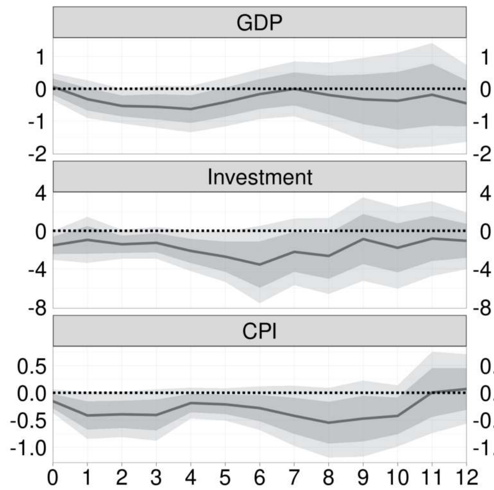
(a) Northwestern regions



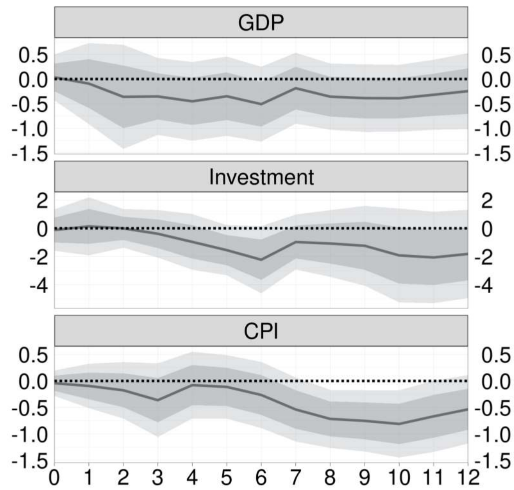
(b) Northeastern regions



(c) Central regions



(d) Southern regions and islands



Note: IRFs of GDP, investment and CPI in the four Italian macro-areas, following a monetary policy shock corresponding to a 100 basis points increase of the three-month OIS rate. The shaded areas are the 68 and 90 percent confidence intervals obtained using Newey-West HAC standard errors.

4.3 Testing for heterogeneity

In order to verify whether the differences in the IRFs between regions are statistically significant, we implemented the Blomquist and Westerlund (2013) test, which proposes a version robust to heteroscedasticity and serial correlation of the slope heterogeneity test by Pesaran and Yamagata (2008). The test was conducted on data for the 21 Italian regions[13] separately for each of the three response variables. Three increasing horizons for the dynamic responses were considered. The test results displayed in Table 2 of Appendix C.2 indicate that, with the only exception of CPI at the short-term horizon (up to one year after the policy shock), the null hypothesis that responses are equal across regions is strongly rejected, indicating significant heterogeneity. The lack of significance in the short-term responses of the price index is unsurprising, as the effects on prices typically materialize with a delay and are therefore relatively subdued in the initial quarters following the shock.

5 Main drivers of cross-region heterogeneity of policy responses

In the previous section, we gathered evidence for the existence of heterogeneous responses across regions; now we would like to shed some light on the drivers of this heterogeneity.

5.1 Methodology

We collected data for a comprehensive set of variables qualifying the regional productive and financial structures, including:

1. AGRISHR, the share of the total regional value added pertaining to the primary sector (source: Istat)

2. INDSHR, the share of the total regional value added pertaining to the industry sector (excluding construction; source: Istat)

3. CONSTSHR, the share of the total regional value added pertaining to the construction sector (source: Istat)

4. GOVSHR, the share of the total regional value added pertaining to the public sector (source: Istat)

5. FIRMSIZE, the average local firm size, measured by the number of employees (source: Istat)

[13]The regions correspond to the second level in EU's *Nomenclature of territorial regions for statistics* (NUTS, see https://ec.europa.eu/eurostat/web/nuts).

6. FIRMAGE, the average age of local firms (measured on incorporated companies alone; source: Cerved)
7. FLRLOANS, the share of medium- and long-term variable-rate loans to households and non-financial corporations (source: Bank of Italy)
8. LEVERAGE, the ratio of financial labilities to the sum of the former and the company's equity (source: Cerved)
9. LIQUIDITY, the ratio of short term financial assets to financial liabilities of equal maturity (source: Cerved)
10. SCORE, the share of public companies with a default risk score equal or greater than 7 (source: Cerved)
11. BANKSTR, the fraction of the total loans accorded to local clients by banks belonging to groups of medium and small size (source: Bank of Italy)

We opted for a static approach using temporal averages of these indicators for each region. The reason is twofold: first, their temporal dynamics are indeed fairly stable; second, and more important, our focus is on explaining the cross-sectional heterogeneity of the responses rather than their over-time variation. Given the presence of strong correlations among the above variables, we use PCA to select a small number of synthetic indicators.[14]

The first indicator is obtained by running PCA on the subset of the first seven indicators listed above. The first principal component, that we refer to as MATINDSTR, explains two thirds of the total variance and can be interpreted as providing a proxy of the strength and maturity of the regional productive structure. It is positively correlated with the industry share of regional value added and negatively correlated with the shares of the primary, construction and public sectors. In addition, it shows a positive correlation with firm size and age—both typical features of mature and consolidated productive systems. Finally, it is positively correlated with the share of medium- and long-term variable-rate loans to households and non-financial corporations. The inclusion of this last variable in the indicator of productive structure resilience is motivated by empirical evidence showing that larger and financially stronger firms are more likely to opt for variable-rate debt, owing to their greater capacity to manage interest rate risk.[15] Not surprisingly, the best scores for MATINDSTR are attained by the Northern industrialised regions of Italy (Lombardia, Emilia Romagna and Piemonte), while the lower values are recorded

[14]See Appendix C.3 for details.

