NARODOWY
BANK POLSKI

NBP Working Paper No. 377

Unemployment level and the non-linear effects of monetary policy in Poland

Paweł Kopiec, Małgorzata Walerych

NBP Working Paper No. 377

Unemployment level and the non-linear effects of monetary policy in Poland

Paweł Kopiec, Małgorzata Walerych

Narodowy Bank Polski
Warsaw 2025

Paweł Kopiec – Narodowy Bank Polski; pawel.kopiec@nbp.pl
Małgorzata Walerych – Narodowy Bank Polski; malgorzata.walerych@nbp.pl

Acknowledgements and disclaimer
This paper represents the opinions of the authors. It is not meant to represent the position of Narodowy Bank Polski. We thank Piotr Denderski, Michał Gradzewicz, Mariusz Kapuściński, Łukasz Postek, Grzegorz Wesołowski, anonymous referee and seminar participants at NBP and INE PAN for helpful discussions and comments. We would like to thank Michał Chrząścik for research assistance.

Published by:
Narodowy Bank Polski
Education & Publishing Department
ul. Świętokrzyska 11/21
00-919 Warszawa, Poland
nbp.pl

ISSN 2084-624X

Contents

Abstract

We investigate whether the transmission of monetary shocks in Poland depends on the level of economic slack. To this end, we estimate smooth transition panel local projections using Poland's regional data and analyze how monetary shocks affect unemployment and prices in regimes of high and low unemployment. Our key finding aligns with economic intuition: the response of unemployment to monetary policy shocks is stronger when economic slack is high, compared to when it is low. Conversely, the adjustment of prices to monetary innovations is more pronounced when idle resources in the economy are scarce, compared to when they are abundant. Our main conclusion is further supported by evidence showing that the difference in the strength of the employment response to monetary shocks, depending on the unemployment level, is more pronounced in sectors producing non-tradable goods than in those manufacturing tradable goods. Moreover, comparing our model with its linear counterpart confirms that monetary transmission in Poland indeed exhibits state-dependence, while the analysis of monetary shock distributions under low and high unemployment shows that our results are not driven by the presence of a regime-dependent pattern in monetary disturbances.

JEL Classification: E24, E52, E58

Keywords: monetary policy transmission, unemployment, local projections, state dependence

1 Introduction

According to standard textbook intuition, when the amount of idle resources in the economy is substantial (e.g., when unemployment is high), adjustments to demand shocks are more quantitative in nature. For instance, in response to a positive demand impulse, companies can easily hire new workers, increase employment, and, consequently, output. At the same time, the corresponding impact of demand shifts on prices is minimal. On the other hand, when unemployment is low and idle resources are scarce, the adjustment is more price-based – companies cannot easily increase production due to a lack of labor, so higher demand results in a rise in prices rather than an increase in production.

This intuition has important implications for predictions about the effectiveness of economic policy depending on the amount of idle resources. In the context of fiscal policy, it echoes Keynesian arguments that government expenditures are more likely to have substantial expansionary effects when unemployment is high. This occurs because larger government spending is less likely to crowd out private demand when the economy has slack. In the case of monetary policy, this pattern suggests that monetary policy shocks (which can be classified as demand shocks) lead to larger adjustments in quantities when unemployment is high than during periods of low unemployment. The opposite can be expected for price adjustments, which are more likely to be substantial when resources in the economy are scarce.

The goal of our paper is to verify the latter claim related to monetary policy in the Polish economy. Importantly, over the past twenty years, Poland has transformed from having one of the highest unemployment rates in Europe to boasting some of the lowest, making it an ideal environment for our analysis.[1] In our work, we study the effects of monetary policy shocks on unemployment rates and prices from Q1 2001 to Q4 2019 - a period which is marked by substantial variation in unemployment rates, not only at the aggregate, but also regional levels. To this end, we construct a non-linear model of local projections that features a state-dependent impact of the unemployment level on the dynamics of the dependent variable. Fur-

[1] The factors supporting economic growth, and hence also the decline in the unemployment rate, in Poland during this period include, among others, increasing globalisation (Szpunar and Hagemejer, 2018), greater participation in global value chains (Hagemejer and Mućk, 2019), and a big improvement in workforce composition, driven primarily by educational attainment(Gradzewicz et al., 2018).

thermore, to exploit the substantial heterogeneity of unemployment rates across voivodships (the highest-level administrative units in Poland), we assume that the model has a panel structure. To address the problem of endogeneity in monetary policy shocks, we use an exogenous measure of monetary policy disturbances from Kapuściński (2023), which employs the methodology developed by Swanson (2021) to Polish data. The model is applied to study the impact of monetary policy on unemployment and prices in two regimes characterized by different levels of economic slack. Our results corroborate the intuition described in the first paragraph: quantity adjustments resulting from monetary policy shocks are more pronounced when the amount of idle resources (measured by the unemployment rate) is large. Specifically, our baseline point estimates predict that a 1 percentage point (p.p., henceforth) decrease in the policy rate leads to a 2.5 p.p. drop in the unemployment rate when labor market slack is large, and a substantially lower drop (0.6 p.p.) when slack is low. The opposite holds for price adjustments associated with monetary policy shocks. In particular, a 1 p.p. monetary accommodation increases the price level by 1.6 percent when unemployment is high and by 4.4 percent (within the horizon of 8 quarters) when unemployment is low. It should be noted, however, that the difference in response to a monetary impulse between the two unemployment regimes is statistically significant only in the case of prices, not quantities. These results are robust to changes in the model's specification, including different parameters governing the transition process between high and low slack regimes, varying numbers of lags, alternative detrending methods, and additional controls.[2]

Moreover, we analyze an alternative explanation for our findings, motivated by Tenreyro and Thwaites (2016): the distributions of monetary policy shocks during periods of high and low unemployment might differ. More specifically, if positive shocks are more common when unemployment is low (and less common when unemployment is high), and if positive shocks have a smaller/larger effect on quantities/prices than negative shocks, then it is likely that our results are driven by this alternative explanation. However, by comparing these distributions in Polish data, we reject this hypothesis.

[2]Note that our results can be interpreted solely as the average responses of macroeconomic variables at the voivodship level - we do not evaluate the aggregate country-wide response in the paper.

To provide further evidence supporting our result, we conduct two additional exercises. First, we follow the intuition developed by Mian and Sufi (2014), which suggests that employment in sectors producing non-tradable goods and services relies heavily on local demand, while employment in sectors producing tradables is more influenced by country-level or foreign demand. This observation, coupled with the fact that monetary policy shocks are classified as demand shocks, implies that if our main result is true, the difference in the reaction of non-tradable employment to monetary policy shocks between high and low unemployment should be larger (at the voivodship level) than the analogous difference for tradable employment. We find that this is indeed the case. Second, we compare our state-dependent model with its linear counterpart and find that the former performs better according to standard model-selection criteria. This, in turn, indicates that conditioning predictions about the future dynamics of unemployment and prices on the level of slack in the economy has strong quantitative foundations.

The rest of the paper is organized as follows. Section 2 discusses the related literature. In Section 3, we develop the baseline model, which is used to study the state-dependent effects of monetary policy, and conduct robustness checks. Section 4 analyzes an alternative explanation for our findings and presents additional supporting evidence. Section 5 concludes.

2 Literature

This project builds on the vast body of literature analyzing the relationship between the impacts of economic policies and the state of the economy. Some of these studies investigate changes in government spending multipliers depending on the cyclical position of the economy (Auerbach and Gorodnichenko, 2012; Owyang et al., 2013; Michaillat, 2014; Ramey and Zubairy, 2018), whereas the others focus on the state-dependent effect of monetary policy (Weise, 1999; Peersman and Smets, 2002; Lo and Piger, 2005; Burgard et al., 2019; Jorda et al., 2020; Alpanda et al., 2021). In terms of methodology, the closest related work to ours is Tenreyro and Thwaites (2016), who use smooth-transition local projections to show that the effects of monetary policy in the U.S. are less powerful in recessions than in booms. In contrast to this study, we exploit panel data from Polish voivodships to examine the strength of the reaction in quantities and prices to monetary shocks during periods of low and high unemployment.

To avoid the problem of the monetary policy endogeneity, we use monetary shocks identified using high-frequency data by Kapuściński (2023). This type of identification is commonly used in the economic literature (e.g., Kuttner, 2001; Cochrane and Piazzesi, 2002; Gürkaynak et al., 2005; Gertler and Karadi, 2015; Altavilla et al., 2019; Jarociński and Karadi, 2020; Swanson, 2021; Kolasa et al., 2025), and it was previously applied to study the transmission of monetary policy in Poland by Kapuściński (2017) and Kightley and Suda (2023).

The theoretical foundations of the non-linear impact of unemployment on macroeconomic stabilization were established by Michaillat (2014), Benigno and Eggertsson (2023), and Benigno and Eggertsson (2024), among others. The first two papers utilize versions of the standard Diamond-Mortensen-Pissarides model to justify the non-linear aggregate supply (AS) curves in the economy, while Benigno and Eggertsson (2024) develop a simplified model incorporating downward nominal wage rigidity and labor rationing to formalize these non-linearities. Both theoretical approaches effectively capture the following mechanism: when the economy is underutilized, increased nominal spending boosts output and reduces unemployment with little impact on prices. However, since labor is fixed in the short term, eventually firms will run out of workers to hire. This leads to the idea that the Phillips curve must become nonlinear at some point: beyond a certain point, further increases in spending will raise inflation rather than output, due to labor shortages.

