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NBP Working Paper No. 375

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Narodowy Bank Polski
Warsaw 2025

Paweł Kopiec – Narodowy Bank Polski

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

ISSN 2084-624X

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Abstract

This paper examines the non-linear impact of unemployment levels on the effectiveness of monetary policy. Using a standard heterogeneous-agent model with uninsured income risk, integrated with a canonical frictional labor market framework, I compare two versions of the model calibrated to reflect high- and low-unemployment regimes in the Polish economy. The findings reveal that the output response to a policy rate change is 60% larger in the high-unemployment scenario than in the low-unemployment one, while price reactions are more pronounced when unemployment is low. Additionally, I investigate the role of incomplete insurance markets in the transmission of monetary policy and assess the welfare implications of policy changes, both at the aggregate level and across different household subgroups.

JEL Classification: D30, D31, D52, E21, E24, E43, E52, E58

Keywords: Monetary Policy, Heterogeneous Agents, Frictional Markets, Unemployment

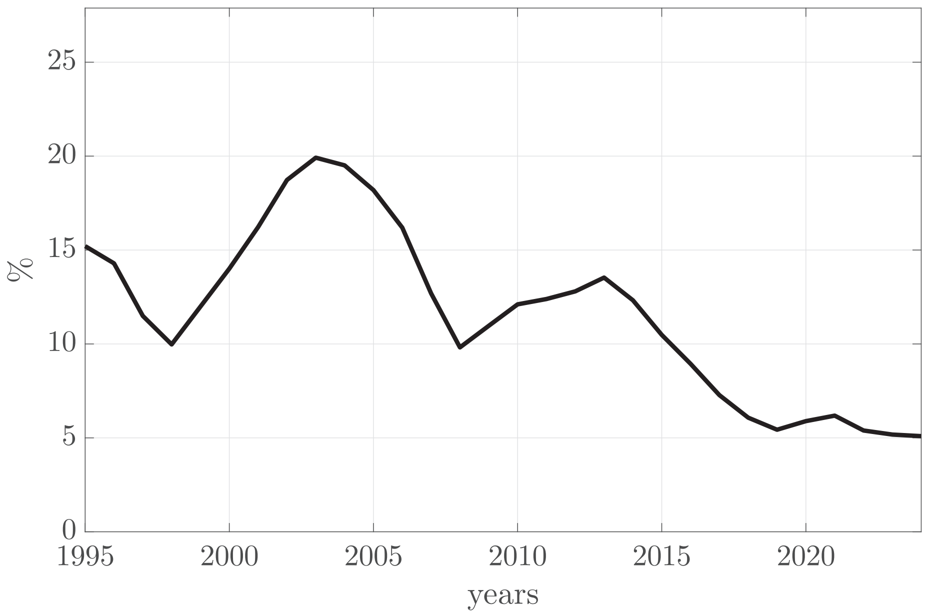
1 Introduction

According to standard textbook logic, the aggregate supply (AS) curve exhibits a certain degree of convexity. As a result, shifts in aggregate demand lead to more significant adjustments in output when economic slack is high compared to when idle resources in the economy are scarce. The opposite applies to prices: when economic slack is low, price adjustments to demand shocks are less pronounced, whereas when slack is high, they are more pronounced. The intuition behind this reasoning is straightforward: since the total population remains relatively fixed even over long periods, firms responding to increased demand will struggle to find additional workers if unemployment is already low. In such a scenario, they compensate by raising prices, as expanding output through hiring is not a viable option. (see Benigno and Eggertsson, 2024). The theoretical basis for the convex aggregate supply (AS) curve was established by Michaillat (2014) and explained using the standard Diamond-Mortensen-Pissarides model of the frictional labor market.

While the role of the AS curve's convexity in the economy's adjustment to demand shocks is well understood, surprisingly little attention has been given to the demand side, represented by the aggregate demand (AD) curve, in the context of macroeconomic responses to such shocks. If, for instance, the magnitude of the AD curve's shift - driven by exogenous factors such as monetary policy disturbances - depends on the economic state, it could significantly influence the overall adjustment in general equilibrium by either dampening or amplifying the effects of the AS curve's convexity. Indeed, Sokolova (2023) finds that aggregate demand behavior may be affected by the level of economic slack: her meta-analysis shows that at a 4% unemployment rate, the marginal propensity to consume (MPC) is approximately 0.22, whereas at an 8% unemployment rate, it rises to around 0.4.

