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Non-linear Effects of Monetary Policy Shocks on Housing: Evidence from a CESEE Country

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

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Non-linear effects of monetary policy shocks on housing: evidence from a CESEE country*

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Abstract

This paper estimates the effects of standard monetary policy shocks on housing and other macro variables in Slovakia, a CESEE country. For that purpose, we use a non-linear local projection model which uncovers asymmetries in these effects around three different dimensions: high versus low economic growth, interest rates and inflation. The main findings in this study are as follows. First, we often find no evidence of standard monetary policy eliciting a contractionary response in house prices or housing investment. Second, evidence is weakest during recessions and periods of low interest rates or low inflation. Third, these findings may be linked to the inability of monetary policy to trigger significant contractionary effects on household lending, which in turn may be linked to the effective lower bound on interest rates, the predominance of fixed-rate mortgages in Slovakia, or interaction between monetary and macroprudential policy. We also provide a discussion on the possible country characteristics that might drive these results and policy implications.

JEL code: C32, C36, E42, E52, E58, R21, R31
Keywords: Monetary policy, nonlinearities, local projections, euro area.

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Non-Technical Summary

This paper examines whether the transmission of conventional monetary policy to the housing sector in Slovakia displays state-dependent nonlinearities. Motivated by the long-standing debate on asymmetric monetary policy effects and by the distinctive structural features of CESEE housing markets, the study evaluates whether the impact of a standard policy tightening varies across periods of high versus low economic growth, interest rates, and inflation. Understanding these asymmetries is especially relevant for a small euro-area economy where mortgage credit has expanded rapidly, fixed-rate loans predominate, and inflation differentials vis-à-vis the euro area have been persistent.

Methodologically, the paper employs the smooth transition local projection framework while the monetary policy shocks are identified using high-frequency changes in the six-month OIS rate around ECB policy announcements. The empirical analysis is conducted using a monthly dataset for Slovakia over 2003–2023, comprising real activity indicators, house prices, lending to households for house purchase, housing supply proxies, household income and savings, and a borrower-based macroprudential stance index. Three nonlinear state variables govern the transitions across regimes: (i) real GDP growth, (ii) the 12-month Euribor, and (iii) HICP inflation.

Our results highlight that the transmission of standard monetary policy in Slovakia varies across different economic regimes. First, the reaction of house prices and investment to a monetary policy shock is only contractionary during states of high economic growth, high rates, and high inflation. Second, monetary policy appears to have a limited effect on new loans for house purchase, which may be a crucial link impairing the transmission to house prices and housing investment. Third, the monetary policy shock tends to trigger an easing in our macroprudential policy stance measure, notably during states of low rates and low inflation, which may counteract the expected contractionary effects of monetary policy.

Policy implications follow directly from these results. First, the weak transmission of monetary policy to household lending—especially in low-rate and low-inflation environments—helps explain why monetary policy has had limited impact on house prices and housing investment over the past two decades. For CESEE countries in the euro area, this underscores the risk that low interest rates may contribute to mortgage-market overheating and misallocation of credit toward real estate. Second, the strong state dependence of monetary transmission high-

lights the need for complementary countercyclical fiscal policy during recessions or low-rate episodes, when monetary policy alone is less potent. Third, the interaction between monetary and macroprudential policies suggests a role for proactive borrower-based measures and countercyclical

1. Introduction

Over the past two decades, several Central, Eastern and Southeastern European (CESEE) countries[1]—including Slovakia—have joined the euro area, thereby abandoning autonomous monetary policy in favor of a common monetary union led by the ECB[2]. While euro adoption has brought clear benefits to CESEE countries, such as economic convergence, lower financing costs, and increased policy credibility (Zuk et al., 2018; Žúdel and Melioris, 2016, among others), the potential risks of such monetary integration must be also taken into consideration. One prominent risk is that euro area interest rates may, at times, be set below the levels appropriate for domestic macroeconomic conditions (Bencik, 2009), which may contribute to overheating pressures in the credit and housing markets (Schadler et al., 2005; Brzoza-Brzezina, 2005). In turn, such a misalignment may weaken the effectiveness of monetary policy transmission, especially during periods of low inflation and low nominal interest rates. Evidence on this matter may provide useful insights for CESEE countries in the euro area and those aspiring to join in the near future.

In parallel, the debate over the asymmetric effects of monetary policy has been ongoing for nearly a century (Eccles and Goldsborough, 1935). While classical expansion versus recession nonlinearity has attracted the attention of economists for a long time, more recently, studied asymmetries are related to the level of interest rates and inflation. However, a large body of related literature shows mixed results across countries[3]. One factor that might explain this outcome is the heterogeneity in the transmission of monetary shocks across countries (IMF, 2024; Corsetti et al., 2022; Battistini et al., 2025, 2023; Pica, 2023).

In these debates about the asymmetric effects of monetary policy, the housing market has emerged as a natural case study. As is often the case, the housing market in Slovakia plays

[1]The CESEE region includes the following states: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Kosovo, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, Turkey, and Ukraine.

[2]In particular, the following CESEE countries joined the euro area: Slovenia (2007), Slovakia (2009), Estonia (2011), Latvia (2014), Lithuania (2015), Croatia (2023).

[3]While Tenreyro and Thwaites (2016), for the US and Alpanda et al. (2021) – for a sample of advanced economies – find that the transmission of monetary policy is weaker during recessions, the opposite results have been highlighted by De Santis and Tornese (2024). Moreover, Ahmed et al. (2024), Borio et al. (2023), and Borio and Hofmann (2017) find that transmission is less effective when interest rates are low. By contrast, Battistini et al. (2022), who study the impact of mortage rates on housing prices and investment, find that the effects are stronger in low interest rate environments. Additionally, the results of Canova and Forero (2024) suggest that during periods of high inflation, the effects of monetary policy on US real activity are lower but last longer. This conclusion is similar to that of Ascari and Haber (2022) but deviates from the results of Gargiulo et al. (2025), who find that monetary policy has a stronger effect on the US labor market when inflation is high.

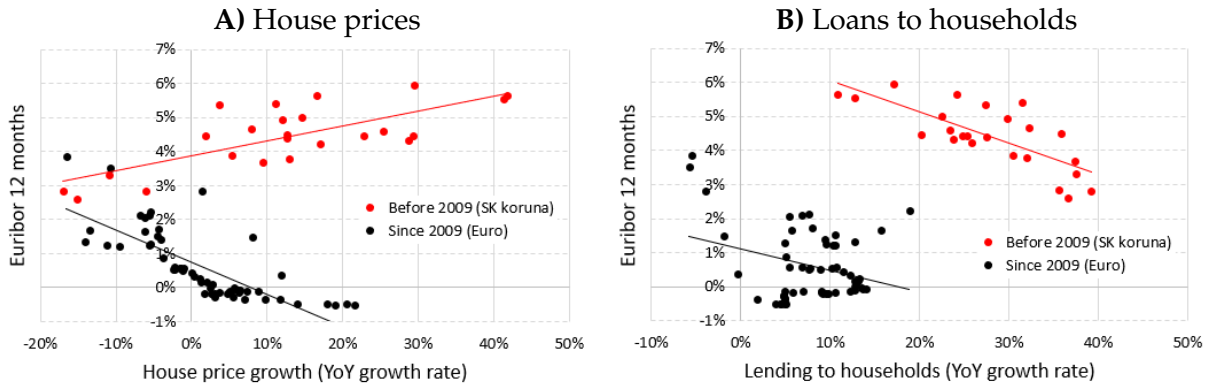
a critical role as a major driver of economic growth, lending to households, and a major component of household wealth. Fluctuations in housing prices can significantly impact consumer spending, borrowing capacity, and overall financial stability. Nonetheless, mortgage lending constitutes a substantial portion of the banking activity. Consequently, shifts in housing demand, prices, and investments may have far-reaching implications for economic stability and growth. Therefore, the sector's sensitivity to interest rate changes and credit conditions makes it a crucial channel through which monetary policies influence the broader economy. Understanding the nonlinear effects of monetary policy on the housing market is essential for policymakers to anticipate potential macro-financial risks. This issue is particularly pertinent for Slovakia, which over the last decade has received several warnings about the buildup of potentially excessive risks in the housing market, including large growth in house prices and mortgage credit (e.g. ESRB, 2022).

Nonetheless, the housing markets in CESEE countries, which are relatively understudied and distinct from those in Western economies (Hildebrandt et al., 2012), provide additional motivation for our study. Some common structural characteristics that these states tend to share are as follows. First, they transitioned to open economies in the 1990s, beginning with very low levels of housing supply and quality. Second, this apparent underinvestment in housing shifted to a period of high growth in lending to households in the 2000s. Third, the low levels of productivity they exhibited during their transition three decades ago are persistent, such that there may be a risk of capital misallocation from non-housing investments to real estate-related investments, making the catching-up of these economies even more challenging. These elements underscore the need to implement policies that can allocate sufficient capital to finance and satisfy housing demand without impairing affordability, sustainable economic convergence, or macro-financial stability.

Against this background, in this study, we investigate whether the transmission of standard monetary policy on housing is affected by different economic states in Slovakia, a CESEE country. In Figure 1, the scatter plots of the Euribor 12 months vis-à-vis house price growth (subplot A) and loans to households growth (subplot B) suggest that some nonlinearities might be present in both bivariate relationships. As these plots hint, one possible asymmetry source may be related to the entrance of Slovakia in the euro area in 2009, as the behavior of those bivariate relationships before (red dots) and since 2009 (black dots) might have changed. In this

paper, we assess three different nonlinearities: high versus low economic growth, interest rates, and inflation. To this end, we employ the smooth transition local projection model (STLP) of Tenreyro and Thwaites (2016), as recently used in the literature for the euro area and member countries (see e.g. Alpanda et al., 2021; Battistini et al., 2022, among others). The significance of this study lies in the potential applicability of its findings at least to other CESEE countries, particularly given the similarities in housing markets and other relevant factors across the region. However, further research is necessary to substantiate this broader relevance.

Figure 1: Euribor 12 m. versus house prices and loans to households, Slovakia.



Notes: Both house prices and loans to households are in year-on-year quarterly growth rates. The sample spans from 2003 Q1 to 2023 Q2.

Our results show that monetary policy transmission in Slovakia is state-dependent across different economic regimes such as high versus low economic growth, interest rates, and inflation. First, the reaction of house prices and investment to a monetary policy shock is contractionary only during states of high economic growth, high rates, and high inflation. Second, monetary policy's effectiveness in eliciting a contractionary response in new loans to households for house purchase is quite limited, which may be a crucial link impairing the transmission to house prices and housing investment. Third, the monetary policy shock tends to trigger an easing in our macroprudential policy stance measure, notably during states of low rates and low inflation, which may counteract the expected contractionary effects of monetary policy, pointing to interactions between monetary and macroprudential policies. To the best of our knowledge, this is the first study to explore asymmetries in monetary policy effects on the housing sector in Slovakia[4] and one of the few exploring nonlinearities with CESEE countries'

[4]Other studies that assess the monetary policy transmission in Slovakia using linear methods are Juraseková (2009) and Kupkovic and Cesnak (2023), which employ sign restrictions to identify the shock.

data[5]. However, none of the latter studies is directly comparable to ours, given that they assess different dimensions of monetary asymmetries.

The findings of this study have important implications for policymakers. First, the ineffectiveness of monetary policy in affecting new lending to households, which may be the main channel driving the ineffectiveness in affecting house prices and housing investment in some states, might have been fueled by the low interest rates observed in Slovakia since the years prior to its accession to the euro area. Despite the obvious benefits of euro area membership, the risk of mortgage market overheating due to relatively low interest rates should not be overlooked. Second, our results highlight the need for state-dependent interventions given the varying effectiveness of monetary policy across different economic environments. A natural candidate for such an intervention is fiscal policy, where proactive and countercyclical measures may stimulate demand more effectively than standard monetary policy. Third, the interactions between monetary and macroprudential policies provide an opportunity to implement borrower-based measures and build buffers that could mitigate the unintended effects of low interest rates in CESEE countries prone to mortgage market overheating (Brzoza-Brzezina et al., 2015; Van Der Ghote, 2020). Authorities may consider implementing and/or tightening such policies as part of the euro area accession package to mitigate unnecessary excessive lending risks upfront.

Related literature. This study is related to several strands of the literature. First, it is related to theoretical studies that describe the channels by which standard monetary policy affects the housing sector, and those that add additional modeling devices to understand the large housing booms and busts observed in real-world data, including nonlinearities. Mishkin (2007) and Bernanke and Gertler (1995) detail the mechanisms through which interest rates and credit conditions affect housing demand, with the latter emphasizing the importance of credit constraints during economic downturns. The seminal paper by Iacoviello (2005) introduced a housing sec-

[5]Four exceptions are the following. First, Cao et al. (2023) assess the spillover effects of monetary policy shocks from core economies on lending in four small open economies, including the Czech Republic, depending on the interest rate level. Second, Papavangjeli and Geršl (2024) assess the transmission of a monetary policy shock to the real economy in Albania using a Threshold VAR. Third, Bikár and Hodula (2018) examine asymmetries in monetary policy transmission in the Czech Republic in terms of the level of government indebtedness. Fourth, De Luigi et al. (2025) examine the effects of monetary policy and its interaction with macroprudential policy in 11 EU-CESEE countries, including Slovakia, across different macropru intensities and exchange rate regimes. Instead, other studies estimate the effects of monetary policy shocks using panel data, including CESEE countries, but do not report the results for individual countries (Brandao-Marques et al., 2021; Burgert et al., 2024; Checo et al., 2024; Sutton et al., 2017).

tor in a DSGE model before the Great Recession further spanned academic interest in including such sector in macro models. Piazzesi and Schneider (2009) explore the role of expectations in housing markets and discuss how anticipated future economic conditions shaped by current monetary policy impact housing decisions. Additionally, Jiménez et al. (2014) investigate how low interest rates can foster risk-taking behavior by financial institutions, potentially leading to nonlinear outcomes in housing markets, particularly under varying economic conditions, which was later rationalized by Abbate and Thaler (2019). Despite these advances, some authors, such as Justiniano et al. (2019) and Guerrieri and Iacoviello (2017), show that replicating large housing booms and busts in theoretical models entails the incorporation of several assumptions and modeling devices, such as collateral and lending constraints, or time-varying expectations about house prices or lending conditions. These studies provide a critical foundation for examining whether the effects of monetary policy on housing exhibit nonlinearity in different economic environments.