[15]These firms typically have more sophisticated financial management practices, greater access to hedging instruments, and stronger cash flow buffers, enabling them to absorb potential interest rate increases more effectively than smaller or less mature firms (see, among others, Faulkender (2005) and Graham and Harvey (2001)).

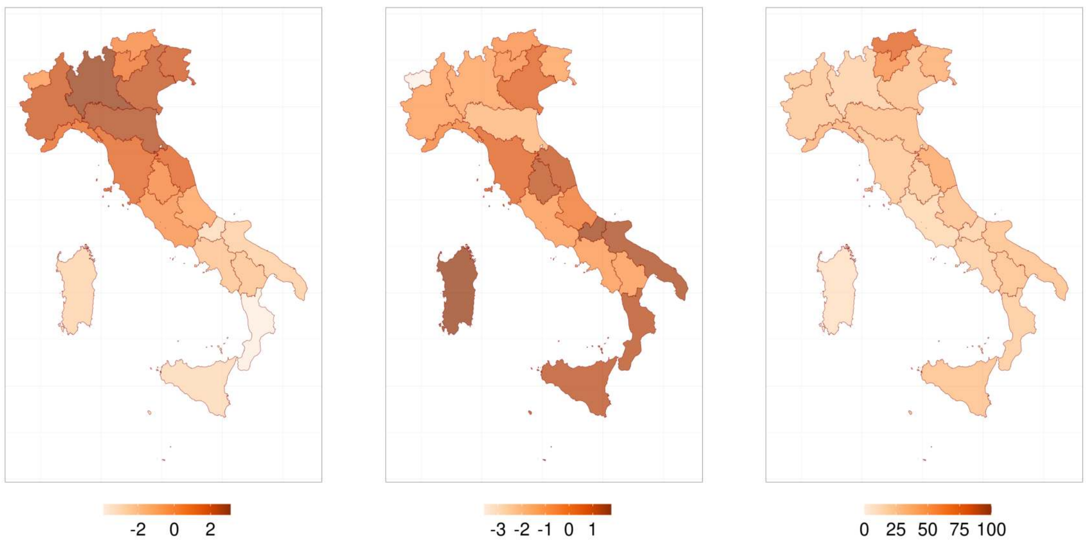
in the Southern regions of the country (the minimum being observed for Calabria and Molise; see figure 4a). Considering the literature recalled above, it is expected that higher values of the MATINDSTR correspond to stronger responses to monetary policy shocks: see *e.g.* Carlino and DeFina (1998) and Pietrunti and Signoretti (2017).

The second synthetic indicator is obtained by applying PCA on the subset of the three indicators of firms' financial conditions. The first principal component explains more than 60 per cent of the total variance. It is positively related to LEVERAGE and SCORE, and negatively related to LIQUIDITY. It can therefore be interpreted as a measure of the fragility of the local firms' financial structure (FINFRAG). Some northeastern regions and central regions show a substantial degree of vulnerability, but no clear North-South trend is observed, as shown in figure 4b. It is expected that more fragile firms should be more affected by policy shocks.

The third indicator is the variable BANKSTR, which measures a very specific and distinct aspect of the local structure of financial intermediation activities. Figure 4c shows that this indicator has a rather uniform distribution among Italian regions, apart from a specific northeastern region, well-known to be populated by a variety of small banks.

Figure 4: Scores of the structural variables across regions

(a) MATINDSTR (b) FINFRAG (c) BANKSTR



Notes: Cartograms of the three structural indicators measuring the strength of the regional industrial system (MATINDSTR), local financial fragility (FINFRAG), and importance of small banks in the regions' financial system (BANKSTR). The colour scale ranges from white, corresponding to lower values of the indicator, to dark red, corresponding to higher values.

Employing these three explanatory variables, we conducted regressions analyses using state-dependent LPs, in the spirit of Cloyne et al. (2023b).

We estimate the following sequence of panel local projections for $h = 0, 1, \ldots, H$

$$Y_{i,t+h} - Y_{i,t-1} = \alpha_i^h + \gamma^h S_t + \sum_{W \in SV} S_t(W_i - \overline{W})\theta_W^h + \sum_{Z \in C} \sum_{j=1}^{m} \beta_{i,j}^Z L^j Z_t + \sum_{k=0}^{h+2} \zeta_{i,k} D_t^{t^*-k} + \epsilon_{i,t}^h \tag{2}$$

where the notation is analogous to the one of equation 1, SV is the set of regional structural variables (MATINDSTR, FINFRAG and BANKSTR), and $\overline{W}$ are the related spatial averages. Here γ^h measures the pooled response across all regions; θ_W^h is the coefficient corresponding to the interaction between the shock and the deviation from the average of the structural variable. When testing for heterogeneity, we examine whether this coefficient is different from zero.