Motivated by these findings, I investigate the state dependence of macroeconomic adjustments to monetary policy shocks using a model that integrates a frictional labor market with a realistic demand framework based on the canonical Bewley-Huggett-Aiyagari model, which features heterogeneous households and uninsured income risk. The first component accounts for the convexities of the aggregate supply (AS) curve, as described by Michaillat (2014), while the second captures key aspects of household consumption behavior. In particular, and in contrast to the standard model with a representative agent, the heterogeneous agent framework

Figure 1: Unemployment rate in Poland: 1995-2014



Notes: The solid line shows the registered unemployment rate in Poland in years 1995-2014. Source: Statistics Poland.

allows for: (i) realistically replicating empirical MPC values, (ii) incorporating precautionary motives and unemployment fears into the analysis, (iii) enhancing the transmission of monetary policy through household demand via channels beyond intertemporal substitution, and (iv) capturing complex monetary-fiscal interactions and redistributive effects.

The model is applied for studying the dependence of the transmission of monetary policy on unemployment level in Poland. As Figure 1 illustrates, the Polish labor market has undergone significant changes over the past three decades: unemployment rates have declined from some of the highest levels in Europe to among the lowest. This shift raises important questions about its impact on monetary policy transmission. Following Bielecki et al. (2025), I divide this period into two subperiods: the first, from 1995 to 2009 (the so-called high-unemployment regime), and the second, from 2010 to 2024 (the low-unemployment regime). I calibrate the model to match empirical labor market moments for each subperiod, including the unemployment rate, labor market tightness, labor share, the ratio of unemployment benefits to real wages, and the job-finding rate. Next, I simulate a monetary policy change in both unemployment regimes and analyze the impulse responses of aggregate variables, the role of incomplete markets in the propagation of monetary policy, and the welfare implications both at the aggregate level and across different household subgroups.

Overall, my findings align with the intuition outlined at the beginning of this section: monetary policy accommodation leads to an output increase of 0.8% in the high-unemployment regime and 0.5% in the low-unemployment regime. The corresponding inflation responses amount to 1.2 and 1.5 percentage points, respectively. Additionally, the aggregate MPC is about 30% higher in 1995–2009 than in 2010–2024, suggesting that the convexity of the AS curve is reinforced by a stronger household demand response to the income effects of general equilibrium feedbacks when unemployment is high. Furthermore, by comparing output reactions in the baseline model with its representative-agent counterpart, I highlight the significant role of market incompleteness in the propagation of monetary policy, which amplifies its output effects by approximately 60% in both regimes. Finally, I examine the welfare consequences of monetary accommodation and find notable differences between unemployed and employed households, among others.

The rest of the paper is structured as follows. Section 2 discusses the related literature. Section 3 presents the model economy. I calibrate the model in Section 4 and I present simulation results in Section 5. Section 6 concludes.

2 Literature

Michaillat (2014), Michaillat and Saez (2019), Benigno and Eggertsson (2023), and Benigno and Eggertsson (2024) establish theoretical foundations for the state-dependent response of the economy to aggregate shocks. Michaillat (2014) applies a version of the standard Diamond-Mortensen-Pissarides model to examine the relationship between economic slack and the effectiveness of changes to public employment. Michaillat and Saez (2019) use a similar framework to study how optimal government spending depends on the unemployment level. Benigno and Eggertsson (2023) apply a related model to obtain the non-linear Phillips Curve. In pursuit of a similar objective, Benigno and Eggertsson (2024) develop an alternative model based on downward nominal wage rigidities. While all these works focus on the supply side of the economy as a source of non-linearities, my paper attempts to extend the analysis by adding a realistic demand block from the canonical Heterogeneous Agent New Keynesian model (HANK, see Kaplan et al., 2018). Empirical studies documenting supply-side non-linearities include Benigno and Eggertsson (2023), Benigno and Eggertsson (2024), and Ahlander et al. (2024).