The theoretical foundations of the asymmetric effects of standard monetary policy shocks are rooted in several economic theories. During expansions versus recessions, the state-dependent effects of monetary policy are often attributed to the financial accelerator mechanism (Bernanke et al., 1996), where credit constraints bind more tightly during recessions, making monetary policy more potent in stimulating demand than during expansions. Additionally, the effectiveness of monetary policy may differ in high versus low interest rate environments because of the zero-lower-bound constraint and differing risk-taking behaviors of financial institutions, which are more pronounced in low-interest-rate settings (Eggertsson and Woodford, 2003). Similarly, in high-versus low-inflation environments, monetary policy may exhibit non-linear effects through several channels, such as menu costs (Alvarez and Lippi, 2020), rational inattention to inflation (Sims, 2010), and the so-called slanted-L (Benigno and Eggertsson, 2023)[6]. According to these theories, standard monetary policy shocks should have smaller effects on real activity during a high inflation period. These theoretical insights suggest that monetary policy transmission can be significantly asymmetric depending on prevailing economic conditions, a hypothesis that this study investigates within the context of Slovakia's housing market.

Second, our study is also related to empirical papers that estimate the nonlinear effects of standard monetary policy shocks, especially if they look at housing sector variables. Using data

[6]See Canova and Forero (2024) for a survey of these channels.

from 18 advanced economies, Alpanda et al. (2021) find that the impact of monetary policy shocks on output and other macro variables is weaker during periods of economic downturns, low household debt, and high interest rates. In addition, based on a panel of 18 advanced countries, Ahmed et al. (2024) find that monetary transmission to economic activity is substantially weaker when interest rates are low, economic growth is low, and debt is high. Using euro area data, Dieckelmann et al. (2024) find that, in a low interest rate environment, a monetary policy shock could lead house prices to decline by a relatively large magnitude. Similarly, Battistini et al. (2022) use both linear and nonlinear local projections to estimate the impact of shocks to mortgage rates on housing investment and prices in the euro area. They find that declines in house prices and housing investment are larger in a low interest rate environment. Using US data, Tenreyro and Thwaites (2016) and De Santis and Tornese (2024) study the transmission of monetary policy to macro variables under different business cycle states and find contradictory results. While the former conclude that monetary policy effects are weaker in recessions, the latter authors report the opposite results. In addition, employing US data, Canova and Forero (2024) find that the responses of monetary policy shocks to output growth, unemployment, and inflation are smaller when inflation is high. Alternatively, Gargiulo et al. (2025) find that when inflation is below a certain threshold, changes in monetary policy have a short-lived effect on prices and no effect on unemployment. Regarding CESEE data, using Albanian data Papavangjeli and Geršl (2024) show that the effect of a monetary policy shock on real GDP differs depending on the level of the credit-to-GDP gap: during periods of positive credit-to-GDP (proxying financial vulnerability), the monetary policy effects are weaker on impact, but larger after one year. Using Slovak data, Kupkovic and Cesnak (2023) find that monetary policy shocks have a large contractionary effect on housing prices, using a linear model and sign restriction identification. De Luigi et al. (2025), show that macroprudential policy can mitigate the effects of monetary policy shocks in CESEE economies, especially under flexible exchange rates. Their findings highlight the importance of coordinated monetary and macroprudential frameworks. We discuss our empirical results vis-à-vis these studies in the discussion section.

The structure of this paper is as follows. Section 1 presents the modeling framework and describes the nonlinearities we study. Section 2 depicts the data used in our estimations. Section 3 showcases our empirical results. Section 4 discusses such results and the potential caveats of this work. Finally, section 5 concludes.

1. Modeling framework

1.1. Monetary policy transmission channels to housing

Monetary policy impacts the economy through a number of established channels, affecting variables from interest rates to asset prices[7]. The *interest rate channel* serves as the primary conduit for monetary policy actions. When central banks adjust policy rates, they directly affect the cost of borrowing, i.e. lending rates, and thus the disposable cash available after repaying current debt payments through the so-called *cash flow channel*. Lowering interest rates reduces borrowing costs, which can stimulate investment and consumption by businesses and households. Conversely, raising rates makes borrowing more expensive, potentially dampening economic activity (Bernanke and Blinder, 1992; Mishkin, 1995). Central banks also influence the economy through the *expectations channel*, shaping economic agents' forecasts about future economic conditions. By signalling future policy actions, central banks can manage expectations about inflation and economic growth, which in turn affect decision-making in the present.

Monetary policy affects the economy through the *valuation of assets*, as articulated by Bernanke et al. (1996) through their exploration of the financial accelerator. Changes in interest rates influence the prices of stocks and real estate, altering household wealth and consumer confidence. For example, lower interest rates generally increase asset prices, enhancing the wealth of asset holders, which can lead to increased spending and further economic stimulation. This channel highlights the interconnectedness of monetary policy, asset prices, and economic activity. The *credit channel* further amplifies the effects of monetary policy beyond the traditional interest rate channel. This channel works through the availability and cost of credit (Bernanke and Gertler, 1995). When monetary policy is expansionary, banks are more likely to lend, given the lower cost of capital and reduced risk associated with borrowing. This can accelerate economic activity by enabling more consumers and businesses to obtain financing for spending and investment. Conversely, contractionary policy can tighten credit conditions, restricting access to capital and slowing economic growth.

These traditional channels illustrate how central bank policies are transmitted to the broader economy, highlighting the complexity and variety of mechanisms at play. The efficacy of these

[7] See IMF (2024) for an exposition of the main housing channels of monetary policy transmission.

channels can vary significantly depending on the state of the economy and financial system, underscoring the need for a nuanced approach to monetary policy. However, despite the incorporation of various modeling devices and financial frictions, accurately replicating the magnitude and dynamics of housing booms and busts within macroeconomic models remains a significant challenge. As shown by Justiniano et al. (2019) and Guerrieri and Iacoviello (2017), among others, generating such pronounced cyclical movements in housing markets requires a careful combination of constraints and assumptions that introduce nonlinearities into the models. These modeling devices, such as borrowing collateral constraints, lending constraints, or shifts in beliefs, are essential to capturing the sharp increases in housing prices followed by steep declines, as observed in real-world data.

Another channel identified in the literature is the *bank risk-taking channel*, which posits that low interest rates, typically resulting from expansionary monetary policy, incentivize banks to assume higher risks in their lending practices, a mechanism that has garnered significant attention following the 2008 financial crisis. As highlighted empirically by Jiménez et al. (2014), when central banks maintain low interest rates, banks may increase their risk exposure by extending credit to borrowers deemed less creditworthy under normal circumstances, thereby amplifying financial vulnerabilities within the economy. This risk-taking behavior is a crucial component of the broader monetary policy transmission mechanism because it can influence asset prices, including those in the housing market, by affecting the availability and cost of credit. Despite its significance, the full implications of the risk-taking channel for macroeconomic stability and optimal monetary policy remain the subject of ongoing research and debate. Abbate and Thaler (2019) further theoretically underscore the complexities of this channel, suggesting that the interplay between monetary policy and bank risk-taking behavior must be carefully considered in the formulation of policies aimed at ensuring financial stability.

Additionally, the *collateral channel*, as explored by Chaney et al. (2012), highlights the critical role of asset prices, particularly real estate values, in influencing firms' borrowing capacity and investment behavior. The authors argue that increases in property values enhance the collateral that firms can offer, thereby improving their access to external financing. This expanded access to credit facilitates greater investment, particularly in capital-intensive projects, which can stimulate economic growth. The study underscores that fluctuations in property prices, driven by changes in monetary policy or other factors, can thus have significant macroeco-

nomic implications by altering firms' balance sheets and their ability to secure financing. The collateral channel, therefore, serves as an important transmission mechanism through which monetary policy impacts the real economy, particularly in sectors heavily reliant on external finance and tangible assets. Further, Doerr (2020) find that housing booms, through the collateral channel, can have a negative effect on aggregate productivity, because real estate prices can distort the allocation of capital and credit in the private sector.

1.2. Smooth transition local projection model

We rely on the smooth transition local projection model (STLP) proposed by Tenreyro and Thwaites (2016), which is a combination of the local projection methodology by Jordà (2005) and the smooth transition regression method by Granger and Terasvirta (1993). This methodology has been also used recently by Battistini et al. (2022) to measure the effect of monetary policy shocks on housing.

Such model is defined in equation (1), where y_t refers to each output variable whose impact, driven by a shock ϵ, we want to analyse along different time horizons $h \in \{0, H\}$ and economic states $j \in \{b, r\}$, such that:

$$y_{t+h} = \tau t + F(z_t)(\alpha_h^b + \beta_h^b \epsilon_t + \gamma^{b\prime} x_t) + (1 - F(z_t))(\alpha_h^r + \beta_h^r \epsilon_t + \gamma^{r\prime} x_t) + u_t \tag{1}$$

where the main coefficient of interest is β_h^j, which captures the effect of the shock ϵ_t on economic variable y_t. Additionally, τt is a linear time trend, α_h^b is a constant and x_t are control variables. The term $F(z_t)$ is a logistic function, i.e. a smooth increasing function, defined as follows:

$$F(z_t) = \frac{\exp\left(\theta \frac{\theta(z_t - c)}{\sigma_z}\right)}{1 + \exp\left(\theta \frac{\theta(z_t - c)}{\sigma_z}\right)} \tag{2}$$

where z_t is the state of the economy, a parameter c accounts for the proportion of the economy spending time in each state and σ_z is the standard deviation of the state variable z. Finally, the parameter θ accounts for the speed of transition switch from one state to another.

1.3. State variables and non-linear narratives

In this study, we consider three different sources of nonlinearities in the standard monetary policy effects. First, we assess whether the state of the business cycle affects monetary transmission using real GDP growth as a proxy for the state. In the last three decades, a large body of empirical literature has analyzed this issue, mainly focusing on US and euro area data, finding mixed results. For example, while Burgard et al. (2019), Lo and Piger (2005), and Peersman and Smets (2002) find that the effects of monetary policy shocks are more contractionary during recessions than during expansions, Alpanda et al. (2021) find the opposite. Similar disagreements have been found in studies using US data[8]. Two explanations that might justify why these effects may be more contractionary during recessions are the following. One is the *financial accelerator* of Bernanke et al. (1996), under which credit constraints bind more tightly during recessions. Another explanation is the loss aversion of consumers and firms such that these agents might react more strongly in periods in which they expect to lose income or revenue.

Second, we evaluate whether the effects of standard monetary policy shocks differ depending on whether reference interest rates are higher or lower, for which we use 12-month Euribor as a rate proxy. Empirical studies find that the impact of monetary policy shocks tends to be more contractionary in a low-interest-rate environment (Alpanda et al., 2021; Battistini et al., 2022; Dieckelmann et al., 2024). This result is consistent with the asset pricing theory, which suggests that a lower interest rate environment leads to larger discounting effects on house prices (Himmelberg et al., 2005; Dieckelmann et al., 2024) and housing investment. However, other studies find the opposite result (Borio et al., 2023; Ahmed et al., 2024; Borio and Hofmann, 2017). In this regard, Borio and Hofmann (2017) point to several possible reasons that may justify such an outcome. For example, persistently low interest rates may make an impaired banking system less able to provide credit and/or generate a disincentive to address debt overhang and resource misallocation issues. Also, Abbate and Thaler (2019) show that during low rates states, banks might choose to take excessively risky investments due to an agency problem that distorts banks' incentives, i.e. the so-called *asset risk-taking channel*, as found by Jiménez et al. (2014) with Spanish credit register data.

[8] With US data, while Weise (1999), Garcia and Schaller (2002), Lo and Piger (2005), Burgard et al. (2019), Bruns and Piffer (2021) and De Santis and Tornese (2024) find that US monetary policy is more effective during recessions, Tenreyro and Thwaites (2016) find the opposite results.

Third, we assess whether the effects of conventional monetary policy shocks change depending on the level of inflation proxied by HICP growth. As pointed out by Canova and Forero (2024), several theories have provided a basis for such an asymmetry, such as menu costs, rational inattention to inflation, and slanted L. Alvarez and Lippi (2020) propose a sticky price model that allows for many temporary price changes, i.e. menu costs, which are larger during high inflation regimes. Rational inattention suggests that agents pay more attention to inflation news in a high-inflation environment (Sims, 2010). Furthermore, according to the slanted L theory (Benigno and Eggertsson, 2023), a higher inflation implies a higher ratio of job vacancies to unemployed workers. According to these theories, standard monetary policy shocks should have smaller effects on real activity during a high inflation period. Empirical papers tend to agree that when inflation is low, the effects of standard monetary policy shocks are more contractionary, both using euro area (Alpanda et al., 2021) and US data (Ascari and Haber, 2022; Canova and Forero, 2024). However, Gargiulo et al. (2025) find the opposite results using US data.