5.2 Results

The results obtained from pooling on progressively wider horizons (i.e. $h \leq 4$, $h \leq 8$ and $h \leq 12$) are reported in Table 3. The most significant and relevant explanatory factor is related to the strength and maturity of the regional productive structure (MATINDSTR); as expected, the interaction coefficient $\theta_{\text{MATINDSTR}}$ has a negative sign, which indicates that monetary policy shocks have a greater impact in regions with higher values of this indicator. Our results also show that heterogeneity remains constant across all horizons for GDP, while it slightly diminishes as the time horizon increases concerning the effects on investments. Conversely, heterogeneity increases with the horizon for inflation; this is consistent with the fact that the effects of monetary policy require more time to display their impact on prices, as observed in Section 4.

The variable representing the fragility of the local firms' financial structure (FINFRAG) is not statistically significant, except in the case of inflation, where the interaction term is statistically significant with a negative sign, indicating that the impact of shocks on this variable is greater in economically more fragile regions.

Finally, the concentration of small banks seems to influence the heterogeneity of responses to shocks by mitigating them, probably thanks to the stronger relationship between small banks and businesses in certain regions, whereby intermediaries may limit the effects of changes in monetary conditions on credit supply. This empirical evidence is consistent with the literature that compares relationship lending and transaction lending (see, among others, Ehrmann et al. (2001), Bolton et al. (2016) and references therein).

The observed heterogeneity is economically relevant: a 1 standard deviation increase of the MATINDSTR factor is associated with a decrease of the policy response of about 0.4 standard deviations for GDP and CPI and of about 0.5 standard deviations for investment. If the FINFRAG indicator is augmented by 1 standard deviation the response of CPI is amplified by 0.3 standard deviations. Finally, increasing the BANKSTR indicator of 1 standard deviation would reduce the GDP response of 0.5 standard deviations.[16]

6 Conclusions

This paper contributes to the literature on the effectiveness and heterogeneity of monetary policy transmission, focusing on Italian regions from 1999 to 2023. Our findings uncover significant heterogeneity in the transmission of monetary policy across Italian regions, which is influenced by their structural characteristics.

In summary, monetary policy has a stronger impact in regions with well-developed industrial systems. On the other hand, a regional banking system characterized by a larger diffusion of small banks seems to mitigate policy effects, albeit only significantly in relation to GDP. Finally, the financial fragility of firms localized in the area appears to have limited relevance, affecting only the inflation response.

We leave to future research the analysis of the regional impact of unconventional monetary policy. Future developments could also include an analysis of the nonlinearities of monetary policy transmission, considering effects related to both the phase of the business cycle and the expansionary or restrictive nature of the shock.

[16]The computations refer to the cases where the interactions are significant and to the horizon h where the maximum effect is recorded.

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A Robustness checks

In this appendix, we list the robustness checks performed to test the validity of our analysis.

- We considered the shocks estimated by Jarociński and Karadi (2020) and made available by the authors online. We considered both the sign restrictions an *poor man's sign restrictions* shocks. After computing impulse response functions using these shocks, we conducted statistical tests that confirm the presence of heterogeneity and the ranking across macro-areas in relation to the effects of monetary policy shocks on different variables. The magnitude and shape of the IRFs is somewhat different. This does not surprise us since Jarocinski and Karadi considered the first principal component of changes in the 1-, 3-, 6-months and 1-year OIS while we only considered changes in the 3-month OIS.

- Our results are stable when we estimate the IRFs on subsamples of the data. To test the validity of our Covid dummies, we estimated IRFs on the pre-2020 subsample and obtained coherent results. We also tried to exclude from the sample the period subject to the zero-lower-bound of interest rates and observed responses similar to the ones obtained in the full sample.

- A final robustness check concerns the selection of the number of lags for the control variables in the LP model. Our choice of using 4 lags was supported by several statistical tests including FPE, AIC and HQIC. Notice that the choice of lag length is less critical in our framework due to the assumed exogeneity of the shocks.[17] As expected, our results are robust to changes in the autoregressive order of the regression equation.

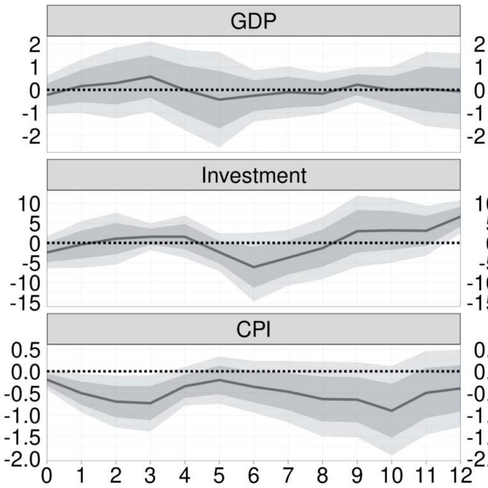
[17] When this is not the case, Brugnolini (2018) underlines the importance of the optimal choice of the lags of the dependent and independent variables in the estimation of the right IRF.