There are numerous empirical works studying how stabilization policies depend on the level of economic slack. In that context, Auerbach and Gorodnichenko (2012), Owyang et al. (2013), and Ramey and Zubairy (2018) analyze patterns related to the effectiveness of fiscal policy. Empirical evidence on state-dependent monetary policy is mixed: Weise (1999), Peersman and Smets (2002), Lo and Piger (2005), Kopiec and Walerych (2025) find that monetary policy stabilizes output and employment more effectively during crises and periods of high economic slack. In contrast, works by Tenreyro and Thwaites (2016), Burgard et al. (2019), Jorda et al. (2020), and Alpanda et al. (2021) reach the opposite conclusion.

In a related paper, Bielecki et al. (2025) combine the standard New Keynesian model with the Diamond-Mortensen-Pissarides framework to examine how monetary policy in Poland depends on unemployment. My work extends their analysis by including incomplete insurance markets and uninsured unemployment risk which, as documented by Kolsrud et al. (2018), Gross et al. (2020), and Sokolova (2023), can significantly influence the consumption behavior of households. In addition to my exploration, Bielecki et al. (2025) estimate the stochastic processes driving the economic fluctuations in the Polish economy in years 1995-2024.

3 Model

3.1 General Description of the Model

Time is infinite and divided into discrete periods. The economy consists of heterogeneous households with a total mass of one (also referred to as consumers/workers). Other agents in the economy include competitive retailers, monopolistically competitive firms (producers), and the government, which comprises both fiscal and monetary authorities.

The model features three markets: a Walrasian market for government bonds (i.e., liquid assets), a consumption goods market with sticky prices, and a frictional labor market, following the standard Diamond-Mortensen-Pissarides framework. Households experience uninsured idiosyncratic shocks to their productivity levels and labor status, meaning they are either employed or unemployed.

3.2 Preferences and Technology

Consumers derive utility from consumption. The instantaneous utility function u satisfies $u' > 0$, $u'' < 0$, and the Inada conditions. Factor $\beta \in (0,1)$ is used by households to discount future utility streams. The production technology, F, used by firms to manufacture consumption goods is linear, with effective labor as the sole input.

3.3 Frictional Labor Market

The mass of job matches, M_t, in period t is determined by a matching technology that combines households (that are jobless at the beginning period of period t) with aggregate vacancies, v_t, posted by manufacturers. The number of jobless households at the start of period t is given by:

$$1 - (1 - \hat{s}) \cdot N_{t-1}$$

where N_{t-1} represents the measure of employed workers participating in the production of consumption goods in period $t-1$. The parameter $\hat{s} \in (0,1)$ denotes the exogenous job separation rate.

The matching technology follows a Cobb-Douglas specification:

$$M_t = A \cdot (1 - (1 - \hat{s}) \cdot N_{t-1})^{\alpha} \cdot v_t^{1-\alpha}$$

where $A > 0$ and $\alpha \in (0, 1)$ are parameters.

Labor market tightness is defined as:

$$x_t \equiv \frac{v_t}{1 - (1 - \hat{s}) \cdot N_{t-1}}$$

and the job-finding rate and the vacancy-filling rate are given by:

$$f_t = f(x_t) = \frac{M_t}{1 - (1 - \hat{s}) \cdot N_{t-1}}, \quad q_t = q(x_t) = \frac{M_t}{v_t},$$

respectively.

The law of motion for aggregate employment reads:

$$N_t = (1 - \hat{s}) \cdot N_{t-1} + M_t.$$

For further analysis, it is useful to define effective separations as:

$$S_t \equiv \hat{s} \cdot (1 - f_t) \tag{1}$$

For clarity, let us elaborate on the timeline of the events on labor market: at the end of period $t - 1$, employed households are separated from their jobs with probability $\hat{s} \in (0, 1)$. Next, at the beginning of period t, these separated workers are pooled together with those who were unemployed in period $t - 1$ (whose mass is equal to $1 - N_{t-1}$). Next, the process of job creation occurs which results in new matches M_t. Subsequently, the employed manufacture goods and the unemployed do not participate in the production.

3.4 Households

Consumers are subject to two types of Markovian idiosyncratic shocks. The first type consists of exogenous changes to household-level labor productivity, z_t. The second type pertains to changes in labor status, which are influenced by endogenous fluctuations in the job-finding rate, f_t.

As in the standard Diamond-Mortensen-Pissarides model, labor supply is inelastic, and the number of time units supplied by households is standardized to unity. A worker enters period t with a stock of bonds b_t. The labor status of a household in period t, denoted by h_t, is either $\bar{u}$ (if unemployed) or $\bar{e}$ (if employed).