Our paper is also related to studies examining the Phillips curve in open economies. Specifically, the model specification used to analyze the impact of monetary policy on prices in our paper is based on the work of Borio and Filardo (2007), which emphasizes the role of foreign factors in influencing domestic price dynamics. In this context, our paper is closely aligned with the works analyzing the Phillips curve in Poland, such as Szafranek (2017) who finds evidence of flattening of the Philips curve and the rising impact of global factors for inflation in Poland, and Łyziak (2019) who argues global demand conditions affect the inflation in Poland indirectly, mainly through the prices of food and energy raw materials..

Lastly, two studies apply structural models to explore the non-linear relationship between monetary policy effects and unemployment in Poland. Bielecki et al. (2025) use a DSGE model with nominal rigidities and labor market frictions to show that changes in labor market transition probabilities and the demographic composition of the workforce affect monetary policy transmission in Poland from 1995 to 2024. In a related study, Kopiec (2025) applies the Heterogeneous Agent New Keynesian model with a frictional labor market to investigate the macroeconomic and welfare effects of monetary policy shocks in Poland under both low- and high-unemployment conditions. In addition to the AS-curve convexities examined Michaillat (2014), Benigno and Eggertsson (2023), and Benigno and Eggertsson (2024), the approach based on the model with incomplete markets applied by Kopiec (2025) allows for capturing the dependce of the aggregate demand's (AD) reaction to monetary policy shocks on unemployment. He finds that uninsured income risk associated with unemployment raises the effectiveness of stabilization policies in the economy featuring a substantial level of idle resources.

3 Baseline model

In this section, we first set out the specification of our baseline econometric model and describe the data. Then we present the main results and discuss their robustness.

3.1 Specification

While analyzing the differences in the transmission of monetary policy shocks in the state of high (H) and low (L) unemployment, we consider two quarterly time series: the registered unemployment rate and (log) consumer price index (CPI). For each of these variables, we run a sequence of the following panel regressions:

$$y_{i,t+j} - y_{i,t-1} = \delta_{ij} + F\left(u_{i,t-1}\right) \cdot \left(\alpha_j^H + \beta_j^H \cdot \epsilon_t + \gamma_j^H \cdot x_{i,t}\right) \tag{1}$$

$$+ \left(1 - F\left(u_{i,t-1}\right)\right) \cdot \left(\alpha_j^L + \beta_j^L \cdot \epsilon_t + \gamma_j^L \cdot x_{i,t}\right) + \xi_{i,t}$$

where $y_{i,t}$ is one out of the two endogenous variables in voivodship i in period t, ϵ_t represents a monetary shock that affects the economy at time t, $F\left(u_{i,t-1}\right)$ is a smooth, increasing function of the previous period's unemployment rate, and $x_{i,t}$ represents the controls.[3] The set of control variables in our baseline specification for each variable includes 4 lags of short term-interest rate, 4 lags of HP-filtered REER, contemporaneous and 4 lags of HP-filtered GDP of the euro area and contemporaneous and 4 lags of HP-filtered VIX index. Additionally, in the regression for the unemployment rate, $x_{i,t}$ contains 4 lags of quarterly changes in unemployment rate and 4 lags of quarterly CPI inflation. In the regressions for prices, $x_{i,t}$ includes 4 lags of quarterly CPI inflation and 4 lags of the HP-filtered unemployment rate. The choice of control variables is based on economic intuition and common practices (see, e.g., Borio and Filardo, 2007; Łyziak, 2019; Szafranek, 2017). However, we also test a number of alternative specifications differing in the number of lags and the set of controls (see section 3.4). Furthermore, δ_{ij} denotes the voivodship-level fixed effect (unit-level trend), α_j^H and α_j^L measure country-level trends, and β_j^H and β_j^L are the

[3] The state of the economy is described by the unemployment rate from the previous period to avoid endogeneity problems. However, as unemployment is a slow-moving variable, its value from the most recent period serves as a reliable indicator of the current state of the labor market.

parameters of our interest measuring the reaction of the endogenous variables to the monetary shock at horizon j, where $j = 0, ..., 8$ in both unemployment regimes. Finally, γ_j^H and γ_j^L are row vectors containing parameters associated with controls.

Additionally, using the aggregate data, we estimate a sequence of auxiliary equations that determine the response of the short-term interest rate to monetary shocks in both unemployment regimes.[4] The results of these estimates are used to standardize the impulse response functions of the unemployment rate and prices.

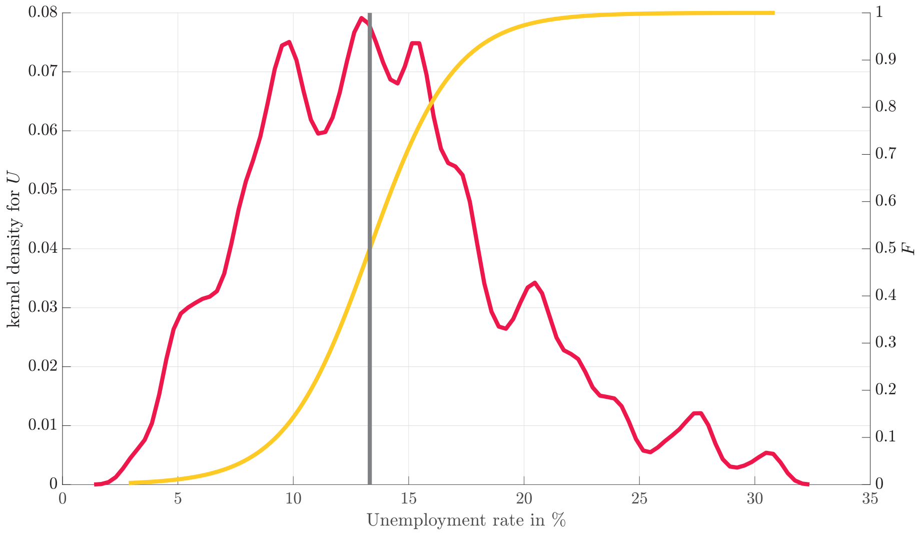
As in Tenreyro and Thwaites (2016), we assume that $F(u_{i,t})$ takes the form of the logistic function:

$$F(u_{i,t}) = \frac{exp\left(\theta \frac{u_{i,t}-c}{\sigma_u}\right)}{1 + exp\left(\theta \frac{u_{i,t}-c}{\sigma_u}\right)} \tag{2}$$

where θ governs the pace at which a unit switches from high to low unemployment, c determines the location of the function, and σ_u denotes the standard deviation of $u_{i,t}$. The higher the value of the parameter θ, the steeper the transition between the two unemployment regimes. In particular, as θ approaches infinity, the model transitions into a discrete regime switching setup, i.e., $F(u_{i,t})$ takes values of 0 or 1. Since identifying the curvature and location of the transition function in the data is difficult, we follow Auerbach and Gorodnichenko (2012) and Tenreyro and Thwaites (2016) and calibrate rather than estimate the parameters of the transition model. Hence, in our baseline specification we set θ equal to 3 and c to the median $u_{i,t}$. The latter value means that for half of the observations in our sample, the function $F(u_{i,t})$ takes values smaller than 0.5, i.e., it provides relatively more information about the behavior in the low-unemployment regime. The transition function $F(u_{i,t})$ from the baseline specification, along with the kernel density of voivodship unemployment rates, is depicted in Figure 1.

[4]See equation (3).

Figure 1: Transition function F and kernel density for the voivodship unemployment rates



Notes: Red line - kernel density of the voivodship unemployment rates, yellow line - function F, grey line - median of the voivodship unemployment rates (value of parameter c).

3.2 Data

We work with the quarterly data covering the period from Q1 2001 to Q4 2019. In our estimations, we intentionally do not include more recent data to avoid issues related to modeling the very atypical period of the COVID-19 pandemic. All data come from publicly available databases. Specifically, unemployment rates and consumer price indices are sourced from voivodships' Statistical Bulletins published by Statistics Poland, the short-term (3-month) interest rate in Poland and the chain-linked GDP for the euro area are from Eurostat, the REER time series is obtained from the BIS database, and the VIX index is sourced from the FRED website. The variables, except for the financial ones, have been seasonally adjusted. The EA output and REER series were expressed in logs before applying the HP-filter.

The series of monetary policy shocks is taken from Kapuściński (2023), who in turns builds on the method proposed and applied to the US case by Swanson (2021). In short, the procedure involves calculating high-frequency changes (2-day window) in interest rates with various maturities around key monetary events and employs factor analysis to describe the variability among these collected interest rate changes with a smaller number of unobservable factors. The three factors having the greatest systematic impact on interest rates around the monetary events are then rotated to give them a structural interpretation as conventional monetary policy, forward guidance, and large-scale asset purchase factors. In our analysis, we use the first of these as an exogenous measure of monetary policy disturbances.