B Figures

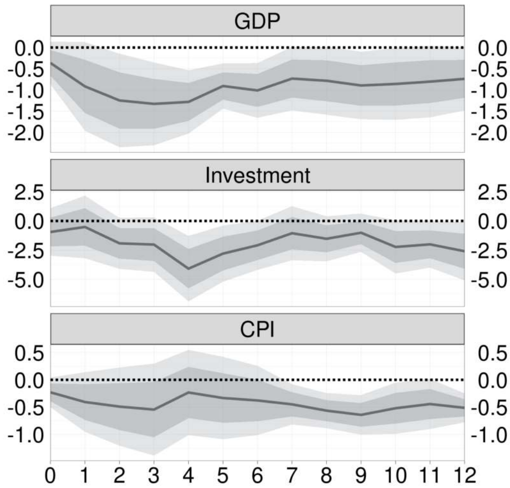
B.1 Impulse response functions

Figure B.1: Monetary policy transmission to real GDP, investment and CPI in the northwestern regions.

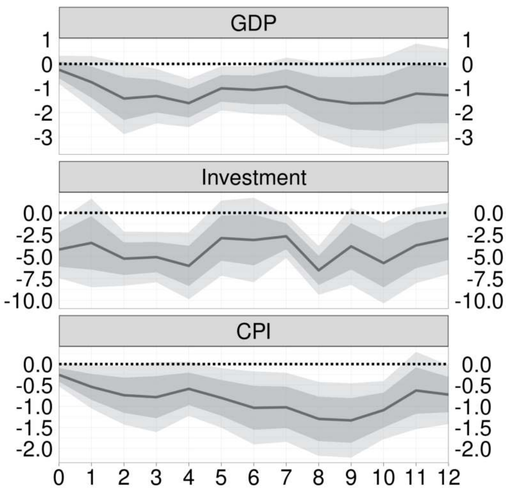
(a) Liguria



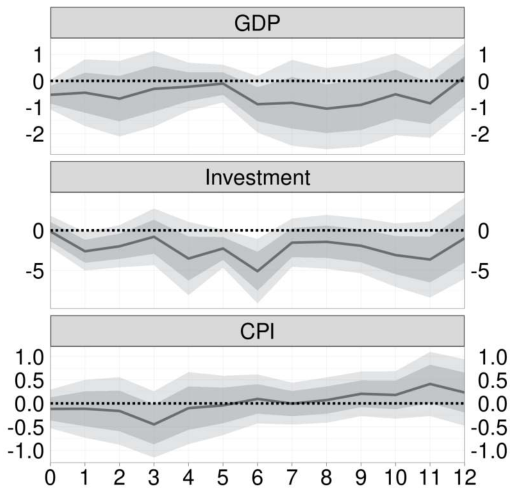
(b) Lombardia



(c) Piemonte



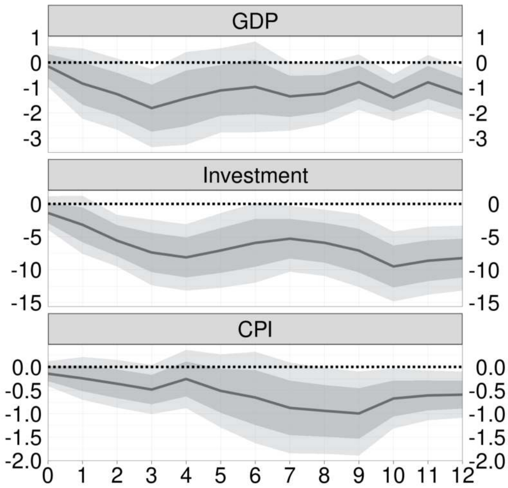
(d) Valle d'Aosta



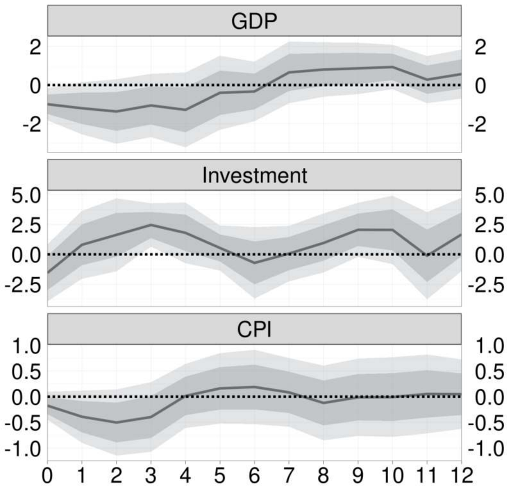
Note: IRFs following a monetary policy shock corresponding to a 100 b.p. increase of the 3-months OIS. The shaded areas are the 68 and 90 percent confidence intervals.

Figure B.2: MP transmission to GDP, investment and CPI in the NE regions.