2. Data

2.1. Our macro dataset

We construct a monthly database of 24 Slovak macroeconomic time series plus the Euribor 12 months[9] from the sample 2003 M1 to 2023 M6. We start our sample in 2003 to include housing supply measures, such as building permits and housing starts. Our dataset includes measures and subcomponents of output, consumption prices and deflators, households' income, unemployment, house prices[10], measures of lending to households and non-financial corporations, savings, housing supply proxies, and an overall measure of macroprudential stance. The latter is an index of borrower-based measures implemented in Slovakia as described in Klacso (2022)[11]. See Table 2 in the Appendix for a detailed description of all variables in the dataset and their transformations.

[9] Before January 2009 we consider instead the Bratislava Interbank Offered Rate (BRIBOR), which was the analogous reference rate used in Slovakia until the country joined the euro area.

[10] We backcast the transactions-based measure of house prices from 2003 to 2005 using the observed growth rates of the offered prices-based measure of house prices provided by specialized data providers NARKS and United Classifieds, which in turn are extracted from selected housing websites.

[11] In particular, we use the measure version which uses weights across macroprudential measures that are based on the stringency of limits in terms of their impact on the volume of new businesses, i.e. option three. Thanks to Ján Klacso (National Bank of Slovakia) for this suggestion and for sharing with us his macroprudential measures data.

Our dataset includes monthly and quarterly variables. Regarding the latter, we use a Chow and Lin (1971) frequency conversion without indicators to obtain the monthly estimates of the quarterly variables[12]. Despite these frequency conversions, which affect 18 of the included variables, we prefer to use a monthly model to avoid identification issues arising from aggregation in low-frequency models, as shown by Alessandri et al. (2023).

2.2. Proxies of monetary policy shocks

Studying monetary policy shocks has been of chief interest to researchers and central bankers. In the euro area, the work by Altavilla et al. (2019) provided a novel database and newly indicators to measure the impact of monetary policy decisions. This recent database is called euro area monetary policy event-study database (EA-MPD) and includes several assets: Overnight Index Swap (OIS) at different maturities[13], sovereign yields, stock prices and exchange rates. As stated in Gertler and Karadi (2015), the shocks need to be estimated in such a way that policy shocks (or surprises) can be considered as exogeneous to other economic and financial variables. Therefore, Altavilla et al. (2019) study each event window precisely, using intraday data, to make sure asset changes reflect purely the market reaction. Moreover, the use of different assets and maturities is crucial to capture different dimensions of monetary policy surprises. Our work focuses on capturing conventional monetary policy shocks, i.e., related to short-term interest rate expectations. Therefore, we rely on the six-month OIS for gathering conventional monetary policy shocks.

2.3. Structural housing sector characteristics

The Slovak housing market exhibits unique characteristics that influence the transmission of monetary policy, particularly through housing investment and prices (Cañizares Martínez, 2025). As summarized in Table 1, Slovakia has one of the highest rates of owner-occupied accommodations in the Euro area (87%), this rate substantially exceeds that of countries like Germany (44%) and France (57%). The high ownership rate may insulate the housing market from rental sector fluctuations but also exposes it to greater sensitivity to housing price changes, impacting household wealth and consumption patterns. In contrast, the rental mar-

[12]Frequency conversion are done using the Matlab library of Quilis (2018).
[13]The following OIS maturities are included: 1,3 and 6 months and 1,2, 5 and 10-year yields.

ket in Slovakia is underdeveloped, comprising only 8% of accommodations. Subsidized rent is minimal, accounting for just 0.7% of the market, which may indicate limited public intervention in the housing market. The immovable property tax as a percentage of total tax revenues is low at 1.4%, which could reflect a favorable policy environment for property owners.

Table 1: Structural differences across euro area housing sectors.

	DE	FR	IT	ES	NL	SK
Housing tenure and public policy						
Owner-occupied accommodation (%), 1999-2019	44.0	57.0	72.7	79.8	55.3	87.3
Rented accommodation (%), 1999-2019	56.0	43.0	18.1	13.9	43.5	8.0
Rent subsidized (%), 2020	6.6	18.5	1.9	3.3	-	0.7
Immovable property tax (% of total tax revenues), 2020	1.1	5.2	3.0	3.1	2.5	1.4
Vacancy rate (%), 1999-2019	8.0	6.9	19.3	15.2	3.6	11.0
Housing finance systems						
Owner with mortgage (%), 2020	18.2	23.1	10.8	26.4	48.8	18.9
Share of adjustable-rate mortgages (%), 2019-2020	11.0	2.0	24.0	35.5	17.0	2.0
Business environment						
Building Permits, 2006 - 2020						
Days	128	189	213	172	198	300
Cost (% of building)	1.3	3.4	3.7	5.0	3.9	0.2
Enforcing contracts, 2004 - 2020						
Days	429	447	1211	513	514	646
Cost (% of claim)	14.4	17.4	28.5	17.5	24.1	27.3

Source: ECB Statistical Data Warehouse, WB (2020), Muellbauer (2022) and OECD (2022). This table builds on Cañizares Martínez (2025) and Cañizares Martínez et al. (2023).

In the 1990s, many CESEE countries, including Slovakia, underwent major structural changes in their housing markets primarily due to the privatization of state-owned assets. This period saw a substantial transfer of property from the public to the private sector, which was often executed by selling state-owned residential properties to tenants at significant discounts. This shift markedly increased the proportion of owner-occupied housing in these countries. The mass privatization led to a high rate of home ownership. However, it also resulted in numerous challenges related to the maintenance and quality of housing stock.

The structure of housing finance in Slovakia is now characterized by a low prevalence of

adjustable-rate mortgages (ARMs), making up only 2% of the market. This is similar to the low rates observed in France but in stark contrast to higher rates in Italy (24%) and Spain (36%). The dominance of fixed-rate mortgages (FRMs) in Slovakia could imply a lower sensitivity of the housing market to short-term interest rate changes, potentially moderating the immediate impact of monetary policy adjustments.

The business environment in Slovakia, particularly regarding real estate development, is challenged by bureaucratic procedures. It takes approximately 300 days to obtain a building permit, the longest duration compared to major Euro area economies, where the process takes between four to seven months. This could significantly delay new housing developments, affecting the supply side of the housing market and potentially leading to price pressures in periods of demand spikes.

These structural characteristics, in particular structure of housing finance may affect the monetary transmission (Corsetti et al., 2022; Calza et al., 2013). The high ownership rates and low prevalence of ARMs in Slovakia might buffer the immediate impacts of policy changes on consumption and investment but also expose households to significant risks in the event of price adjustments. These structural insights not only aid in understanding the housing sector's dynamics in Slovakia but also enrich the analysis of how monetary policy impacts through various channels in differing economic and regulatory environments.

These findings highlight the complexity of housing market reforms in transition economies and underline the importance of integrated policies that address both market dynamics and social needs. The transformation of the housing markets in CESEE countries, including Slovakia, is closely tied to ongoing economic transitions and integration processes within the broader European context. Policymakers have been urged to implement measures to stabilize the housing market, improve housing quality, and ensure affordability, particularly through enhanced regulatory frameworks and targeted economic policies.

3. Results

3.1. Empirical specifications

The empirical specification of our baseline model, that is, the smooth transition local projection

model of Tenreyro and Thwaites (2016), is as follows. First, given that our target in this study is to assess the effects of standard monetary policy in a euro area country, we choose as our baseline policy rate the Euribor 12 months rate, as commonly done in the literature. In addition, we use as our standard monetary policy shock proxy the six month OIS rate changes in the press release window, taken from the EA-MPD database of Altavilla et al. (2019). Our sample ranges from 2003 M1 to 2021 M6, where the response variables are measured up to two years later, that is, using data up to 2023 M6. For each of the equations we estimate, we use the same set of control variables, x_t. In particular, we include the following variables: new loans to households for house purchase, house prices[14], housing investment, housing starts[15], compensation per employee, households savings ratio, employees, and a macroprudential stance measure. All monetary variables are in real terms and deflated using the private consumption deflator. We work with log levels of volume variables.

Regarding the empirical specification of the three nonlinearities that we explore, we proceed as follows. First, to model the expansion versus recession non-linearity, we define Z_t as a seven-month moving average of real monthly GDP growth along the lines of Tenreyro and Thwaites (2016). By contrast, we use no lags for this state variable, which we prefer to avoid confounding datapoints corresponding to possibly different states. Following Tenreyro and Thwaites (2016) and Auerbach and Gorodnichenko (2011) we calibrate rather than estimating the parameters of the smooth transition model, which applies to the three nonlinearities we consider. In particular, we define a recession as the worst 9 percent period in our sample, which roughly implies assuming a threshold between expansion and recession at about 0% monthly GDP growth. In addition, the intensity of regime switching when Z_t changes, namely θ, is set to 1, which provides a rather smooth transition across states. See the resulting probability of being in the high GDP growth state in Figure 9 in the Appendix, subfigure A, along with the probabilities of being in high interest rates (subfigure B) and high inflation states (subfigure C), calculated as explained in the next paragraph[16].

Second, to model the nonlinearity regarding high versus low interest rates, we choose as a state variable Z_t a seven-month moving average of 12 months Euribor interest rate. Then, we

[14]Our baseline measure of house prices is the one published by Eurostat. As a robustness check, we also use a measure of offered prices, reported by the NBS, that builds on the data providers NARKS and United Classifieds.

[15]Housing starts is a measure of housing supply, which is found to be relevant when assessing the effects of monetary policy shocks (Albuquerque et al., 2024).

[16]The correlation coefficients across the three obtained series corresponding to the probabilities of being in states characterized by high economic growth, high interest rates and high inflation are low, i.e. in the range [-0.08, 0.50].

define a low interest rate state as a monetary environment in the lowest 64 percent period in our sample, which corresponds to roughly 2% in the Euribor 12 months. In addition, we set the intensity of regime-switching $\theta = 3$, which is an intermediate degree of intensity. Third, in modeling a high versus low inflation nonlinearity, we choose as a state variable Z_t seven months moving average of the year-on-year HICP growth rate. We define a low-inflation environment as one that involves the lowest 19 percent of HICP growth in our sample, which implies a threshold value of roughly 0% inflation. Finally, we define the intensity of regime-switching $\theta = 3$. In all cases, we do not include lags of the policy rate as an additional control. The robustness of our results to these modeling choices is assessed in Section 4.3.

3.2. The effects of a standard monetary policy shock

The impulse responses we obtain when estimating the effects of a standard monetary policy shock in Slovakia are reported in Figures 2 to 4, which exhibit our results accounting for the three nonlinearities we consider, i.e. high versus low GDP growth, interest rates and HICP inflation, respectively. In particular, while the results for the linear model are shown in the second column, columns third and fourth exhibit those related to high and low states, respectively. The responses using the linear model point to a non-significant impact of a standard monetary policy shock in the four housing-related variables in which we mainly focus, namely house prices, housing investment, new loans to households for house purchase and housing starts. These results motivate the need to consider non-linear models[17]. In that vein, the use of non-linear models may help in understanding whether the effects after a monetary policy shock might be affected by nonlinearities, i.e. generating asymmetric effects across economic regimes.

Figure 2 exhibits the effects of a standard monetary policy shock on our variables of interest during expansions and recessions. First, the impact on our policy rate is significant and positive, and it vanishes quickly, independently of the economic regime. Conversely, the reaction of house prices is not symmetric across different economic regimes. Instead, we observe a significant contractionary response in house prices only during the expansionary regime, though such decline is rather subdued. Alternatively, during recessions the effect of a monetary policy

[17]First, we assess the hypothesis that the transmission from policy rates to mortgage rates may be impaired, but we do not find evidence of it. In particular, using a bivariate Proxy-SVAR (see results in Figure 8), we find a statistically significant effect of a standard monetary policy shock to the Slovak mortgage rate.

shock on house prices is not statistically significant, though its mean effect is expansionary. In the case of housing investment, its response during expansions is also contractionary, but only after one year. In contrast, during recessions the effect is not significant. Additionally, the responses of both new loans to households for house purchases and housing starts, i.e. a proxy of housing supply, are not significant in any of the two states. Finally, total employment declines significantly after a monetary policy shock during expansions, while the effect is not significant during recessions (see the rest of the impulse responses in Appendix C.2). Overall, our results suggest that standard monetary policy is less effective in Slovakia during recessions.