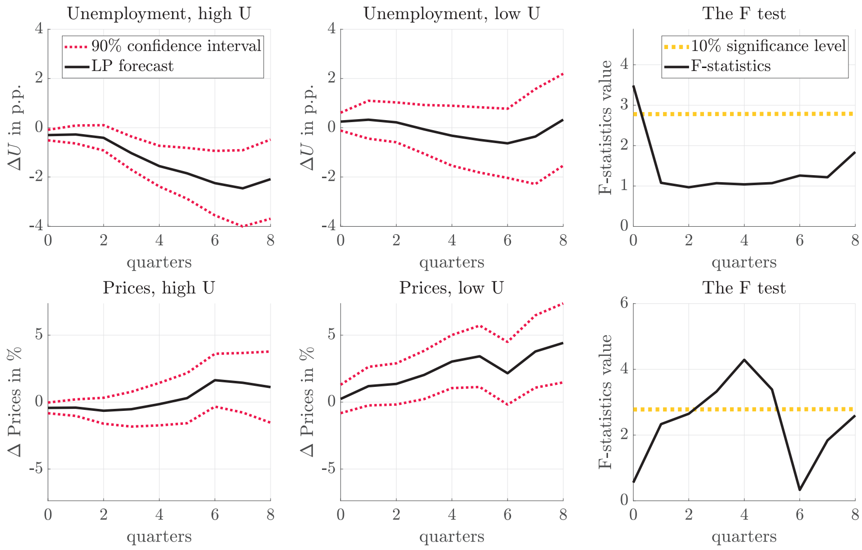
3.3 Results

This section presents our baseline results. The first row of Figure 2 shows the impulse responses of unemployment to an accommodative monetary policy shock of 1 p.p. that occurs in period 0. This shock corresponds to both the high-unemployment regime (first column) and the low-unemployment regime (second column). From a technical perspective, the impulse responses shown in the first and second columns are equal to the values of the parameters β_j^H and β_j^L in equation (1), scaled so that the monetary shock leads to a 1 p.p. drop in the policy rate (the standardization procedure is discussed later). Following the monetary accommodation, the unemployment rate in the high-unemployment regime lowers, reaching a minimum of -2.5 p.p. below the counterfactual scenario (in which there are no monetary disturbances) after 7 quarters. The impulse response corresponding to the low-unemployment regime decreases less sharply, reaching a minimum of -0.6 p.p. after 6 quarters. To interpret and compare these figures, it is useful to re-express them as a decrease in the number of unemployed workers. To do so, the values of the impulse responses of the unemployment rate must be multiplied by the size of the labor force. Since the latter exhibits only minor changes over time in the data[5], our results imply that the maximum decline in the number of unemployed people after an accommodative monetary shock in a high-unemployment regime is around 4 times stronger than in a low-unemployment regime.

Note that the majority of 90% confidence intervals related to the impulse responses in the high-unemployment regime do not contain zero, which is not the case for the response when unemployment is low. This, coupled with a large quantitative difference between the two impulse responses discussed above, may indicate that the quantitative adjustment to monetary policy shocks is more pronounced when economic slack is high. This, in turn, suggests that our result aligns with the intu-

[5] Specifically, according to the Labor Force Survey data, the size of the labor force between 2001 and 2019 ranged from 16.2 to 17.1 million.

Figure 2: Impulse response functions: unemployment and prices, baseline model



Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

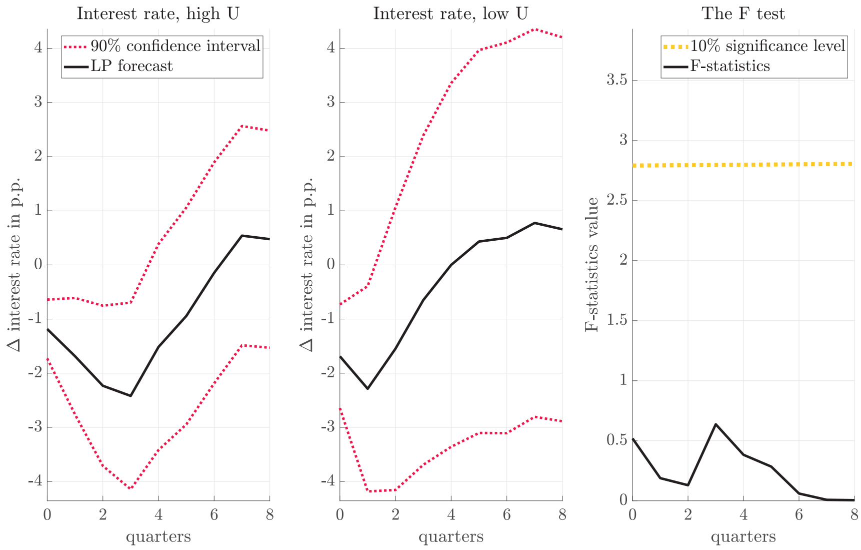
itions outlined in the introductory part of the paper: policy tends to stabilize the economy more effectively when the amount of idle resources is larger. To verify this claim further, let us test the following linear restriction imposed on the model:

$$\beta_j^H = \beta_j^L.$$

The third column of Figure 2 reports the value of the F-test statistic, which indicates that, for all periods (except period 0), we cannot reject the hypothesis that the IRFs in columns one and two are the same. This, in turn, suggests that the conclusion regarding the dependence of quantitative adjustments on the unemployment level should be interpreted with some caution.

Let us turn to the responses related to prices, which are shown in the second row of Figure 2. The maximum value of the central tendency when unemployment is high is 1.6%, while the corresponding value for the low-unemployment regime is 4.4%. This indicates that the rise in the price level resulting from a monetary accommodation of 1 p.p. is almost three times larger when economic slack is small. Moreover, more than half of the confidence intervals related to the impulse response in the low-unemployment regime do not contain zero. Additionally, and unlike in

Figure 3: Impulse response functions: nominal interest rates



Notes: The first two columns show the impulse response to an accommodative monetary policy shock. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

the case of unemployment IRFs, the null hypothesis that $\beta_j^H = \beta_j^L$ can be rejected for $j \in \{3, 4, 5\}$. This may indicate that the difference in price adjustment between the two regimes is more pronounced than the difference in quantitative adjustment. To summarize, the response of prices to a monetary policy shock is consistent with the intuitions discussed in the introduction: when the amount of idle resources in the economy is limited, firms are more likely to raise prices in response to a positive demand shock.

We conclude this section with a discussion of the standardization of the results displayed in Figure 2. Following Tenreyro and Thwaites (2016), we construct an auxiliary model to calculate the response of policy rates to a monetary policy shock. The estimated equation takes the following form:

$$y_{t+j} = F\left(u_{t-1}\right) \cdot \left(\tilde{\alpha}_j^H + \tilde{\beta}_j^H \cdot \epsilon_t + \tilde{\gamma}_j^H \cdot x_t\right) \tag{3}$$

$$+ \left(1 - F\left(u_{t-1}\right)\right) \cdot \left(\tilde{\alpha}_j^L + \tilde{\beta}_j^L \cdot \epsilon_t + \tilde{\gamma}_j^L \cdot x_t\right),$$

where y_{t+j} is the the short-term (3-month) interest rate in period $t + j$ and u_{t-1} denotes the country-wide unemployment level in period $t - 1$. Although equation (3) bears certain similarities to the baseline model (see equation (1)), there are several important differences: lagged unemployment that enters the function F is measured at the aggregate level and vector x_t contains only the lagged values of the dependent variable. The last assumption about a limited set of explanatory variables (when compared to the baseline model) is motivated by the structure of an analogous auxiliary model used by Tenreyro and Thwaites (2016) and by the fact that the number of observations in the country-level sample is considerably lower than in the sample containing panel data.

Figure 3 shows the responses of nominal interest rates to an accomodative monetary policy shock when unemployment is high (i.e., $\left\{-\tilde{\beta}_j^H\right\}_{j=0}^8$, see the right panel) and when it is low (i.e., $\left\{-\tilde{\beta}_j^L\right\}_{j=0}^8$, see the middle panel). The value of the F-test statistic displayed in the right panel is very low, indicating that the null hypothesis $\tilde{\beta}_j^H = \tilde{\beta}_j^L$ cannot be rejected, suggesting that the reaction of policy rates to a monetary policy shock can be considered almost regime-invariant.

As previously mentioned, we use $\tilde{\beta}_0^H$ and $\tilde{\beta}_0^L$ for the standardization of the regression coefficients corresponding to monetary policy shocks in the baseline model. More specifically, the first two columns of Figure 2 display the values $-\beta_j^H/\tilde{\beta}_0^H$ and $-\beta_j^L/\tilde{\beta}_0^L$ for $j \in \{0, 1, ..., 8\}$, which, by construction, can be interpreted as the responses of unemployment and prices to a monetary policy shock that decreases policy rates by 1 p.p. when unemployment is high and low, respectively.