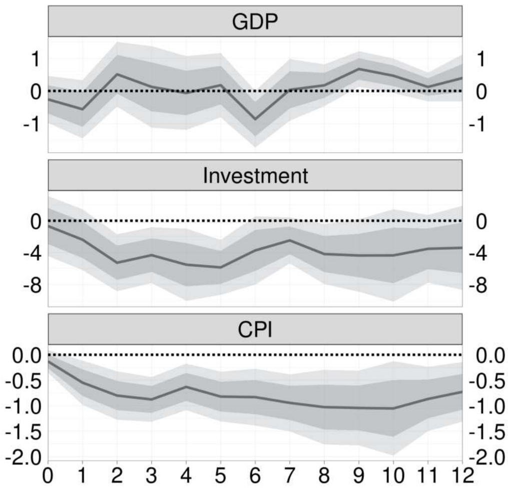
(a) Emilia Romagna



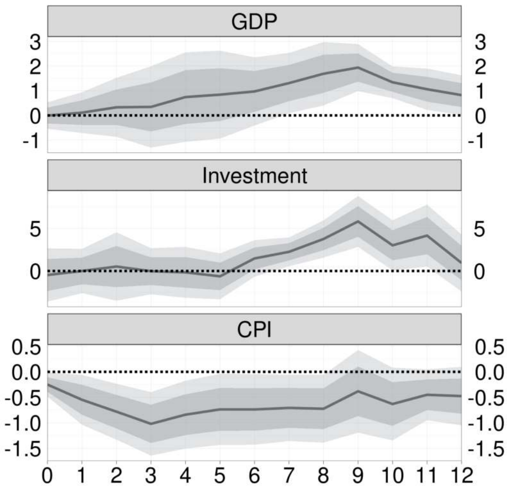
(b) Friuli Venezia Giulia



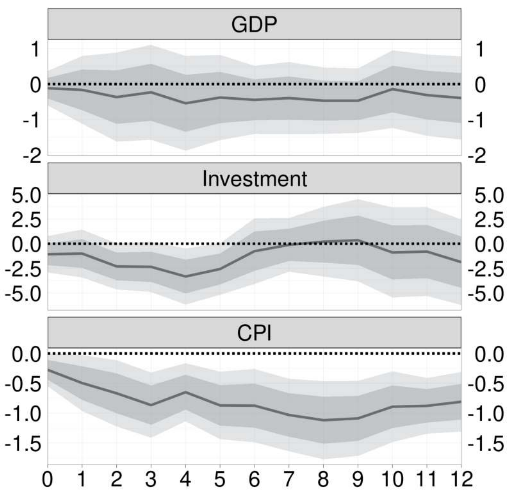
(c) Autonomous province of Trento



(d) Autonomous province of Bolzano



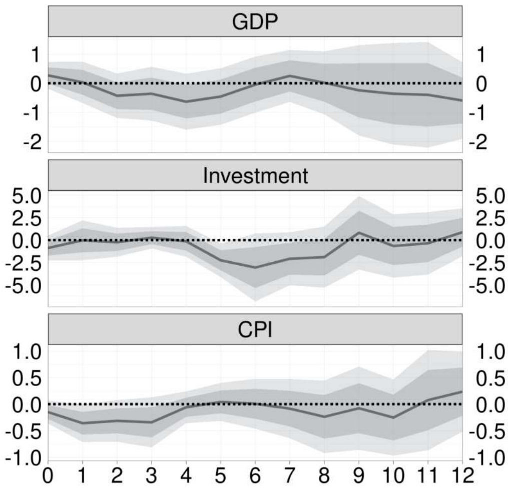
(e) Veneto



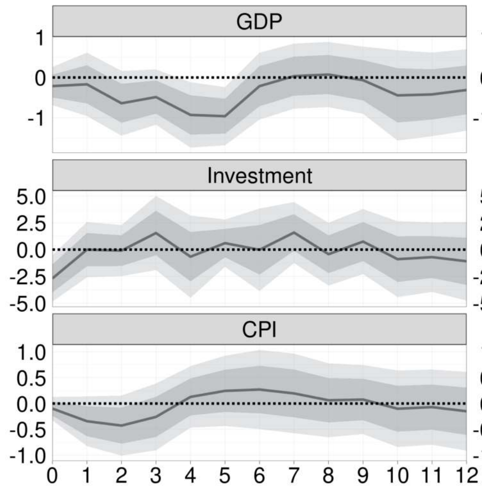
Note: IRFs following a monetary policy shock corresponding to a 100 b.p. increase of the 3-months OIS. The shaded areas are the 68 and 90 percent confidence intervals.

Figure B.3: Monetary policy transmission to real GDP, investment and CPI in the central regions.