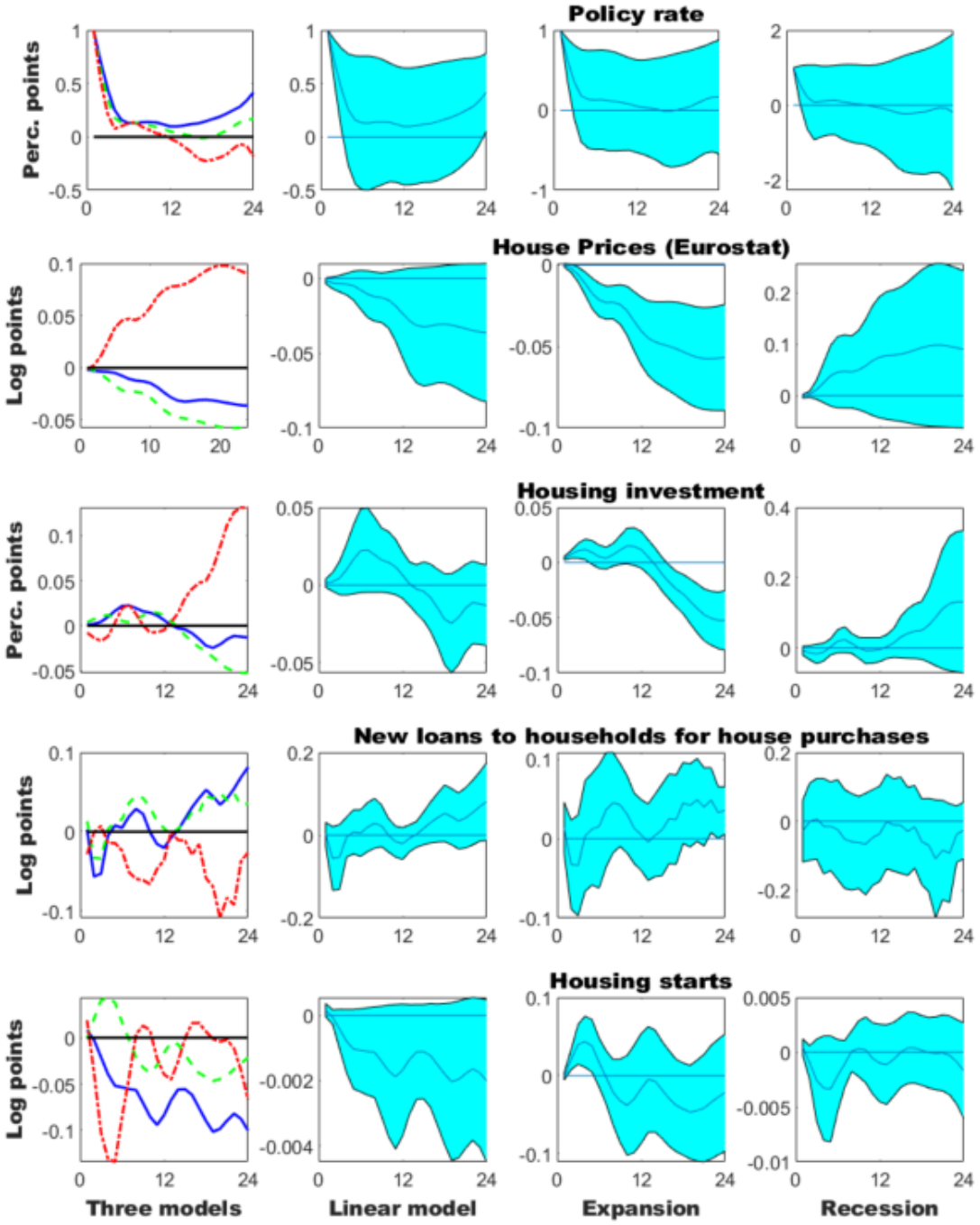
Figure 3 shows the impact of a standard monetary policy shock again on our variables of interest, but across different periods of high and low interest rates. In that setup, the reactions of house prices, housing investment and housing starts during the high rates regime are significant and contractionary after few months, while being economically modest. The reaction of new loans to households for house purchases is also contractionary only in the very short run. Instead, during the low rates regime, the responses of house prices, housing investment, new lending and housing starts are mostly not statistically significant. Notably, during the low rates regime, we also observe that the index of borrower-based measures, i.e. a proxy of macroprudential policy eases (see the rest of the impulse responses in Appendix C.3), which would facilitate the access to housing finance despite the increase in interest rates, pointing to a link between monetary policy and macroprudential policy. All in all, our results suggest that standard monetary policy is not effective in Slovakia in a low rates context.

Finally, Figure 4 reports the effects of a standard monetary policy shock across different regimes of high and low HICP inflation on our main variables of interest. In this framework, during the high inflation regime house prices and housing starts exhibit a significant contractionary response during all the considered horizon. In the case of housing investment and new loans, their responses are also mostly contractionary, though to a less significant extent. Instead, during the low inflation regime, house prices exhibit a not statistically significant response. In addition, housing investment and new loans to households for house purchase-only during the first year after the shock in the case of this latter variable-show a significant and expansionary response, which is surprising[18]. Observing the rest of impulse responses reported in the

[18]Notably, along these lines, De Luigi et al. (2025) report "credit puzzles" when estimating the effects of monetary policy shocks using data from other CESEE countries such as Poland, Bulgaria, Latvia, Slovenia, Lithuania and Croatia.

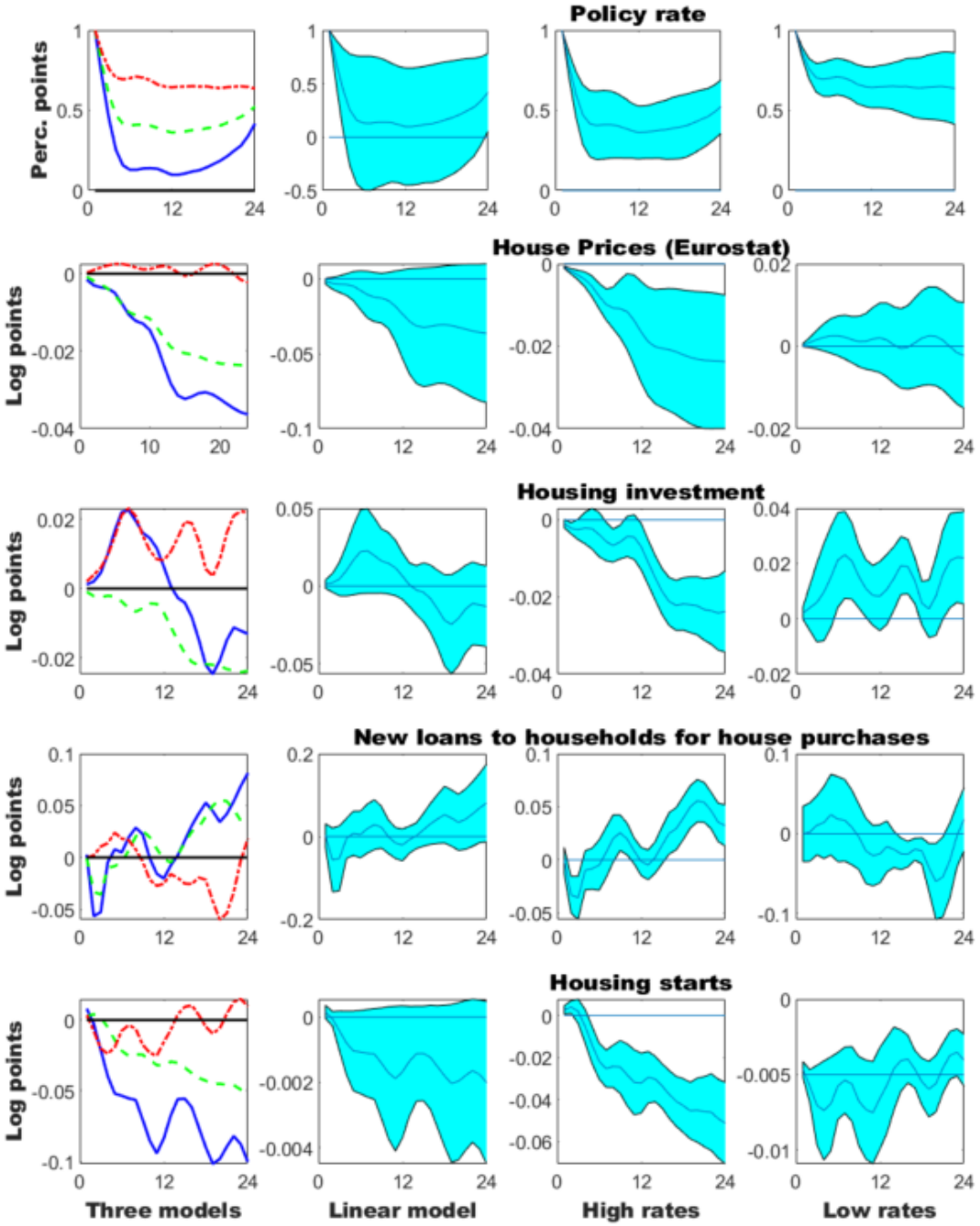
Appendix C.4 we can hint two reasons that might be driving these results. First, during the low inflation regime households appear to consume a larger share of their savings after the monetary policy shock. Second, the macroprudential policy stance index exhibits an easing tick, also favoring the demand of housing assets. Therefore, our results find no significant evidence of standard monetary policy effects in Slovakia during the low inflation regime, which is also consistent with our results regarding the low interest rate regime.

Figure 2: IRFs to a monetary policy shock (+100 bp), SV = real GDP growth



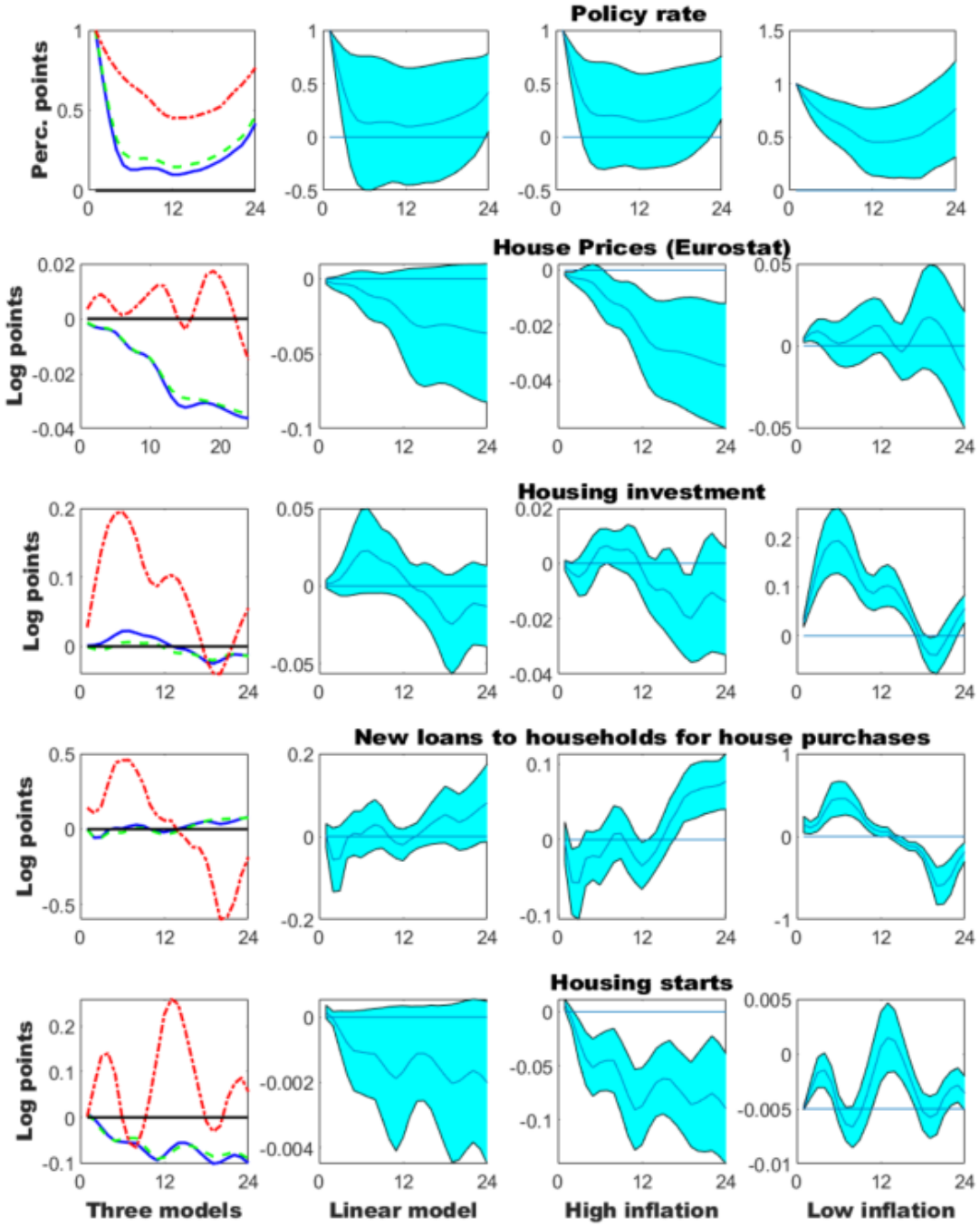
Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in an expansion state, and the red dotted line the response in a recession state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in an expansion, and the fourth column the interval around the response in a recession. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

Figure 3: IRFs to a monetary policy shock (+100 bp), SV = Euribor 12 m.



Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in a high rates state, and the red dotted line the response in a low rate state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in a high rates state, and the fourth column the interval around the response in a low rates state. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

Figure 4: IRFs to a monetary policy shock (+100 bp), SV = HICP Inflation



Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in a high inflation state, and the red dotted line the response in a low inflation state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in a high inflation state, and the fourth column the interval around the response in a low inflation state. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

3.3. Robustness exercises

To assess the robustness of our findings, we perform the following exercises. First, we reestimate our three baseline models using different measures of house prices and households' income, one at a time. In particular, we start by including the measure of house prices provided by NARKS and United Classifieds, that is, Slovak data providers, instead of our baseline measure published by Eurostat. The re-estimation of the three models yields similar results. Additionally, we perform a similar exercise by substituting our measure of wages, namely real compensation per employee, with two other similar measures, such as the real average wages and real disposable income, one at a time. Again, the results are analogous to those obtained in our baseline models. Second, we reestimate our baseline models by substituting our standard monetary policy shock proxy, that is, changes in the 6-month OIS rates, for the 1-year rate, i.e. another plausible proxy for conventional monetary policy shocks. Again, we find no significant differences in our results.

4. Discussion

In this empirical study, we estimate the effects of a standard monetary policy shock in Slovakia focusing in the impacts on the housing sector across three nonlinearities, namely high versus low economic growth, interest rates, and inflation. As we report in the previous section, the effectiveness of monetary policy varies significantly across different economic states, with many cases showing no evidence of a contractionary response in house prices, housing investment or new loans for house purchase. This suggests that the traditional channels through which monetary policy operates may be impaired during low inflation or low interest rate periods. In this section we discuss such results in two steps. First, we review and compare our results with the few papers we found studying similar topics using CESEE countries data (subsection 4.1). Second, we provide rationales to explain our results in subsections 4.2 and 4.3. Finally, we acknowledge the limitations in our study in subsection 4.4.

4.1. Connection with the literature

Our results pointing to a muted effect on housing-related variables after a standard monetary policy shock during recessions is along the lines of the empirical evidence reported by Ten-

reyro and Thwaites (2016) with US data and Alpanda et al. (2021) using data from 18 advanced economies. To explain this result, the authors point to the presence of collateral and debt service constraints on household borrowing and refinancing. In addition, the non-contractionary impact of a monetary policy shock during periods of low interest rates is similar to Borio and Hofmann (2017) and Ahmed et al. (2024) - with data from 18 advanced economies -, which point to the flattening of the Phillips curve as a possible explanation.

Regarding the related empirical literature using CESEE countries' data, available studies are remarkably scarce. To the best of our knowledge, there are only few studies that are related to ours. The first is Kupkovic and Cesnak (2023), who study the effects of rising borrowing costs on house prices in Slovakia during 2004 Q2 - 2022 Q2 using an structural VAR model in which several economic shocks are identified using a combination of zero and sign restrictions. While we can compare our linear results to the impulse responses obtained by these authors regarding their monetary policy shock (Chart 3 in their study), we acknowledge that the notable differences between the two studies make comparability challenging. A critical difference is that Kupkovic and Cesnak (2023) model the contractionary monetary policy shock as a positive shock to the 10 year government bond spread identified via sign restrictions. Instead, in our paper we use as a policy rate the Euribor 12 months, and identify the shock using changes in the OIS rate at short maturities as a shock proxy[19]. These authors find that a monetary policy shock that increases the lending rate by 5 basis points triggers a 1.5% decline in housing prices and a 7% drop in mortgage loans, which is quite a strong response. Our monetary policy shock also triggers a contractionary mean response in house prices, considering our linear model, but is much more modest and rather non-significant. Also, we find that the response of new loans to households for house purchase is muted.

Second, Papavangjeli and Geršl (2024) study the transmission of monetary policy and financial conditions shocks to the real economy in Albania, a CESEE country, using a threshold Bayesian VAR model in which the state variable is the credit-to-GDP gap, that is, a measure of excess

[19]Long-term yields can convey additional information about risk premia or the effects of unconventional monetary policy (e.g., asset purchase programs), and are a combination of both monetary policy shocks and expectations. Therefore, it is unclear whether we are identifying the same monetary shock. Another notable difference with respect to our study is that Kupkovic and Cesnak (2023) identify the monetary policy shock using a combination of zero and sign restrictions, which imposes a structure on the responses of economic variables that we do not impose in our external instrument identification, and that could avoid reporting non-contractionary housing variable responses by construction.

credit[20]. In this model, the monetary policy rate is the repo rate, and the shocks are identified using Cholesky recursive ordering. Therefore, there are also relevant differences between this study and our setup, which warrant caution when comparing the results[21]. In this framework, the authors report that, as a result of a contractionary monetary policy shock, when the credit-to-GDP gap is positive, there is no evidence of a statistically significant contraction in any of the four variables included in the model on top of the interest rate, notably real GDP, the CPI index, and the credit-to-GDP gap, which is surprising. Thus, this is an example in which a monetary policy shock exhibits a state-dependent and non-contractionary response on macro variables using CESEE countries data. Also, it is related to our results pointing to a non-contractionary response of real activity measures during some particular states.

Third, Burgert et al. (2024) study the effects of interest rates on house prices and their relationship with interest rate levels, the output gap, credit conditions, and the housing cycle in 29 OECD countries, including some CESEE countries such as Hungary and the Czech Republic. Although it is important to approach the comparison of their findings with ours with caution, it is possible to derive several noteworthy conclusions from this analysis. The authors demonstrate that when credit conditions are loose, a monetary policy shock initially leads to an expansion in the growth of credit and housing prices. Therefore, the results closely align with ours and might be linked to a limitation within the credit lending channel related to a lack of monetary synchronization between Slovakia and the Euro Area. As we shall explain in the following two subsections, Slovak lending rates during the accommodative monetary policy period have been lower than the euro area average, helping to explain persistently higher levels of mortgage loans, driving house prices growth (see subsection 5.3 for further details).

Fourth, Checo et al. (2024) developed specific monetary policy shocks for emerging markets, including Poland and Hungary, to evaluate the transmission of monetary policy to macroeconomic conditions. Although the results may not be perfectly comparable due to variables analyzed and the model specifications, the authors emphasize that the effects of monetary policy can be influenced by idiosyncratic factors. Therefore, one might consider that if a particular country is not in sync with those sharing a common monetary policy, the anticipated response

[20]The credit-to-GDP gap is measured as the difference between current nonfinancial corporate debt ratio over GDP and the corresponding long-term trend.

[21]The main differences are as follows. First, we identify our monetary policy shock using an external instrument instead of recursive ordering. Second, we do not consider credit as a state variable. Third, these authors use the repo rate as a standard monetary policy rate proxy.

to policy decisions may not be as desirable. In the next two subsections, we provide further insights along these lines.

Finally, De Luigi et al. (2025) employ a smooth-transition vector autoregressive (ST-VAR) model and Cholesky shock identification to analyze how short-term interest-rate shocks influence economic outcomes across 11 EU-CESEE countries, including Slovakia, over the period 2000–2019. Particularly, they focus on non-linearities across differing macroprudential policy intensity and exchange-rate regimes. They document that in countries with flexible exchange rates, monetary policy tightenings tend to have more persistent effects—yet these can be substantially mitigated by macroprudential easing when the policy environment is already tight. By contrast, such offsetting dynamics are markedly weaker in economies with fixed exchange rates. The results underscore that macroprudential tools can serve a moderating role on monetary policy impulses, signaling the need for coordinated policy design to uphold both financial and price stability, especially in fragile macrofinancial contexts. Notably, they find no evidence of monetary policy affecting Slovak GDP or prices.

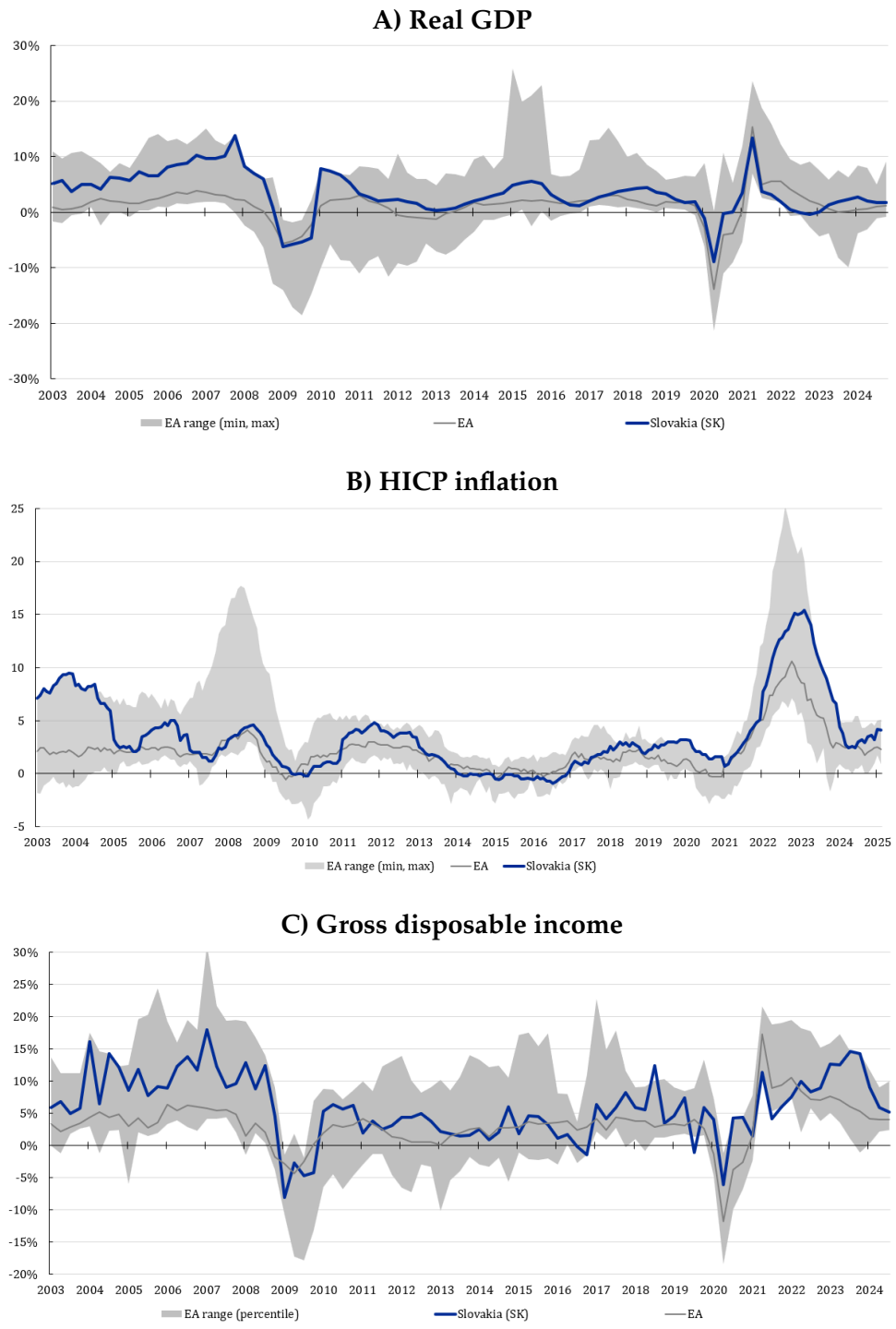
4.2. Economic synchronization vis-à-vis the euro area

The divergence between Slovakia's economic conditions and those of the broader euro area raises important questions about the degree of synchronization needed for monetary policy to operate effectively across the currency union. Our findings reveal that in Slovakia, standard contractionary monetary policy shocks often fail to generate the expected declines in house prices and housing investment, particularly during periods of economic slack, low inflation, and low interest rates. This asymmetry in policy transmission suggests that monetary policy in Slovakia operates with considerable frictions and is often state-contingent. Specifically, our impulse response functions show that during recessions, monetary policy resembles the classic "pushing on a string" scenario (Tenreyro and Thwaites, 2016), with little to no contractionary effect on key housing indicators.

This muted transmission is further compounded by Slovakia's persistently higher inflation rates compared to the euro area average, as shown in Figure 5 B). The elevated inflation differential arguably calls for tighter monetary conditions in Slovakia than those prescribed by the ECB's common stance. In this context, the uniform policy rate may not adequately reflect Slovakia's domestic macroeconomic environment, reducing the efficacy of monetary transmission

and potentially requiring complementary fiscal and macroprudential measures.

Figure 5: Selected macro variables, Slovakia versus euro area



Notes: Y-axis denote annual growth rates. EA range includes the EA-20 country members. Data source: ECB SDW.