One remark is in order here. The magnitude of the monetary policy effects on unemployment and inflation in Figure 2 may seem surprisingly large. This, however, is due to the scale of the monetary disturbance – as it can be inferred from Figures 3 and 4, a shock that lowers the policy rate by 1 p.p. can be viewed as an extreme event. To address this issue, Figure 9 in the Appendix reports impulse responses to average monetary policy shocks corresponding to one standard deviation when unemployment is high and low.[6]

3.4 Robustness checks

To assess the reliability of the main findings, we now examine the robustness of our key results to different modeling choices. Specifically, we estimate models where: i) the value of the parameter θ in the transition function is chosen to minimize the BIC

[6]We used the weights described by formulas (4) and (5) to compute the standard deviations of monetary shocks in the high- and low-unemployment regime, respectively.

criterion in the model estimating the immediate response of the unemployment rate; ii) the value of the parameter θ in the transition function is chosen to minimize the BIC criterion in the model estimating the immediate response of inflation; iii) the value of the parameter c is set to the 80th percentile of voivodship unemployment rates (as in Tenreyro and Thwaites 2016); iv) the number of lags is set to 2 instead of 4; v) foreign variables are detrended using a linear trend instead of the HP filter; vi) the set of controls additionally includes the quarterly changes in log oil prices; vii) the set of controls in the model for inflation includes the level of the unemployment rate instead of the HP-detrended unemployment rate; viii) country-level state-dependent trends α_j^H and α_j^L are replaced by regional state-dependent trends α_{ij}^H and α_{ij}^L, and the fixed effect δ_{ij} is replaced by δ_j (see, e.g., Alpanda et al., 2021); and ix) country-level parameters c and σ_u in function F are replaced by unit-specific values c_i and $\sigma_{u,i}$ to account for potential structural differences across regional labor markets.

A glance at the impulse responses of unemployment and inflation presented in the Appendix (Figures 10-18) allows us to conclude that our main results are not sensitive to the specification changes described above. In all cases, the response of the unemployment rate is stronger in a high-unemployment regime, while inflation reacts more strongly when unemployment is low.

4 Alternative explanation and additional supporting evidence

The main result of Section 3 is that, when labor market slack is high, monetary shocks induce stronger responses in unemployment compared to periods of low slack, while the opposite is true for price adjustments. This section aims to provide additional evidence supporting this conclusion. We begin by examining an alternative explanation for our findings, inspired by Tenreyro and Thwaites (2016), which suggests that the results can be explained by different distributions of monetary policy shocks under high- and low-unemployment conditions. We then proceed with further experiments that directly support our main result: the first is an analysis of the regional demand responses (at the voivodship level) to monetary policy, and the second compares our baseline model with the standard linear (i.e., non-state-dependent) model.

4.1 Distribution of shocks under high and low unemployment

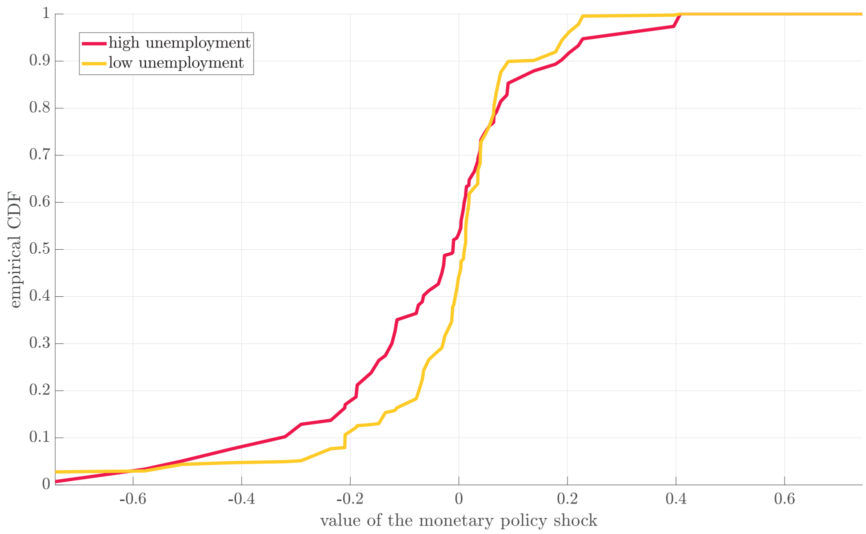
The main message of this paper is that monetary transmission in Poland depends on the unemployment level. However, one could argue that the differences in the economy's response to monetary disturbances might not stem from the state of the economy *per se*, but rather may be driven by the different distribution of shocks in both unemployment regimes and the asymmetry in the responses to certain types of monetary shocks. If, for example, positive shocks are more common when unemployment is low (and less common when unemployment is high), and if positive shocks have a smaller/larger effect on quantities/prices than negative disturbances, then it is likely to drive our results. To address this concern we first define the empirical distribution of shocks in the high-unemployment regime:

$$DF^{H}\left(\epsilon_t\right) = \frac{\frac{1}{N} \cdot \sum_{i=1}^{N} F\left(u_{i,t-1}\right)}{\frac{1}{N} \cdot \sum_{t=1}^{T} \sum_{i=1}^{N} F\left(u_{i,t-1}\right)} \tag{4}$$

and the complementary one related to the state of low unemployment:

$$DF^{L}\left(\epsilon_t\right)=\frac{\frac{1}{N}\cdot\sum_{i=1}^{N}\left(1-F\left(u_{i,t-1}\right)\right)}{\frac{1}{N}\cdot\sum_{t=1}^{T}\sum_{i=1}^{N}\left(1-F\left(u_{i,t-1}\right)\right)} \tag{5}$$

Figure 4: CDFs of shocks in two regimes

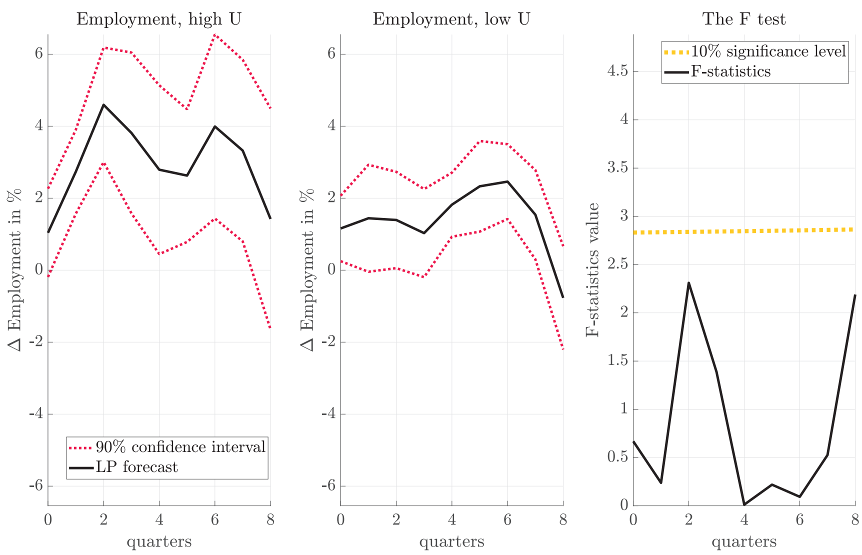


The CDFs corresponding to $DF^{H}\left(\epsilon_t\right)$ and $DF^{L}\left(\epsilon_t\right)$ are presented in Figure 4. To formally compare them, we apply the Kolmogorov-Smirnov test. Based on the test results, we cannot reject the hypothesis that the distributions of monetary shocks in both unemployment regimes are identical (p-value $= 0.22$). Thus, we conclude that the main findings of this paper are not driven by the presence of a regime-dependent pattern in the monetary shocks.

4.2 Shifts of the voivodship-level demand and the local unemployment level

To provide further support for our main result regarding the dependence of the effects of monetary policy on unemployment, we conduct an additional empirical experiment based on four premises. First, monetary policy shocks can be classified as demand shocks. Second, the reactions of unemployment and employment to monetary disturbances are closely related (employment negatively co-moves with unemployment). Third, employment in sectors producing non-tradable goods is heavily influenced by local demand shocks (see Mian and Sufi, 2014 and Hazell et al., 2022). Fourth, the local unemployment level is an important factor affecting household demand at the voivodship level (through unemployment fears and differences in consumption patterns between the employed and unemployed, as documented by Kolsrud et al. (2018), Gross et al. (2020), and Sokolova (2023), among others). Given these premises, one can expect that if our main result holds, the dependence of changes in non-tradable employment (driven by monetary policy) on labor market slack should be more pronounced than the dependence of tradable employment responses on the unemployment level.

Figure 5: Impulse response functions: employment



Notes: The figures show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method.

To verify this claim, we estimate a model analogous to the baseline model of unemployment (described by equation (1)) where unemployment differentials are replaced by the corresponding differentials in the logged number of employed persons in the enterprise sector. The data on employment (total and in tradable/non-tradable sectors) cover the period from Q2 2008 to Q4 2019 and are sourced from voivodships' Statistical Bulletins published by Statistics Poland. We classify industry as a sector producing tradables and we define the following as non-tradable goods and services: construction of buildings, specialised construction activities, retail sales, accommodation and food service activities, real estate activities, and administrative/support service activities.