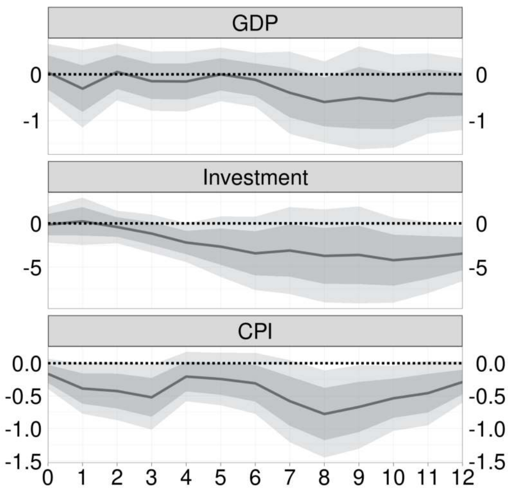
(a) Lazio



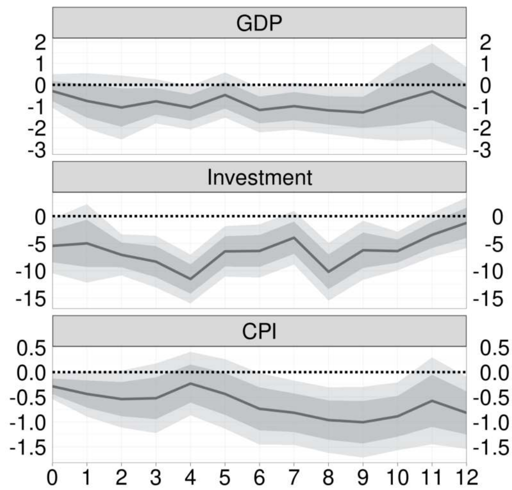
(b) Marche



(c) Toscana



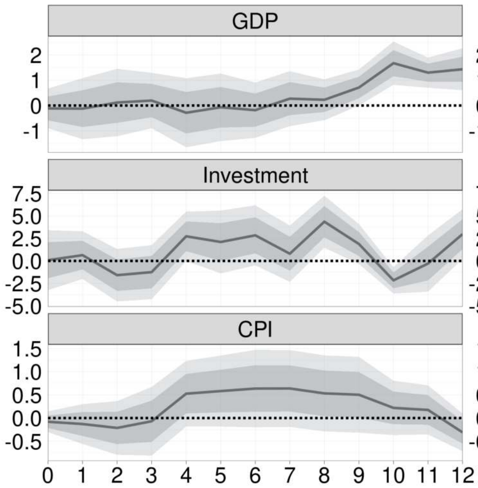
(d) Umbria



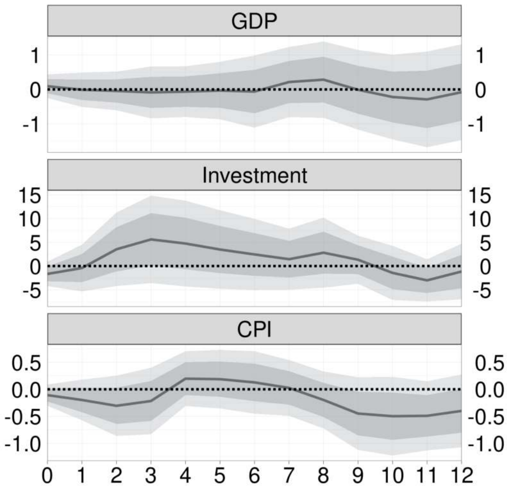
Note: IRFs following a monetary policy shock corresponding to a 100 b.p. increase of the 3-months OIS. The shaded areas are the 68 and 90 percent confidence intervals.

Figure B.4: MP transmission to GDP, investment and CPI in southern regions.