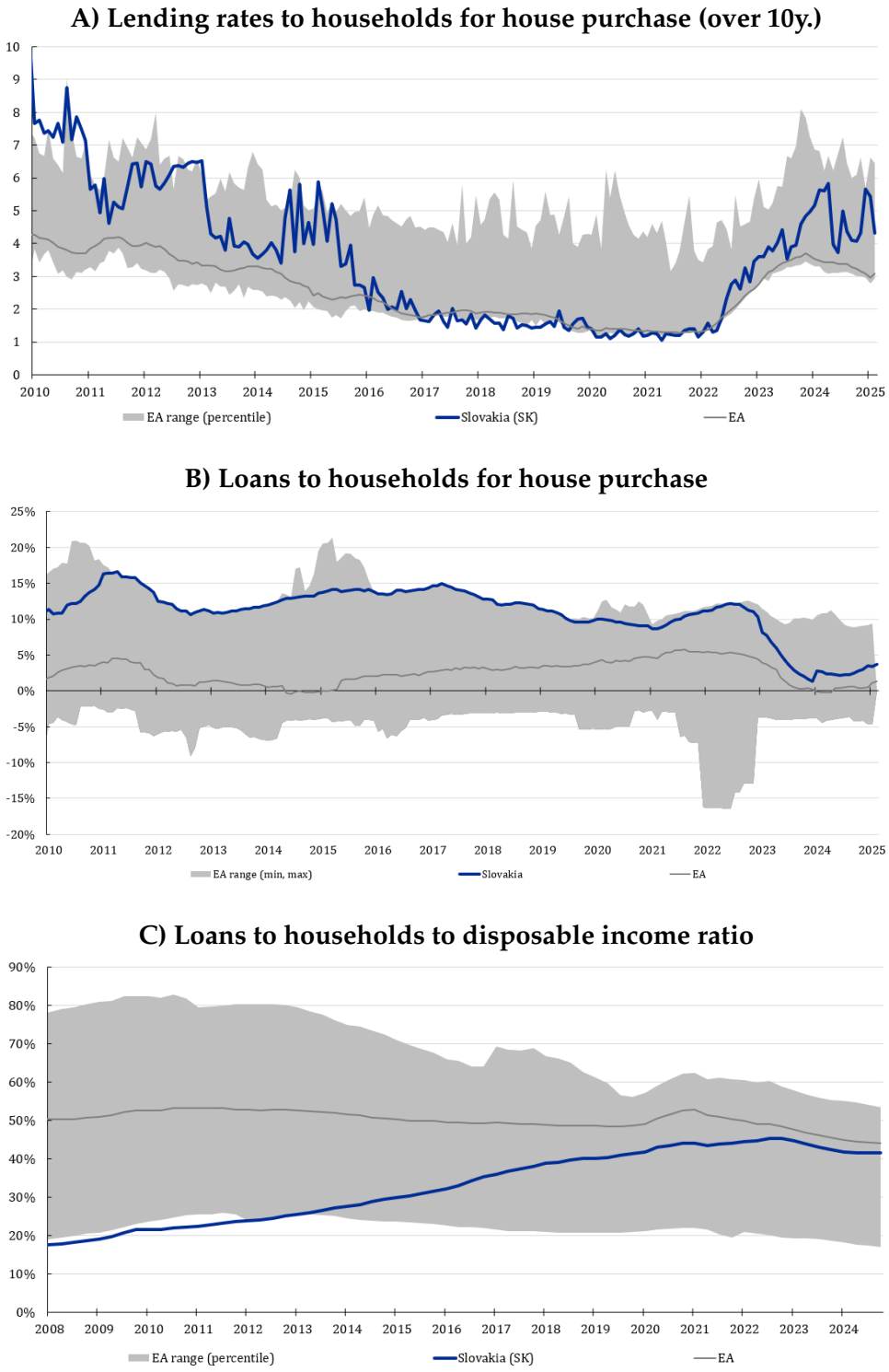
4.3. Financial non-synchronization vis-à-vis the euro area

In addition to the real-side divergence, Slovakia's financial structure introduces important asymmetries in the monetary transmission mechanism relative to other euro area countries. One key feature is the predominance of fixed-rate mortgages, which decouple household debt servicing costs from short-term interest rate fluctuations. As a result, changes in the ECB policy rate take longer to affect household borrowing behavior, reducing the immediate effectiveness of monetary policy. This delayed pass-through weakens the responsiveness of consumption and housing investment to rate hikes and makes the policy impulse more gradual and uncertain.

Before Slovakia adopted the euro in 2009, lending rates were considerably higher, reflecting both the sovereign risk premium and limited market competition. However, since euro area accession—and especially after 2016—intensified competition among commercial banks drove mortgage rates to historically low levels, often at the bottom range among euro area peers. This structural shift contributed to the expansion of household credit and likely reduced the sensitivity of borrowing to marginal changes in the policy rate. Figure 6 B) highlights another dimension of this non-synchronization: the persistent growth in loans for house purchases, with a clear inverse relationship between lending rates and credit growth only emerging in the 2022–2025 period.

This trajectory of interest rate convergence and compressed lending margins in Slovakia is in line with trends observed in other CESEE countries following euro adoption and increased financial integration (Égert et al., 2006). These structural and institutional characteristics suggest that monetary policy transmission in Slovakia operates differently—and less forcefully—than in core euro area countries, underscoring the need for coordinated national policies to address heterogeneity within the monetary union.

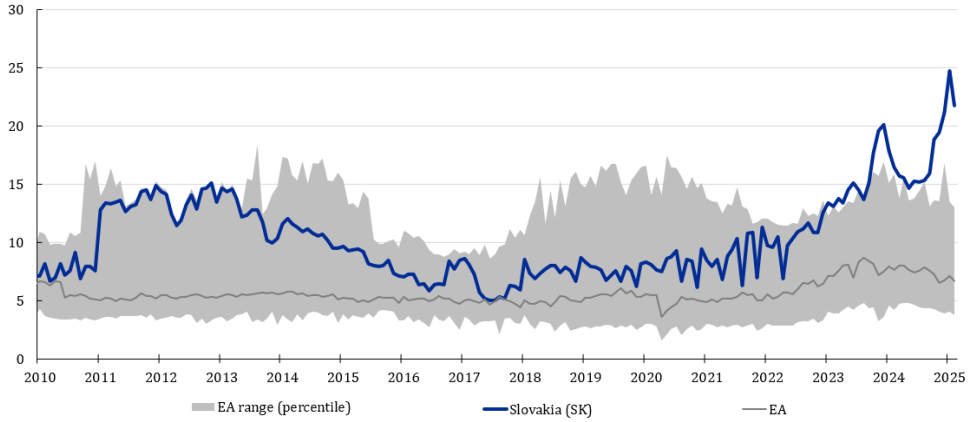
Figure 6: Selected monetary indicators, Slovakia versus euro area



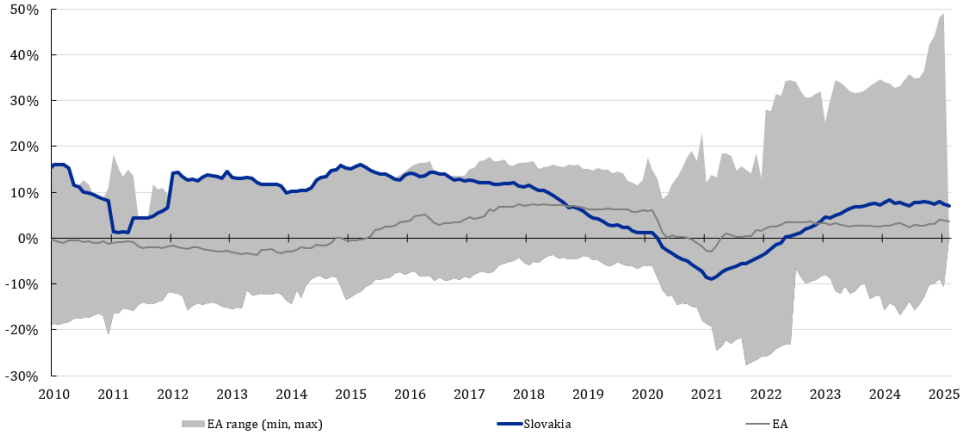
Notes: Y-axis in subplot A) is the lending rate in percent, while in B) and C) denote annual growth rates. EA range includes the EA-20 country members. Data source: ECB SDW.

Figure 6 (cont.): Selected monetary indicators, Slovakia versus euro area

D) Lending rates to households for consumption (up to 1y.)



E) Loans to households for consumption



Notes: Y-axis in subplot D) is the lending rate in percent, while in E) denote annual growth rates. EA range includes the EA-20 country members. Data source: ECB SDW.

4.4. Limitations of this study

This study, while providing valuable insights into the nonlinear effects of standard monetary policy shocks on the Slovak housing market and other variables, is subject to several limitations. First, the analysis is constrained by the small sample size due to the relatively short time series available for Slovakia. This limitation may affect the robustness of the results and their ability to capture long-term trends or structural changes within the housing market. Second, the study relies on a euro area-wide monetary policy shock proxy rather than a Slovak-specific one, because of insufficient liquidity in Slovakia's money market. While this approach is necessary given the data constraints, it may not fully capture the unique characteristics of monetary policy transmission in the Slovak economy. Finally, the lack of a structural macro DSGE model

in this study implies that our interpretation of the transmission channels through which monetary policy shocks impact the housing market is, to some extent, speculative. These limitations should be considered when interpreting the findings and drawing broader conclusions.

5. Conclusions

The aim of this study is to explore asymmetries in the impact of standard monetary policy transmission in Slovakia, a CESEE country, with a focus on the housing sector. Specifically, we examine three different non-linearities: high versus low economic growth, interest rates, and inflation. To achieve this, we utilize a monthly smooth transition local projection model and high-frequency identification.

Our results highlight that the transmission of monetary policy in Slovakia varies across different economic regimes. First, the reaction of house prices and investment to a monetary policy shock is only contractionary during states of high economic growth, high rates, and high inflation. Second, monetary policy appears to have a limited effect on new loans for house purchase, which may be a crucial link impairing the transmission to house prices and housing investment. Third, the monetary policy shock tends to trigger an easing in our macroprudential policy stance measure, notably during states of low rates and low inflation, which may counteract the expected contractionary effects of monetary policy.

Based on the findings of this study, the following policy implications emerge. First, the limited impact of monetary policy on lending for house purchase may explain the lack of evidence that monetary policy affected house prices or housing investment in Slovakia over our sample, which might have been fueled by the low lending rates in Slovakia observed since the years prior to its accession to the euro area. Despite the obvious benefits of euro area membership, the risk of overheating due to relatively low interest rates should not be overlooked. Unintended consequences from that front could be especially relevant for CESEE countries, where rapid housing indebtedness dynamics could pose risks to financial stability and long-run growth prospects. As such, overinvestment in housing markets could crowd out capital from other more productive uses. Second, our results highlight the need for state-dependent interventions given the varying effectiveness of monetary policy across different economic environments. A natural candidate for such an intervention is fiscal policy, where proactive fiscal measures when economic growth is weak, such as increased public spending or subsidies targeted at critical

sectors, may stimulate demand more effectively than standard monetary policy. Third, the interactions between monetary and macroprudential policies provide an opportunity to implement borrower-based measures and build buffers that could mitigate the unintended effects of low interest rates in CESEE countries prone to mortgage market overheating. Authorities may consider implementing and/or tightening such policies as part of the euro area accession package to mitigate lending exuberance risks upfront.

Future research could explore several avenues to deepen our understanding of the nonlinear effects of monetary policy on housing markets. First, estimating similar nonlinear models for other EA-CESEE countries could clarify whether there is more evidence of ineffective state-dependent monetary policy. Second, building a structural macro model including the main features that are relevant in our study would help rationalize our empirical findings, capture the specific mechanisms through which monetary policy impacts housing markets, and highlight the mechanisms that can impair monetary policy effectiveness in some states. Third, the same macro model may be used to assess how macroprudential policy may be used in EA-CESEE countries and future members to mitigate unintended consequences of euro area membership, notably a possible mortgage market overheating from a low interest rate setting.

Appendices

A. Data

Table 2: Overview of macro time series in the dataset

N	tcode	Frequency	Source	Variable
1	3	Q	SUSR	Real GDP
2	3	Q	SUSR	Real private consumption
3	3	Q	SUSR, NBS	Real business investment
4	3	Q	SUSR	Real housing investment
5	3	Q	SUSR	Real government consumption
6	3	Q	SUSR, NBS	Real general government revenue to GDP ratio
7	1	M	SUSR	Unemployment rate (% of labour force)
8	2	Q	SUSR	Employees
9	2	Q	SUSR	Total employment
10	2	M	SUSR	Industrial production index
11	3	Q	SUSR	Real average wage, total
12	3	Q	SUSR	Real compensation per employee
13	3	Q	SUSR	Real disposable household income
14	5	M	Eurostat	HICP
15	5	Q	Eurostat	Private consumption deflator
16	3	Q	Eurostat	Real house prices, transactions-based
17	3	Q	NARKS, UC	Real house prices, offered prices-based
18	3	M	NBS	Real loans to households
19	3	M	NBS	Real loans to NFCs
20	3	Q	NBS	Real savings
21	1	Q	SUSR	Household saving ratio (% of disposable income)
22	3	Q	SUSR	Building permits, dwellings
23	3	Q	SUSR	Housing starts, dwellings
24	1	M	NBS	Macroprudential stance (BBM-based) measure
25	1	M	ECB	Euribor 12 months

Notes: tcodes equal to 1, 2, 3, 4 and 5 refer to no transformation, differences, logs, log-differences, and year-on-year growth rates, respectively. Q time series frequency means that the corresponding variable is originally quarterly and have been converted to monthly frequency using the Chow and Lin (1971) frequency conversion without indicators. M frequency means that the corresponding variable is monthly, so no frequency conversion has been applied. Real terms are calculated using the private consumption deflator. SUSR is the Statistical Office of Slovakia. NBS means National Bank of Slovakia. UC stands for United Classifieds, a housing data provider. NFCs are non-financial corporations. ECB is the European Central Bank. X12-ARIMA seasonal adjustment is applied when necessary.

Figure 7: Variables in our dataset, 2003 M1 - 2023 M6.