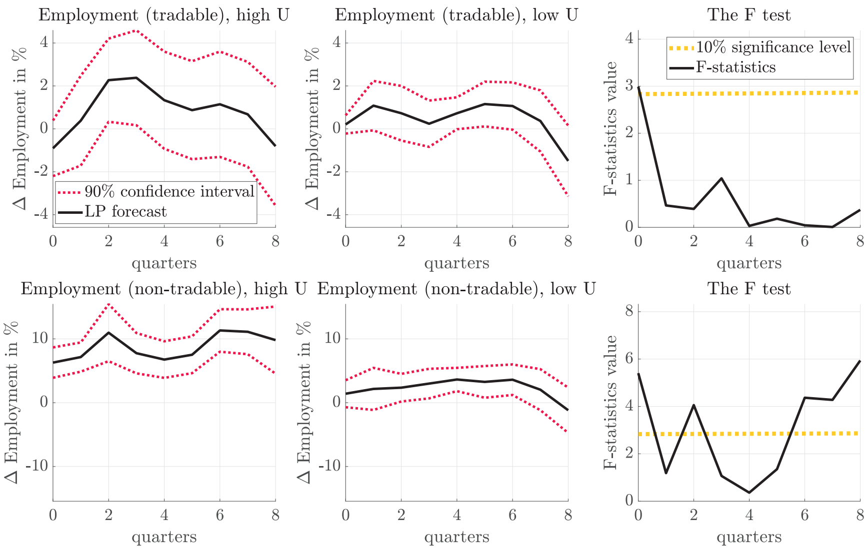
To justify the second premise underlying our experiment (i.e., the negative co-movement of unemployment and employment), Figure 5 displays the responses of total employment to an accommodative monetary policy shock of 1 p.p.[7] Following the drop in interest rates, employment in the high-unemployment regime rises, reaching a maximum of 4.6% above the counterfactual scenario (in which there is no accommodation). The increase in employment in the low-unemployment regime is more moderate, peaking at 2.5%. Moreover, for both regimes, there are horizons for which the confidence intervals of the main tendencies do not contain zero. Similarly to the baseline model of unemployment, the F-test statistic indicates that the null hypothesis – that the responses of total employment in both regimes are the same – cannot be rejected.

[7]Note that the absolute values of employment responses (expressed as percentages) are more pronounced than the corresponding unemployment responses (expressed in percentage points). This can be explained by a simple two-state model of the labor market, in which changes in the number of employed workers are equal to changes in the number of unemployed workers, multiplied by -1 (i.e. $dU/dE = -1$ and U can be expressed as a function of E). In that situation, the relationship between the change in unemployment (expressed in percentage points) and change in employment (expressed as percentages) is given by:

$$\frac{d\left(\frac{U(E)}{U(E)+E}\right)}{\frac{dE}{E}} = -\frac{E}{U+E} < -1$$

i.e., the changes to employment are more pronounced in absolute terms.

Figure 6: Impulse response functions: employment in tradable and non-tradable sectors



Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Let us now turn to the main experiment of this section that compares the impulse responses of tradable and non-tradable employment when unemployment is high and low. Figure 6 shows the results: the first row displays the responses of tradable employment when unemployment is high (left panel) and low (middle panel). The right panel presents the F-test statistic comparing the impulse responses of tradable employment in both unemployment regimes.

Note that tradable employment increases following the monetary policy shock in both regimes. However, consistent with the intuition discussed in Section 1, the increase is more pronounced in the high-unemployment regime (peaking at 2.4%) compared to the low-unemployment regime (with a maximum of 1.1%). As the F-test statistics in the right panel indicate, however, these reactions cannot be considered statistically different.

The second row of Figure 6 displays the responses of non-tradable employment. These responses are not only larger than those of tradable employment (reaching maxima of 11.3% and 3.6% when unemployment is high and low, respectively), but the difference between them is also statistically significant for the majority of the response horizons j. This, in turn, supports our initial intuition outlined at the beginning of this subsection: changes in non-tradable employment, which depend heavily on shifts in local demand driven by monetary policy, are significantly influenced by unit-level unemployment – a factor that notably impacts household consumption behavior. This pattern is less pronounced in the case of tradable employment.

To assess the robustness of these findings, we estimate models with alternative definitions of non-tradable employment. Specifically, we consider three additional models, each excluding a different component of the non-tradable employment defined above. First, we remove specialized construction activities from the set of sectors initially classified as non-tradable, as some specialized construction workers may exhibit mobility across voivodships. Second, we exclude accommodation and food services, as part of the demand for these services in a given voivodship may be generated by households from other regions. Third, we eliminate administrative and support services, as the associated employment may also depend on demand from other voivodships. As Figures 19-21 show, these modifications to the definition of non-tradable employment do not alter our main conclusion regarding the significant dependence of its reaction to monetary policy shocks on unit-level unemployment.

4.3 Comparison with the linear model

In the final step of our analysis, we compare our state-dependent model with its linear counterpart, given by:

$$y_{i,t+j} - y_{i,t-1} = \alpha_{ij} + \beta_j \cdot \epsilon_t + \gamma_j \cdot x_{i,t} + \xi_{i,t} \tag{6}$$

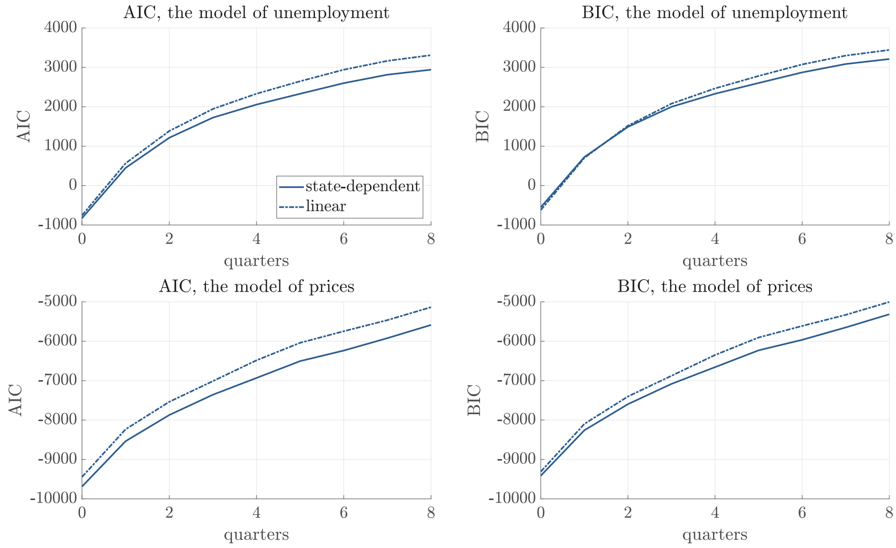
The impulse responses of unemployment and prices to the monetary policy shock (see Figure 7) fall between the corresponding responses in the high- and low-unemployment states. The comparison of information criteria values for linear and state-dependent models estimated for various horizons j (Figure 8) reveals that, in general, the latter outperforms the former. The only exception (according to the Bayesian information criterion) occurs in the models estimating the short-term ($j = 0, 1, 2$) reaction of unemployment.

This suggests that the non-linear model from Section 3 is better suited for analyzing the responses of unemployment and prices to monetary policy shocks than its linear counterpart. This, in turn, forms the fundamental rationale for justifying our modeling approach.

Figure 7: Impulse response functions: unemployment and inflation, linear model

Notes: Panels show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method.

Figure 8: Information criteria: linear vs. state-dependent model



Notes: Panels show the values of information criteria (AIC - the Akaike information criterion, BIC - the Bayesian information criterion) for models featuring different values of forecasting horizons.

5 Conclusions

This paper provides empirical evidence that the monetary transmission in Poland depends on the level of unemployment. Specifically, we find that monetary policy shocks lead to more pronounced adjustments in unemployment when labor market slack is high, and more significant price adjustments when slack is low. These findings are based on the smooth transition panel local projections estimated using Poland's regional data from Q1 2001 to Q4 2019 and are robust to numerous variations in the model specification. Importantly, they do not seem to be driven by a state-dependent distribution of the monetary disturbances themselves, but rather by differences in the economic effects of shocks under varying levels of labor market slack.

To further support our conclusions regarding the presence of state-dependent patterns in monetary transmission, we conduct two additional exercises. First, we examine the differences in employment responses between sectors producing tradable and non-tradable goods under two unemployment regimes. Given that employment in the latter sectors is more influenced by regional conditions, if our conclusions hold, the strength of its response to monetary shocks should depend more strongly on the (locally measured) unemployment rate compared to the employment reaction in tradable sectors. Crucially, our analysis confirms that this is certainly the case. Second, we compare our state-dependent model with its linear counterpart and find that the former outperforms the latter, which suggests that monetary transmission in Poland indeed exhibits state dependence.

References

Alpanda, S., Granziera, E., and Zubairy, S. (2021). State dependence of monetary policy across business, credit and interest rate cycles. *European Economic Review*, 140(C).

Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R., and Ragusa, G. (2019). Measuring euro area monetary policy. *Journal of Monetary Economics*, 108(C):162–179.

Auerbach, A. J. and Gorodnichenko, Y. (2012). Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*, 4(2):1–27.

Benigno, P. and Eggertsson, G. B. (2023). It is Baaack: The Surge in Inflation in the 2020s and the Return of the Non-Linear Phillips Curve. NBER Working Papers 31197, National Bureau of Economic Research, Inc.

Benigno, P. and Eggertsson, G. B. (2024). The Slanted-L Phillips Curve. NBER Working Papers 32172, National Bureau of Economic Research, Inc.

Bielecki, M., Makarski, K., Walerych, M., and Zajkowska, O. (2025). Monetary policy with tight and slack labor market. Technical report.