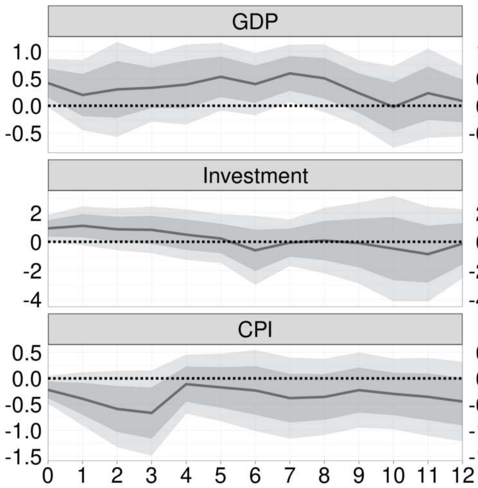
(a) Abruzzo



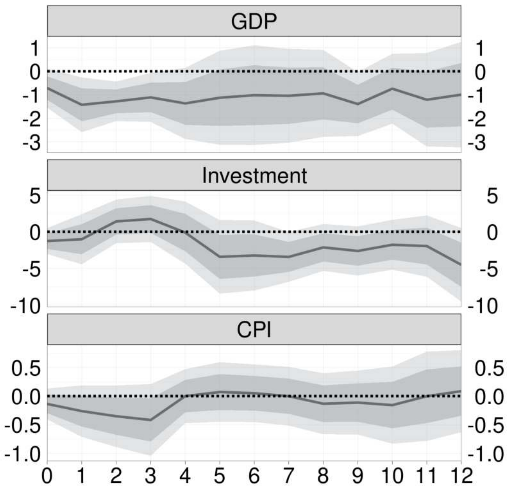
(b) Molise



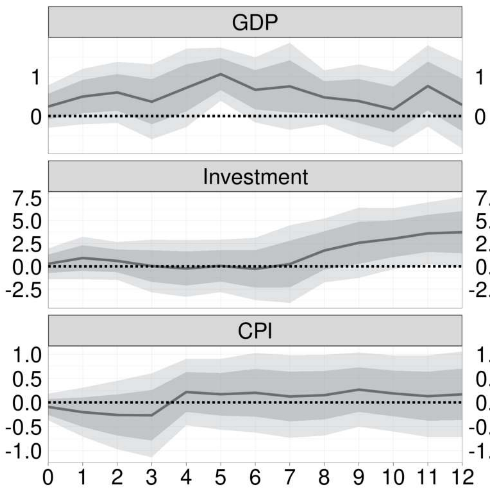
(c) Puglia



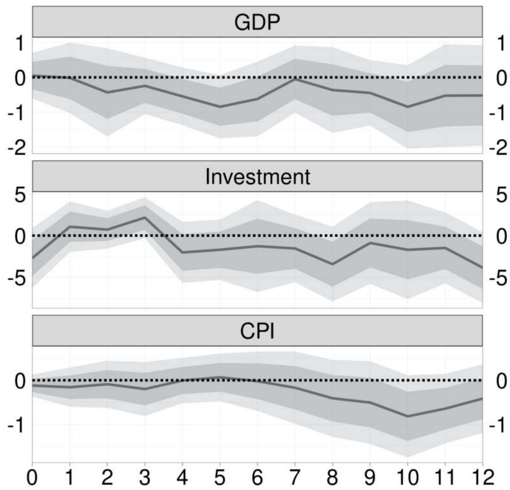
(d) Basilicata



(e) Calabria



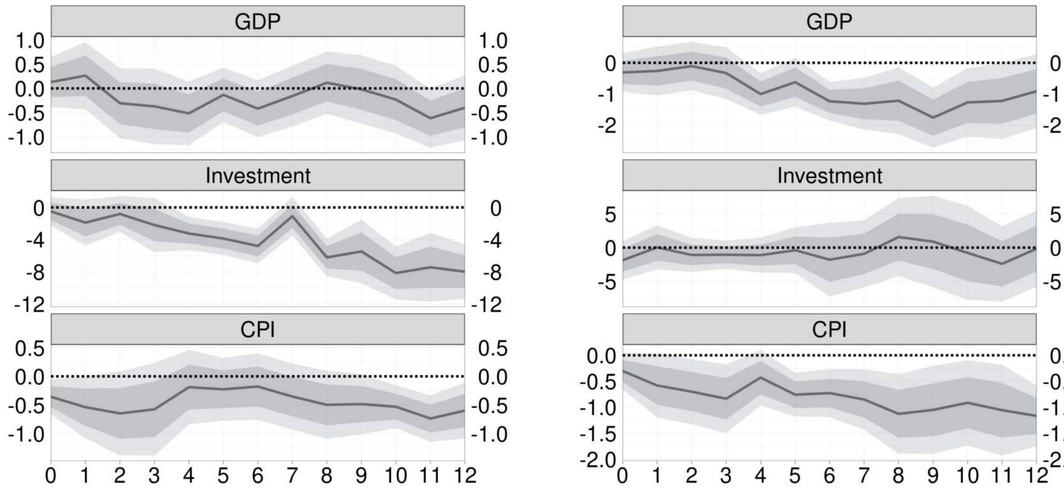
(f) Campania



Note: IRFs following a monetary policy shock corresponding to a 100 b.p. increase of the 3-months OIS. The shaded areas are the 68 and 90 percent confidence intervals.

Figure B.5: Monetary policy transmission to real GDP, investment and CPI in the main Italian islands.

(a) Sicilia (b) Sardegna



Note: IRFs following a monetary policy shock corresponding to a 100 b.p. increase of the 3-months OIS. The shaded areas are the 68 and 90 percent confidence intervals.

C Tables

C.1 Descriptive statistics

Table 1: Descriptive statistics of variables.

	N	mean	median	Stand. dev.	Interquart. range	1st quartile	3rd quartile
Gdp *	2,016	0.349	0.758	4.446	3.857	-1.421	2.437
Inv *	2,016	0.921	1.674	12.946	14.176	-6.270	7.906
Infl *	2,016	2.598	2.447	13.326	2.244	1.060	3.303
MP shock	100	0.037	0.001	0.370	0.107	-0.032	0.075
MATINDSTR	21	0.000	0.341	2.157	3.686	-1.935	1.751
FINFRAG	21	0.000	-0.201	1.350	2.070	-0.803	1.267
SMBANGRPSHR	21	0.000	-2.056	14.814	7.821	-7.450	0.371

Note: * Statistics computed on year-on-year changes. Quarterly data.

C.2 Testing for Slope Heterogeneity Results

Table 2: Tests of the heterogeneity of responses to monetary policy shocks across Italian regions.

Test type	**GDP**		**Investment**		**Inflation**	
	Test stat.	p-value	Test stat.	p-value	Test stat.	p-value
	$h \leq 4$					
Delta	5.660	0.000	6.472	0.000	-0.615	0.538
Delta adj.	5.678	0.000	6.492	0.000	-0.617	0.537
	$h \leq 8$					
Delta	11.682	0.000	11.777	0.000	2.020	0.043
Delta adj.	11.703	0.000	11.798	0.000	2.024	0.043
	$h \leq 12$					
Delta	17.227	0.000	16.806	0.000	2.637	0.008
Delta adj.	17.249	0.000	16.827	0.000	2.640	0.008

Note: The tests were carried out in Stata utilizing the XTHST package by Bersvendsen and Ditzen (2021). The HAC robust version of the tests were implemented (Kernel: Bartlett with average bandwith=6).