Employed individuals earn income y_t given by $w_t \cdot z_t$, where w_t is the mean real wage in the economy. Unemployed individuals receive income y_t, which consists of an unemployment benefit equal to $\mu_t \cdot w_t$, where $\mu_t \in (0, 1)$ is the replacement rate set by the government. The unemployment benefit is uniform across all unemployed consumers and independent of individual characteristics, reflecting the structure of Poland's unemployment insurance system. Individual income y_t is taxed at rate $T_t(y_t)$.

Households allocate their available resources (i.e., savings and income) to purchasing consumption goods c_t and accumulating liquid assets b_{t+1}. As in the canonical model of uninsured idiosyncratic risk by Aiyagari (1994), there is a liquidity constraint:

$$b_{t+1} \geq -\bar{b},$$

where $\bar{b} \geq 0$ is a constant.

The nominal interest rate on government bonds is denoted by i_t, and Π_t represents the ratio of the price of consumption goods in period t to that in period $t-1$, with P_t and P_{t-1} denoting the respective price levels. The real interest rate R_t is defined as:

$$R_t \equiv \frac{1 + i_{t-1}}{\Pi_t}.$$

A worker employed in period t becomes unemployed in period $t+1$ with probability S_{t+1}, while an unemployed household in period t gains employment in period $t+1$ with probability f_{t+1}.

Given these conditions, the maximization problem of a consumer with asset holdings b_t, productivity level z_t, and labor market status h_t can be formalized using the following Bellman equation:

$$V_t(h_t, z_t, b_t) = \max_{c_t,\, b_{t+1}} \Big\{ u(c_t) + \mathbb{I}_{\{h_t = \bar{e}\}} \cdot \beta \cdot \mathbb{E}_t \left[(1 - S_{t+1}) \right. \tag{2}$$

$$\left. \cdot V_{t+1}(e, z_{t+1}, b_{t+1}) + S_{t+1} \cdot V_{t+1}(u, z_{t+1}, b_{t+1}) \right]$$

$$+\mathbb{I}_{\{h_t=\bar{u}\}} \cdot \beta \cdot \mathbb{E}_t \left[f_{t+1} \cdot V_{t+1}\left(e, z_{t+1}, b_{t+1}\right) \right.$$

$$\left. + \left(1 - f_{t+1}\right) \cdot V_{t+1}\left(u, z_{t+1}, b_{t+1}\right) \right] \}$$

subject to:

$$\begin{cases} c_t & +b_{t+1} & = R_t \cdot b_t + \left(1 - T_t\left(y_t\right)\right) \cdot y_t \\ b_{t+1} & \geq -\bar{b} \end{cases}$$

where:

$$y_t = y\left(h_t, z_t\right) = \begin{cases} w_t \cdot z_t & \text{if } h_t = \bar{e} \\ \mu_t \cdot w_t & \text{if } h_t = \bar{u} \end{cases}$$

where V_t is the time-dependent value function and $\mathbb{I}$ is the indicator function.

Households take variables f_{t+1}, S_{t+1},R_t, w_t, μ_t and the tax scheme T_t as given. As in Guerrieri and Lorenzoni (2017), by $c_t\left(h, z, b\right)$ and $b_{t+1}\left(h, z, b\right)$ I denote policy rules of a worker featuring individual state variables $h_t = h$, $z_t = z$, $b_t = b$.

3.5 Retailers

Identical and competitive retailers buy intermediate goods $\left\{Y_{j,t}\right\}_{j\in[0,1]}$(varieties) produced by manufacturers, indexed by $j \in [0, 1]$. Retailers use the packaging technology described by the Dixit-Stiglitz aggregator:

$$Y_t = \left(\int_0^1 Y_{t,j}^{1-\frac{1}{\gamma}} dj \right)^{\frac{1}{1-\frac{1}{\gamma}}}$$

to produce a uniform consumption good, which is subsequently sold to consumers. The parameter $\gamma > 1$ denotes the elasticity of substitution between intermediate goods.