Borio, C. E. V. and Filardo, A. (2007). Globalisation and inflation: New cross-country evidence on the global determinants of domestic inflation. BIS Working Papers 227, Bank for International Settlements.

Burgard, J. P., Neuenkirch, M., and Noeckel, M. (2019). State-Dependent Transmission of Monetary Policy in the Euro Area. *Journal of Money, Credit and Banking*, 51(7):2053–2070.

Cochrane, J. H. and Piazzesi, M. (2002). The fed and interest rates: A high-frequency identification. *The American Economic Review*, 92(2):90–95.

Gertler, M. and Karadi, P. (2015). Monetary Policy Surprises, Credit Costs, and Economic Activity. *American Economic Journal: Macroeconomics*, 7(1):44–76.

Gradzewicz, M., Growiec, J., Kolasa, M., Postek, Ł., and Strzelecki, P. (2018). Polandâs uninterrupted growth performance: new growth accounting evidence. *Post-Communist Economies*, 30(2):238–272.

Gross, T., Notowidigdo, M. J., and Wang, J. (2020). The Marginal Propensity to Consume over the Business Cycle. *American Economic Journal: Macroeconomics*, 12(2):351–384.

Gürkaynak, R. S., Sack, B., and Swanson, E. (2005). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking*, 1(1).

Hagemejer, J. and Mućk, J. (2019). Export-led growth and its determinants: Evidence from central and eastern european countries. *The World Economy*, 42(7):1994–2025.

Hazell, J., Herreno, J., Nakamura, E., and Steinsson, J. (2022). The Slope of the Phillips Curve: Evidence from U.S. States. *The Quarterly Journal of Economics*, 137(3):1299–1344.

Jarociński, M. and Karadi, P. (2020). Deconstructing Monetary Policy Surprises - The Role of Information Shocks. *American Economic Journal: Macroeconomics*, 12(2):1–43.

Jorda, O., Schularick, M., and Taylor, A. M. (2020). The effects of quasi-random monetary experiments. *Journal of Monetary Economics*, 112(C):22–40.

Kapuściński, M. (2017). Monetary policy and financial asset prices in Poland. *Bank i Kredyt*, 48(3):263–294.

Kapuściński, M. (2023). Updated estimates of the role of the bank lending channel in monetary policy transmission in Poland. Technical report.

Kightley, M. and Suda, J. (2023). The impact of monetary policy on employment in Poland through the lens of disaggregated data. In for International Settlements, B., editor, *Inflation and labour markets*, volume 127 of *BIS Papers chapters*, pages 251–263. Bank for International Settlements.

Kolasa, M., Walerych, M., and Wesołowski, G. (2025). Monetary-fiscal interactions during large-scale asset purchase programs. Technical report.

Kolsrud, J., Landais, C., Nilsson, P., and Spinnewijn, J. (2018). The Optimal Timing of UI Benefits: Theory and Evidence from Sweden. *American Economic Review*, 108(4):985–1033.

Kopiec, P. (2025). Labor market slack, household inequality and monetary policy. Technical report.

Kuttner, K. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of Monetary Economics*, 47(3):523–544.

Lo, M. C. and Piger, J. (2005). Is the Response of Output to Monetary Policy Asymmetric? Evidence from a Regime-Switching Coefficients Model. *Journal of Money, Credit and Banking*, 37(5):865–886.

Łyziak, T. (2019). Do global output gaps help forecast domestic inflation? Evidence from Phillips curves for Poland. *International Journal of Forecasting*, 35:1032–1041.

Mian, A. and Sufi, A. (2014). What Explains the 2007–2009 Drop in Employment? *Econometrica*, 82:2197–2223.

Michaillat, P. (2014). A Theory of Countercyclical Government Multiplier. *American Economic Journal: Macroeconomics*, 6(1):190–217.

Owyang, M. T., Ramey, V. A., and Zubairy, S. (2013). Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data. *American Economic Review*, 103(3):129–134.

Peersman, G. and Smets, F. (2002). *Are the effects of monetary policy in the euro area greater in recessions than in booms?* Monetary Transmission in Diverse Economies. Cambridge University Press.

Ramey, V. A. and Zubairy, S. (2018). Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data. *Journal of Political Economy*, 126(2):850–901.

Sokolova, A. (2023). Marginal Propensity to Consume and Unemployment: a Meta-analysis. *Review of Economic Dynamics*, 51:813–846.

Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics*, 118(C):32–53.

Szafranek, K. (2017). Flattening of the New Keynesian Phillips curve: Evidence for an emerging, small open economy. *Economic Modelling*, 63(C):334–348.

Szpunar, P. and Hagemejer, J. (2018). Globalisation and the Polish economy: macro and micro growth effects. In for International Settlements, B., editor, *Globalisation and deglobalisation*, volume 100 of *BIS Papers chapters*, pages 273–289. Bank for International Settlements.

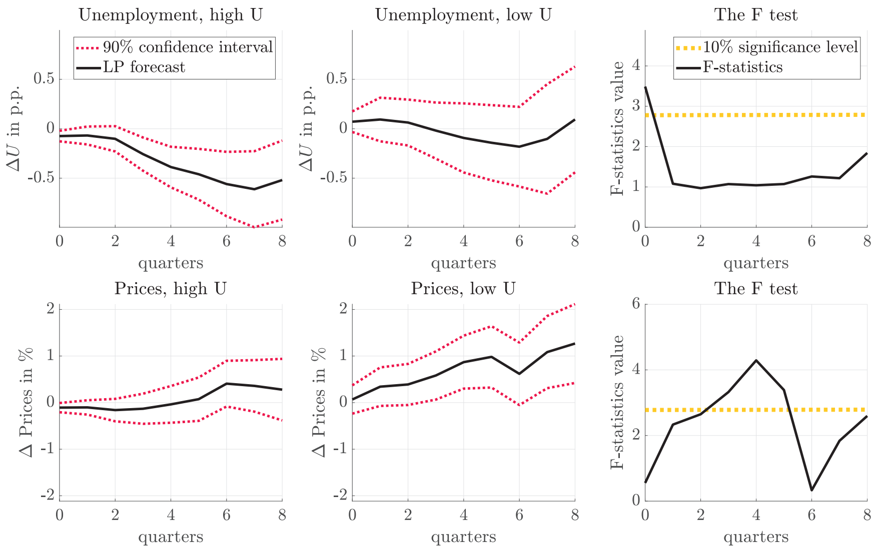
Tenreyro, S. and Thwaites, G. (2016). Pushing on a String: US Monetary Policy Is Less Powerful in Recessions. *American Economic Journal: Macroeconomics*, 8(4):43–74.

Weise, C. L. (1999). The Asymmetric Effects of Monetary Policy: A Nonlinear Vector Autoregression Approach. *Journal of Money, Credit and Banking*, 31(1):85–108.

Appendix

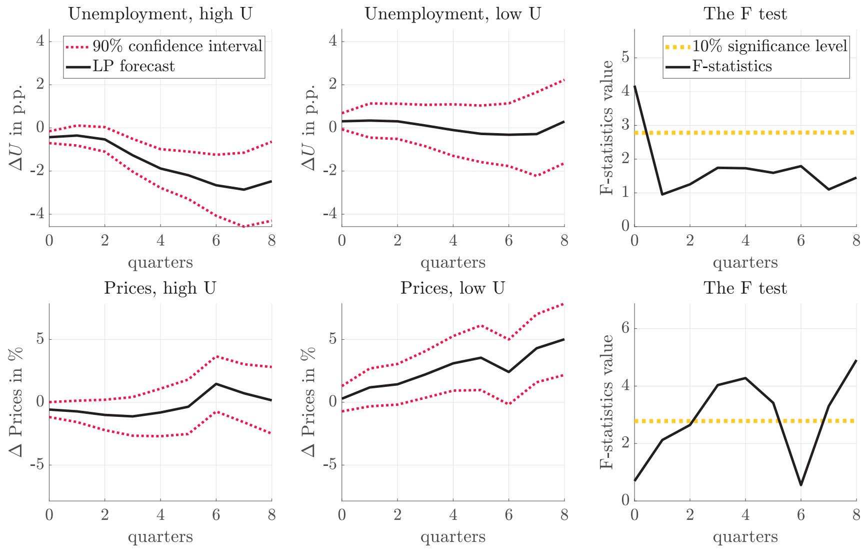
Additional figures

Figure 9: Impulse response functions: unemployment and inflation, alternative standardization of the monetary policy shock size