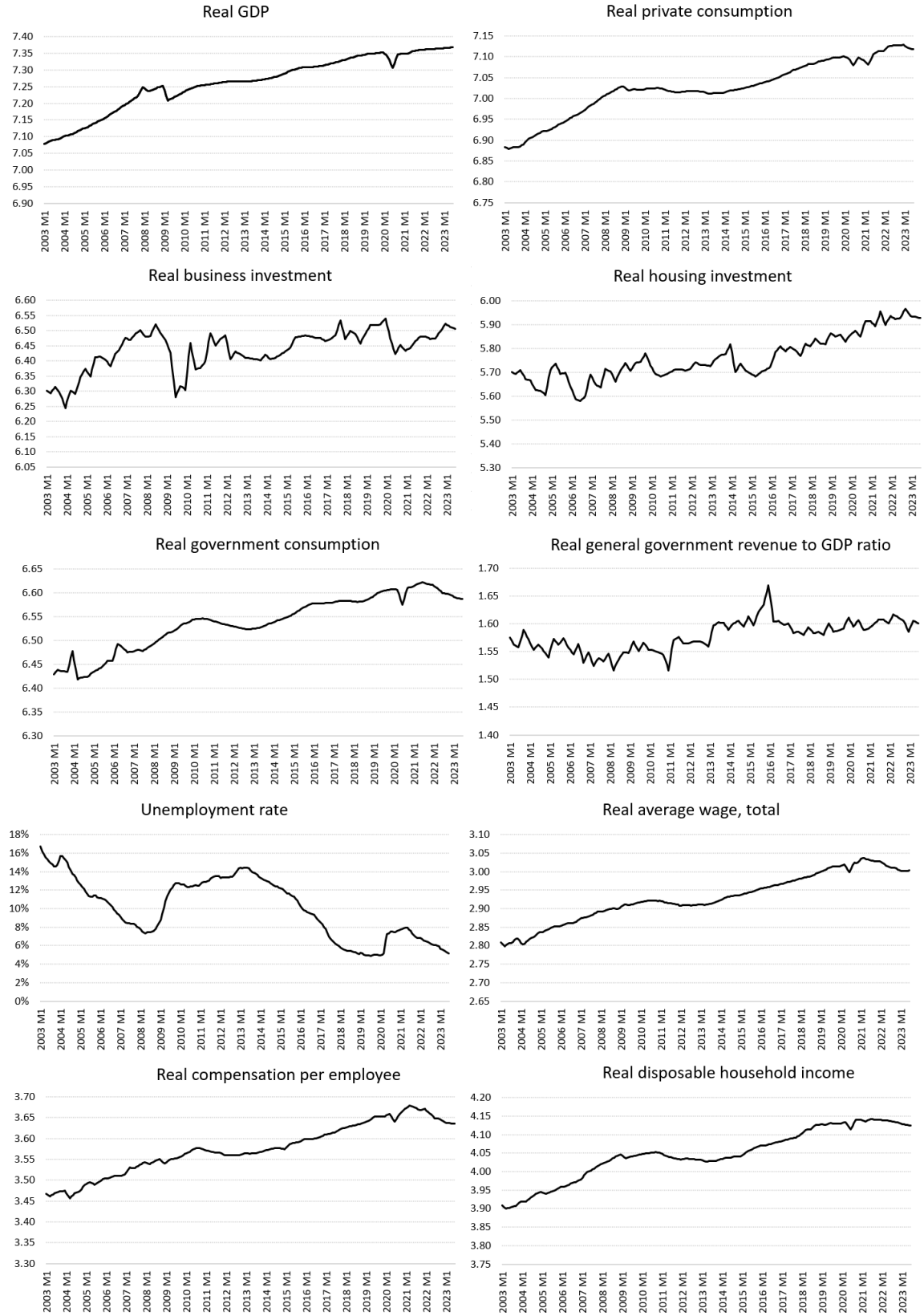


Figure 7 (cont.): Variables in our dataset, 2003 M1 - 2023 M6.

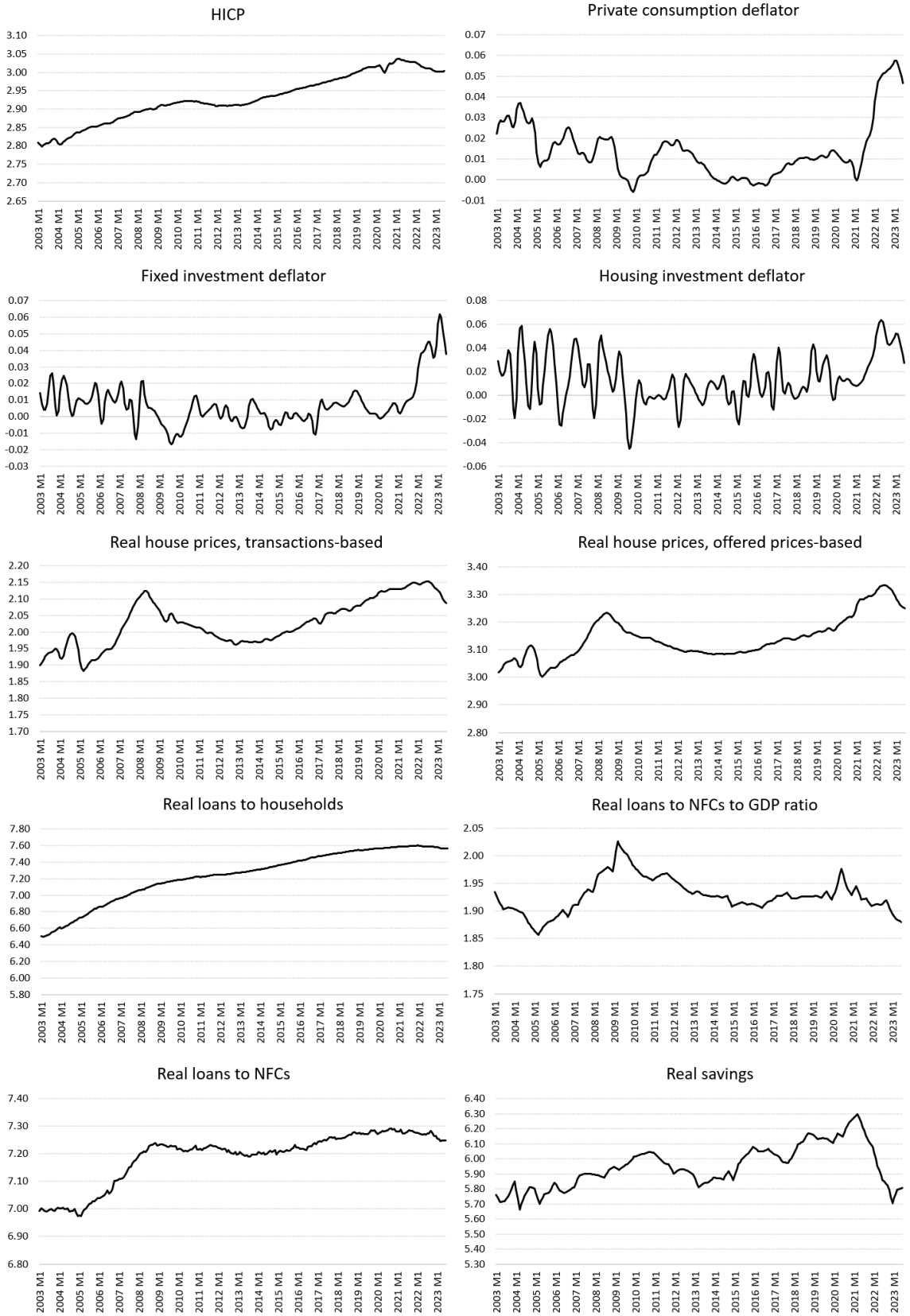
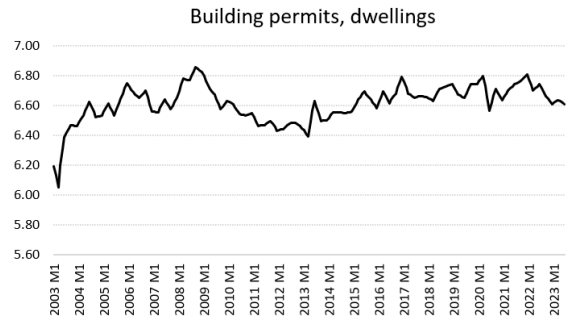
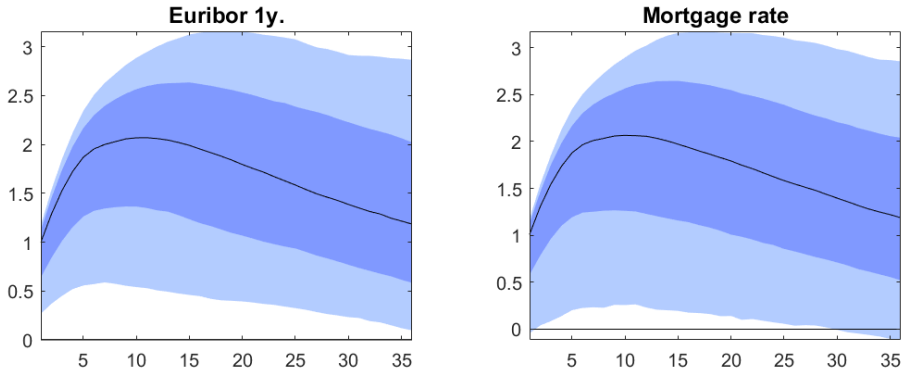


Figure 7 (cont.): Variables in our dataset, 2003 M1 - 2023 M6.



B. Pass-through to the mortgage rate

Figure 8: Bivariate Proxy-SVAR. IRFs from a +100bp monetary policy shock



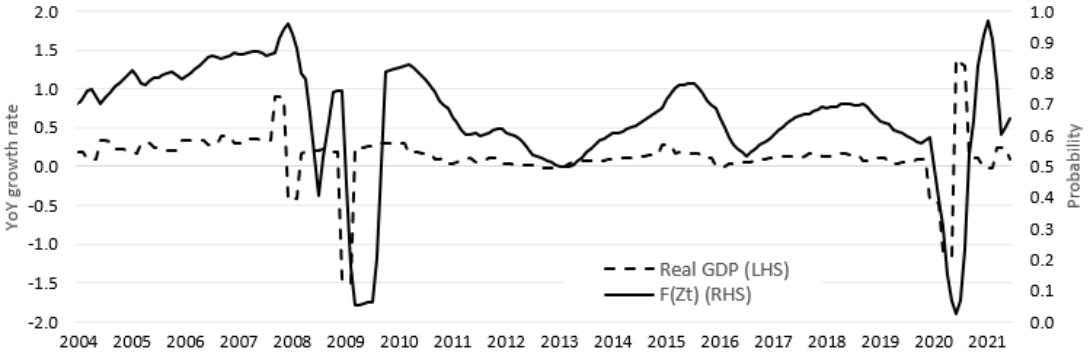
Notes: Impulse responses to a positive 100 bp monetary policy shock after estimating a bivariate Bayesian Proxy-SVAR including the Euribor 1 year as a policy rate and the average mortgage rate. Data sample ranges from January 2004 to June 2023, employing Minnesota priors and 12 lags. The external instrument used to identify the monetary policy shock is the changes in 1-month OIS rates, extracted from the EA-MPD database from Altavilla et al. (2019). Light (dark) blue bands report 90 (68)% credible sets.

C. Additional results

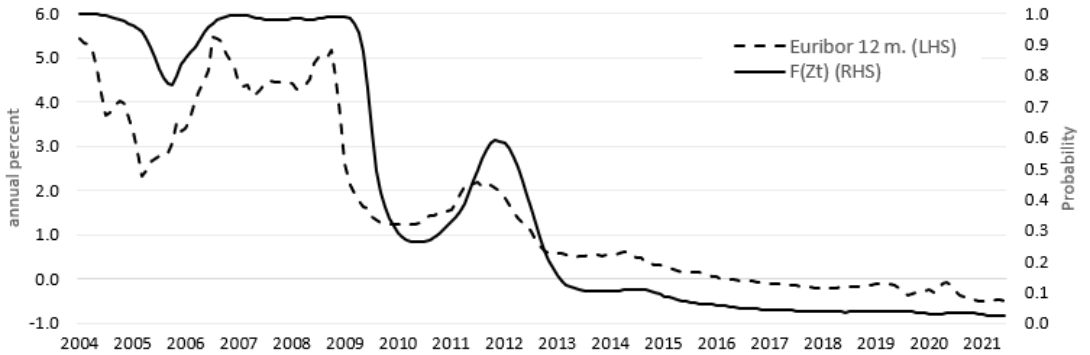
C.1. State variables versus regime changes

Figure 9: State variables versus regime changes.

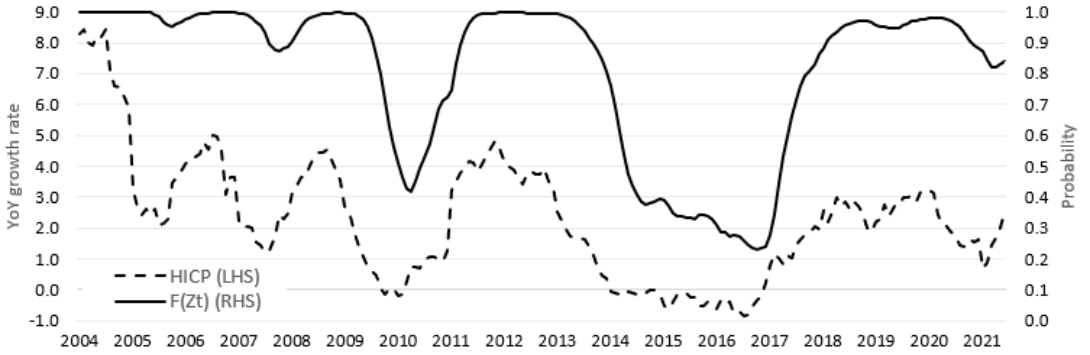
A) Non-linearity: Real GDP growth.