C.3 Principal Components Analysis

```
Principal components/correlation                 Number of obs    =         21
                                                 Number of comp.  =          7
                                                 Trace            =          7
    Rotation: (unrotated = principal)            Rho              =     1.0000

    --------------------------------------------------------------------------
       Component |   Eigenvalue   Difference         Proportion   Cumulative
    -------------+------------------------------------------------------------
           Comp1 |      4.65509      3.58601             0.6650       0.6650
           Comp2 |      1.06908      .455176             0.1527       0.8177
           Comp3 |      .613908      .237973             0.0877       0.9054
           Comp4 |      .375934      .249172             0.0537       0.9591
           Comp5 |      .126762     .0234196             0.0181       0.9773
           Comp6 |      .103342     .0474669             0.0148       0.9920
           Comp7 |     .0558756            .             0.0080       1.0000
    --------------------------------------------------------------------------

Principal components (eigenvectors)

  ------------------------------------------------------------------------------------------
    Variable |    Comp1     Comp2     Comp3     Comp4     Comp5     Comp6     Comp7 | Unexpl.
  -------------+----------------------------------------------------------------------+----
     agrishr |  -0.3396    0.4846   -0.0639    0.7297    0.2055   -0.0054   -0.2665 |       0
      indshr |   0.3378    0.3524   -0.7181    0.0436   -0.1503    0.2769    0.3806 |       0
    costrshr |  -0.2771    0.6725    0.0205   -0.6422   -0.0457   -0.0852   -0.2207 |       0
      govshr |  -0.4435   -0.0010    0.1475   -0.1031    0.5035    0.3524    0.6271 |       0
    firmsize |   0.4365   -0.0102   -0.1565   -0.1493    0.8126   -0.0223   -0.3189 |       0
     firmage |   0.3909    0.2419    0.5309    0.0621   -0.1234    0.6871   -0.1249 |       0
    flrloans |   0.3921    0.3606    0.3895    0.1284    0.0631   -0.5650    0.4742 |       0
  ------------------------------------------------------------------------------------------

. predict indstruc_new, score
(6 components skipped)

. label var indstruc "indstruc_new"

. pca leverage liquidity score

Principal components/correlation                 Number of obs    =         21
                                                 Number of comp.  =          3
                                                 Trace            =          3
    Rotation: (unrotated = principal)            Rho              =     1.0000

    --------------------------------------------------------------------------
       Component |   Eigenvalue   Difference         Proportion   Cumulative
    -------------+------------------------------------------------------------
           Comp1 |      1.84848      1.09648             0.6162       0.6162
           Comp2 |      .751998      .352472             0.2507       0.8668
           Comp3 |      .399525            .             0.1332       1.0000
```

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
leverage	0.6363	-0.1977	0.7457	0
liquidity	-0.5977	0.4847	0.6386	0
score	0.4877	0.8520	-0.1903	0

C.4 Results of state dependent LPs obtained with structural factors

Table 3: Drivers of heterogeneity in the responses of GDP, investment and inflation to monetary policy shocks.

VARIABLES	(1) reg_gdp_ldiff_h4 gdp	(2) reg_gdp_ldiff_h8 gdp	(3) reg_gdp_ldiff_h12 gdp	(4) reg_inv_ldiff_h4 inv	(5) reg_inv_ldiff_h8 inv	(6) reg_inv_ldiff_h12 inv	(7) reg_infl_ldiff_h4 infl	(8) reg_infl_ldiff_h8 infl	(9) reg_infl_ldiff_h12 infl
shock	-0.315***	-0.251***	-0.245**	-1.902**	-1.235**	-1.311**	-0.406***	-0.423***	-0.437***
	[0.084]	[0.082]	[0.090]	[0.827]	[0.438]	[0.472]	[0.036]	[0.054]	[0.058]
indshk	-0.111**	-0.117**	-0.108**	-0.716**	-0.402*	-0.320	-0.033*	-0.060**	-0.073**
	[0.048]	[0.046]	[0.048]	[0.339]	[0.194]	[0.219]	[0.017]	[0.024]	[0.026]
finshk	0.101	0.097	0.078	0.152	0.195	0.192	-0.052**	-0.076**	-0.100**
	[0.073]	[0.061]	[0.061]	[0.559]	[0.292]	[0.272]	[0.024]	[0.036]	[0.042]
banshk	0.013***	0.019***	0.024***	0.038	0.034	0.039	-0.004*	-0.002	-0.000
	[0.003]	[0.004]	[0.004]	[0.034]	[0.023]	[0.025]	[0.002]	[0.003]	[0.003]
Constant	0.744***	1.267***	1.467***	4.669***	3.006***	3.808***	0.918***	1.754***	2.529***
	[0.005]	[0.004]	[0.004]	[0.018]	[0.025]	[0.025]	[0.002]	[0.003]	[0.003]
Observations	10,290	18,144	25,662	2,016	18,144	25,662	10,290	18,144	25,662
R-squared	0.484	0.420	0.382	0.589	0.368	0.362	0.325	0.288	0.238

Robust standard errors, clustered at region level, in brackets
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents the results of state-dependent local projections obtained with the interaction of selected structural factors affecting the IRFs coefficients of GDP, investment, and inflation.