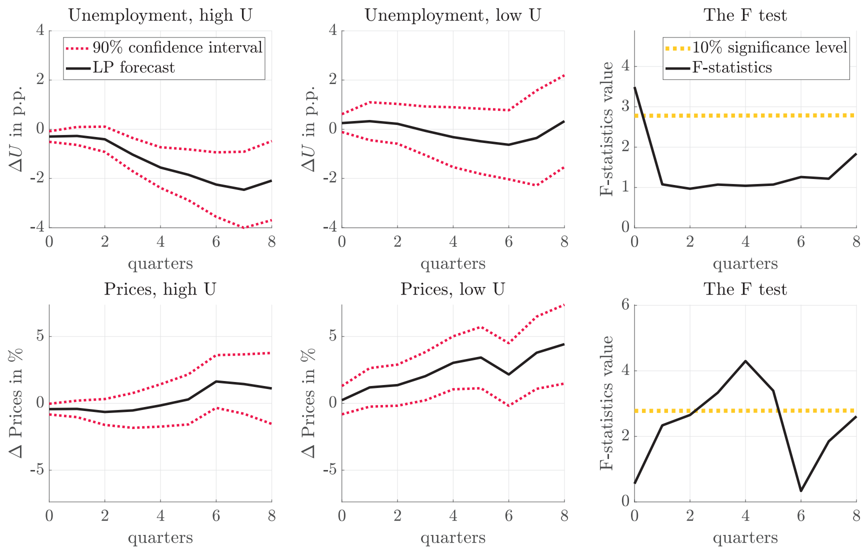
Notes: The first two columns show the impulse responses to a monetary policy shock that decreases the short-term interest rate by one standard deviation in the high- and low-unemployment regime, respectively. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 10: Impulse response functions: unemployment and inflation, θ =1.39



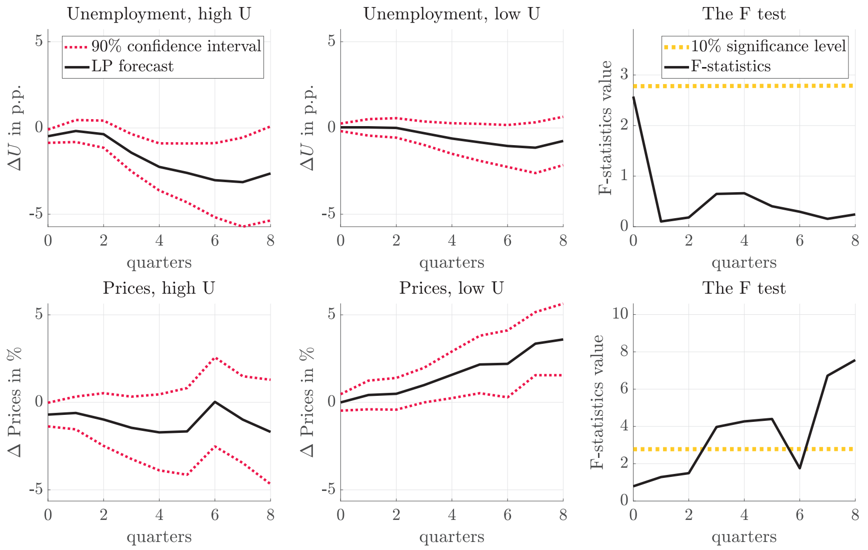
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero. The value of parameter θ was chosen to minimize BIC criterion in the model estimating the immediate response of unemployment rate.

Figure 11: Impulse response functions: unemployment and inflation, θ = 2.98



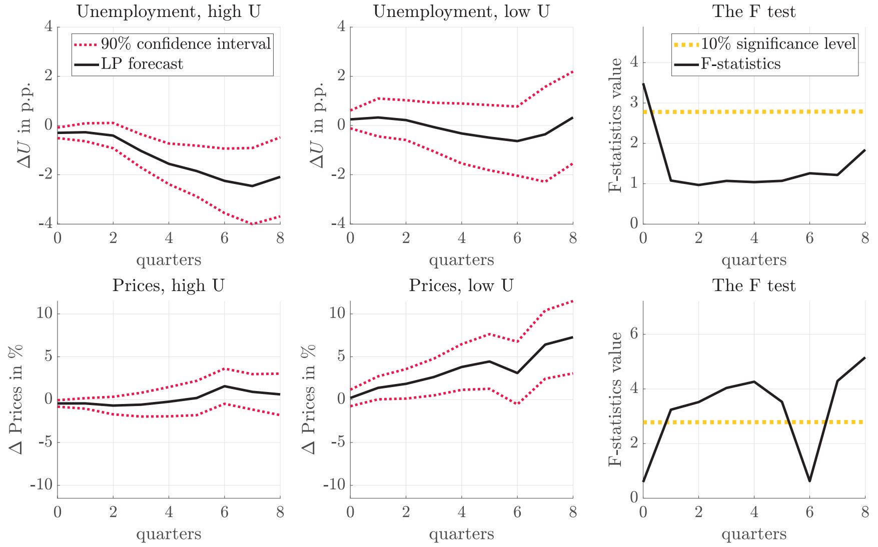
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero. The value of parameter θ was chosen to minimize BIC criterion in the model estimating the immediate response of inflation.

Figure 12: Impulse response functions: unemployment and inflation, c - 80th percentile of $u_{i,t}$



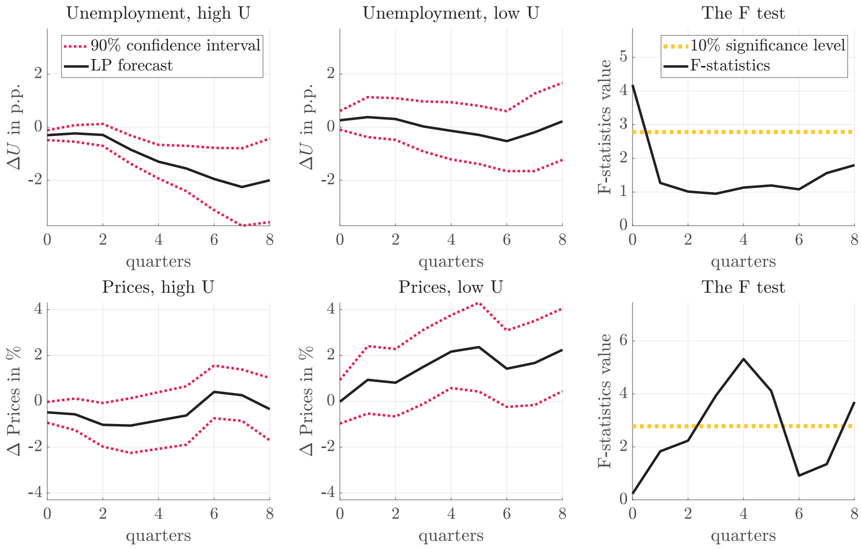
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 13: Impulse response functions: unemployment and inflation, two lags



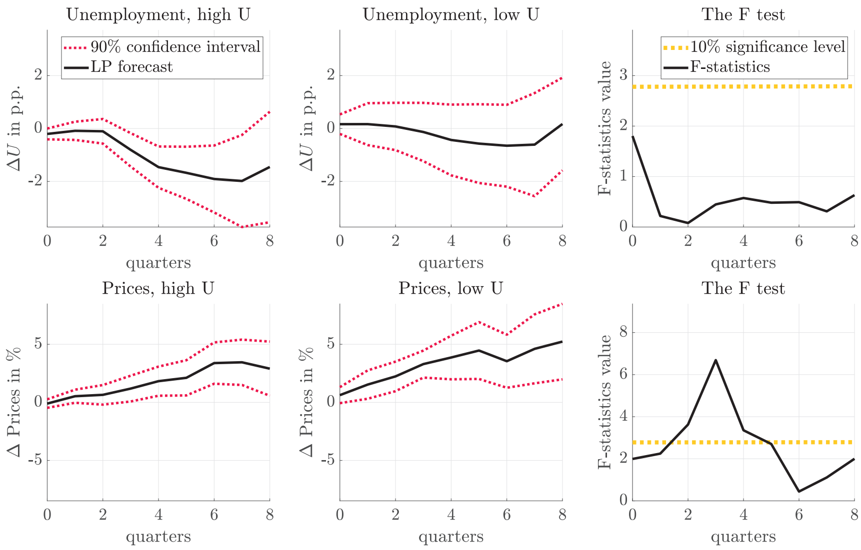
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 14: Impulse response functions: unemployment and inflation, linear detrending



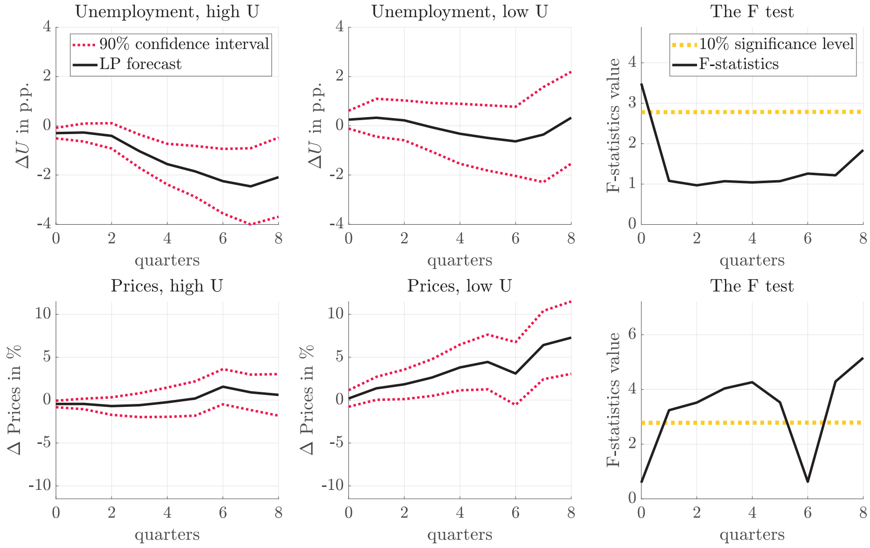
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero. The foreign control variables (REER, VIX and EA output) are detrended using a linear trend.