B) Non-linearity: Euribor 12 m.



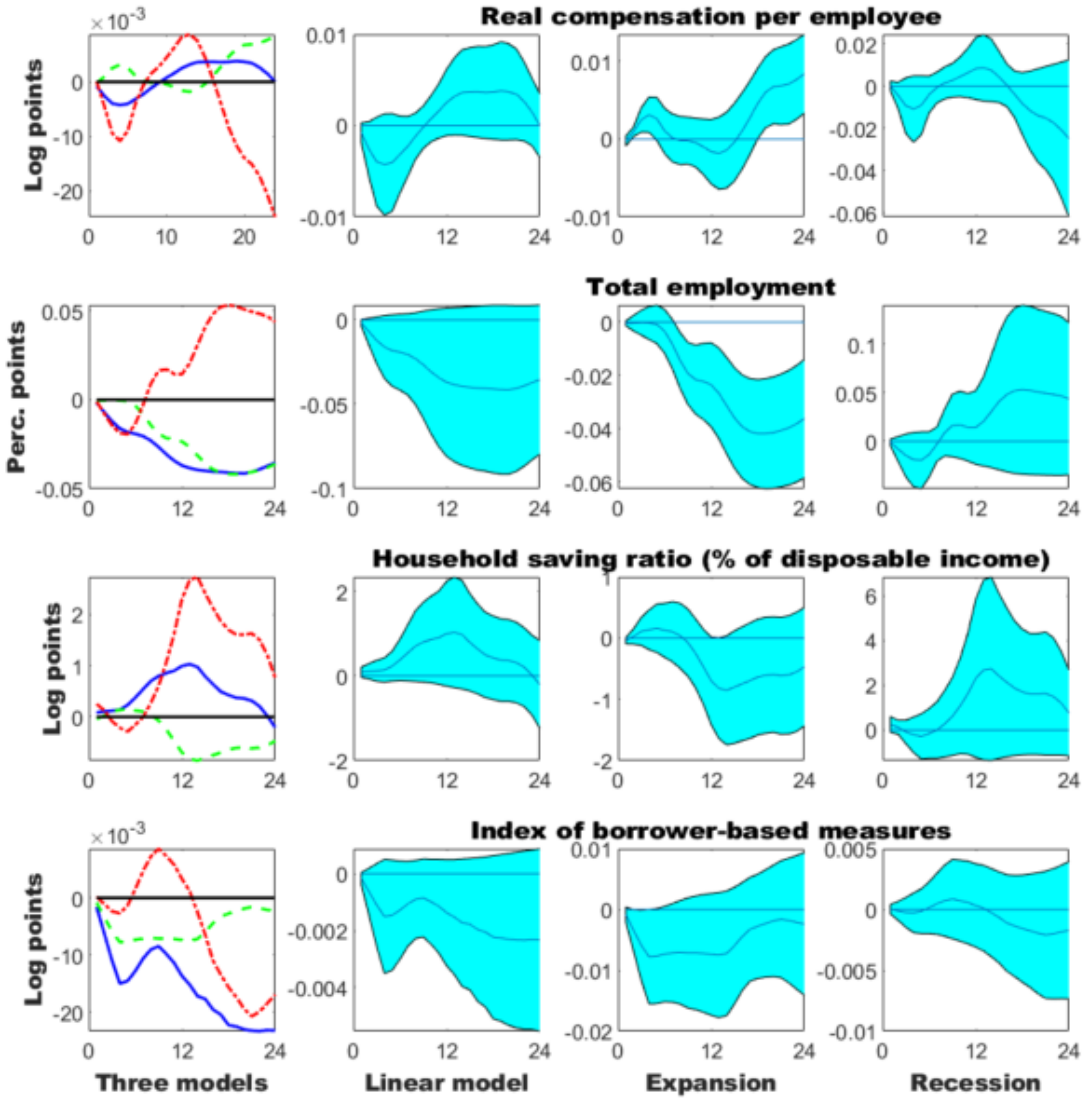
C) Non-linearity: HICP inflation.



Notes: F(Zt) refers to the probability of being either in the high real GDP growth state (subplot A), high interest rate state (subplot B), or the high inflation state (subplot C).

C.2. Non-linearity: Expansions versus recessions

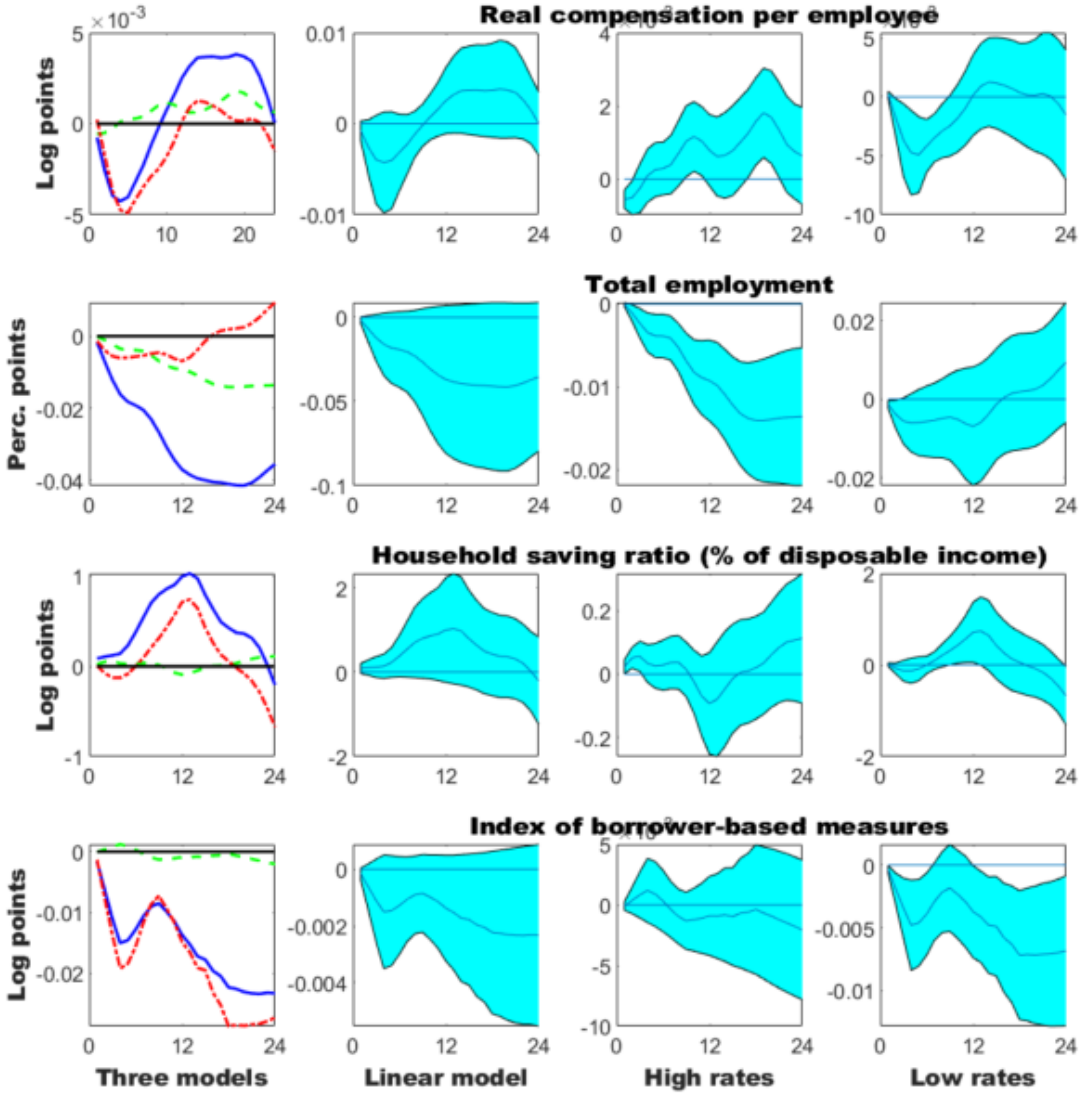
Figure 2 (cont.): IRFs to a monetary policy shock (+100 bp), SV = real GDP growth



Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in an expansion state, and the red dotted line the response in a recession state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in an expansion, and the fourth column the interval around the response in a recession. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

C.3. Non-linearity: High versus low interest rates

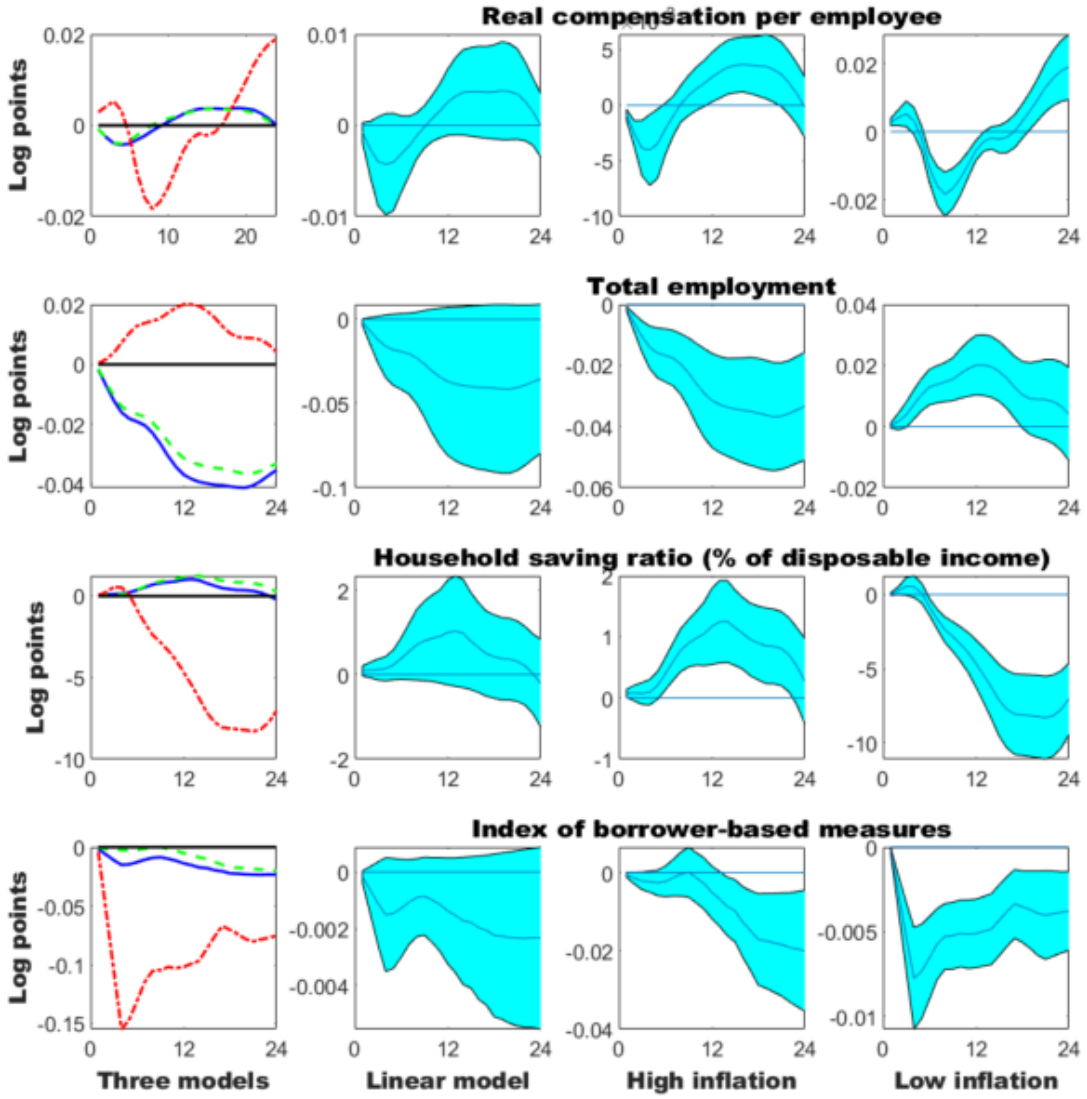
Figure 3 (cont.): IRFs to a monetary policy shock (+100 bp), SV = Euribor 12 m.



Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in an expansion state, and the red dotted line the response in a recession state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in an expansion, and the fourth column the interval around the response in a recession. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

C.4. Non-linearity: High versus low inflation

Figure 4 (cont.): IRFs to a monetary policy shock (+100 bp), SV = HICP inflation.



Notes: X-axis mean months after the shock. Confidence intervals refer to 68% credible sets. In the first column, the solid blue line shows the response in a linear model, the green dashed line shows the response in an expansion state, and the red dotted line the response in a recession state. The second column shows a 68% confidence interval around the linear model, the third column the same interval around the response in an expansion, and the fourth column the interval around the response in a recession. Controls: new loans to households for house purchase, house prices, housing investment, housing starts, compensation per employee, households savings ratio, employees, and a macroprudential stance measure.

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