Figure 15: Impulse response functions: unemployment and inflation, oil prices as a control variable



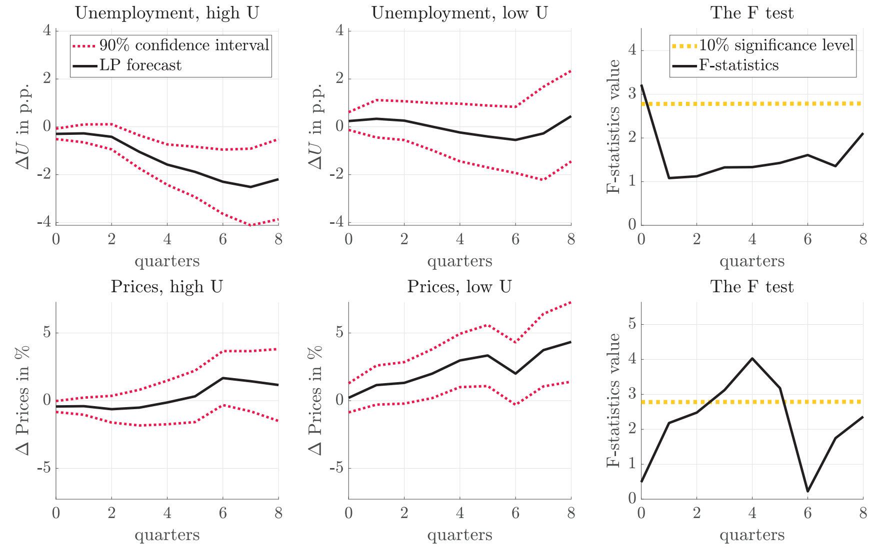
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero. The set of control variables additionally includes the quarterly changes in log oil prices.

Figure 16: Impulse response functions: unemployment and inflation, level of unemployment as a control variable in the model for inflation



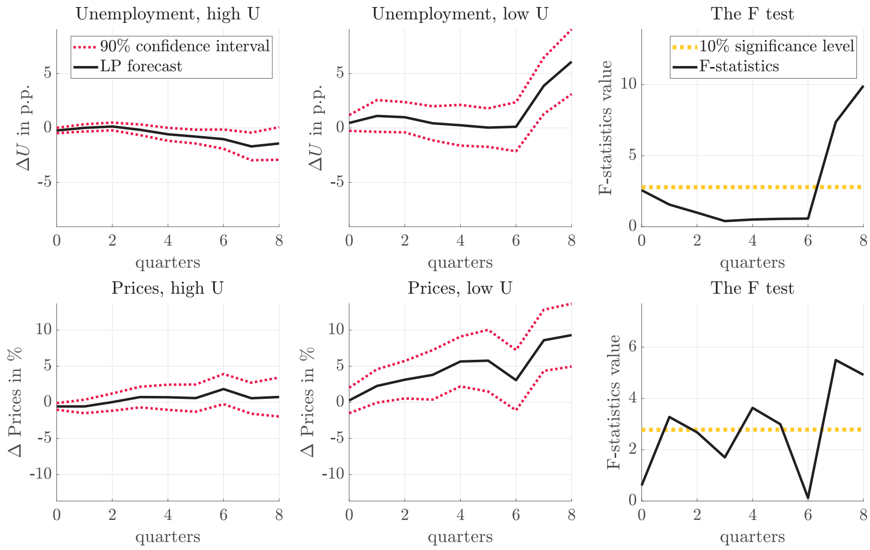
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero. The set of control variables in the model for inflation includes the level of the unemployment rate instead of the HP-detrended unemployment rate.

Figure 17: Impulse response functions: unemployment and inflation, regional state-dependent trends



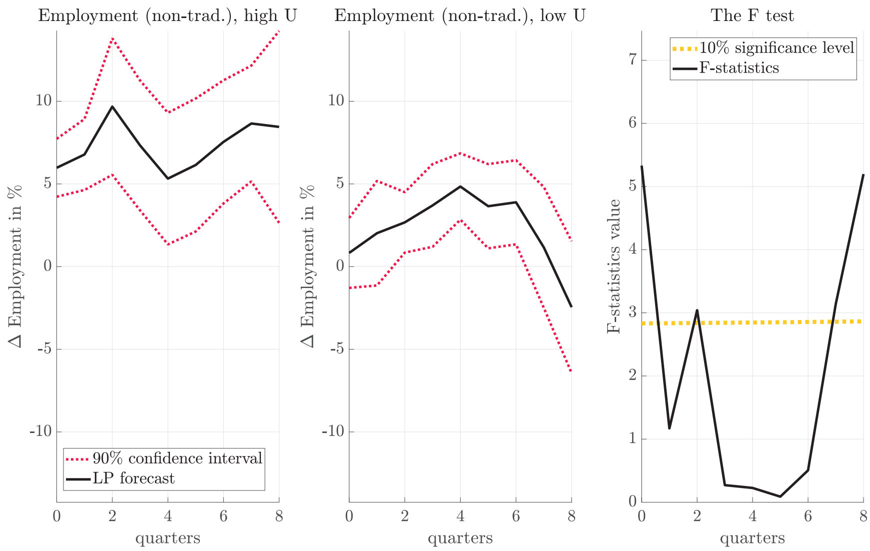
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 18: Impulse response functions: unemployment and inflation, unit-level parameters c_i and $\sigma_{u,i}$



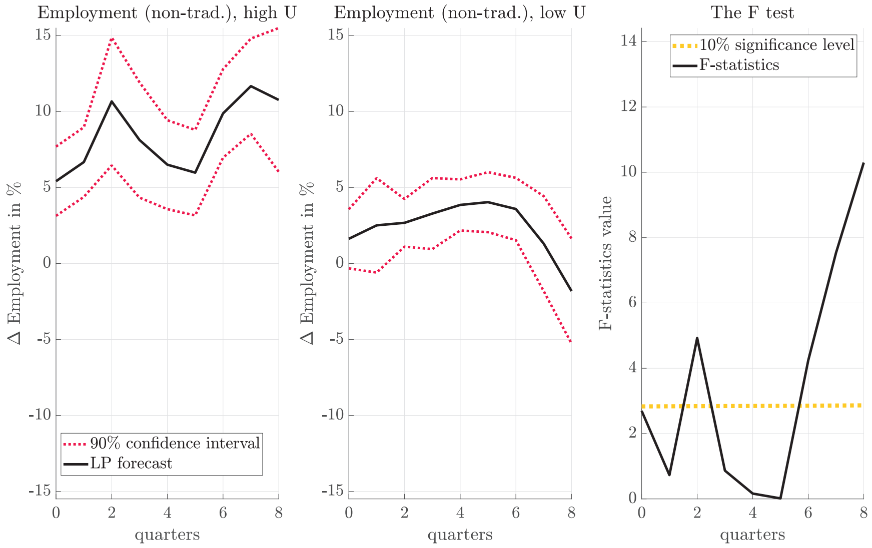
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 19: Impulse response functions: employment in non-tradable sectors, excluding specialized construction activities



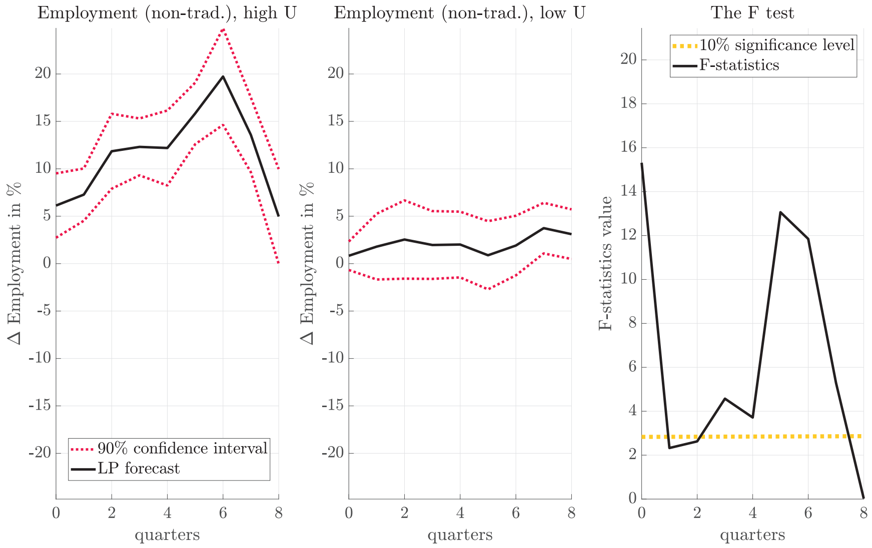
Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 20: Impulse response functions: employment in non-tradable sectors, excluding accommodation and food service activities



Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

Figure 21: Impulse response functions: employment in non-tradable sectors, excluding administrative and support service activities



Notes: The first two columns show the impulse response to a monetary policy shock that decreases the short-term interest rate by 1 percentage point on impact. The standard errors are calculated using the Driscoll-Kraay method. The third column shows F-statistics testing the hypothesis that the difference between the coefficients under high and low unemployment is zero.

nbp.pl