Retailers choose varieties $\left\{Y_{j,t}\right\}_{j\in[0,1]}$ to maximize their profits:

$$P_t \cdot Y_t - \int_0^1 P_{j,t} \cdot Y_{j,t} dj,$$

where $P_{j,t}$ is the price of a variety manufactured by firm j. The necessary condition reads:

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\gamma} \cdot Y_t \tag{3}$$

which determines the demand faced by the producer of intermediate good j. The economy-wide price level P_t is given by:

$$P_t = \left(\int_0^1 P_{j,t}^{1-\gamma} dj\right)^{\frac{1}{1-\gamma}}.$$

.

3.6 Producers

Manufacturers are indexed by $j \in [0,1]$ and produce intermediate goods. To integrate the Diamond-Mortensen-Pissarides model with the canonical model of uninsured idiosyncratic income risk, I follow Gornemann et al. (2016). Specifically, it is assumed that firms cannot discriminate between workers with different productivity. In other words, producer j employs effective labor $\mathbb{E}_z z_t N_{j,t}$ where $N_{j,t}$ is the number of workers in firm j.

The average labor productivity is standardized to one and manufacturer j produces variety $Y_{j,t}$ using technology F with effective labor $\mathbb{E}_z z_t N_{j,t}$:

$$Y_{j,t} = F\left(\mathbb{E}_z z_t N_{j,t}\right) = \mathbb{E}_z z_t N_{j,t} = N_{j,t}.$$

To introduce inflation persistence in the model, I follow Gali and Gertler (1999) and assume that there are two types of firms: backward-looking firms, indexed by $j \in [0, \Lambda^B]$, and standard forward-looking manufacturers, known from the textbook New Keynesian model, indexed by $j \in (\Lambda^B, 1]$. The firm-level variables of the former have superscripts B and the latter are denoted by F.

As in Gali and Gertler (1999), it is assumed that backward-looking firms set prices according to the following rule:

$$P_{j,t}^B = P_{t-1} \cdot \Pi_{t-1}$$

and their production level is then determined by equation (3):

$$Y_{j,t}^B = \left(\frac{P_{j,t}^B}{P_t}\right)^{-\gamma} \cdot Y_t.$$

Given the linear production technology, we have $N^B_{j,t} = Y^B_{j,t}$ which, together with the law of motion for labor, determines the vacancy-posting decision of the backward-looking firm:

$$v^B_{j,t} = \frac{N^B_{j,t} - (1-\hat{s}) \cdot N^B_{j,t-1}}{q_t}.$$

Let us now turn to forward-looking firms. Instead of using the price-setting protocol based on Calvo (1983) (as it is the case in Gali and Gertler, 1999), I follow Rotemberg (1982) by assuming that price-setting decisions are subject to quadratic adjustment costs proportional to the total output generated by all forward-looking firms N^F_t:

$$\frac{\phi}{2} \cdot \left(\frac{P^F_{j,t} - P^F_{j,t-1}}{P^F_{j,t-1}}\right)^2 \cdot N^F_t$$

where $\phi > 0$ is a constant. Following Hagedorn et al. (2019a), I assume that these costs take the so-called "as-if" form, meaning they do not influence firm's actual profits, but producers optimize their behavior as if they did. Hagedorn et al. (2019a) introduced this assumption to prevent unrealistic "price-adjustment booms" associated with significant price adjustment costs when large price movements occur at the zero lower bound. I adopt this assumption in this paper for analogous reasons, as I use global methods to study transition dynamics resulting from potentially large shocks.

Forward-looking firms optimize subject to demand curves (equation (3)) and the law of motion for labor:

$$N^F_{j,t} = (1-\hat{s}) \cdot N^F_{j,t-1} + q_t \cdot v^F_{j,t} \tag{4}$$

Symmetrically to price adjustment costs, it is assumed that vacancy posting is also "as-if".

All this implies that the firm's profits $d^F_{j,t}$ are given by:

$$d^F_{j,t} \equiv \frac{P^F_{j,t}}{P_t} \cdot Y^F_{j,t} - \mathbb{E}_z z_t \cdot w_t \cdot N^F_{j,t} - \Psi \tag{5}$$

where $\Psi > 0$ is a fixed cost. Note that $d^B_{j,t}$ is defined analogously.

Forward-looking producers discount future profits and "as if" costs using real interest rates, leading to the following maximization problem:

$$\max_{\left\{v^F_{j,t},P^F_{j,t},Y^F_{j,t},N^F_{j,t},d^F_{j,t}\right\}_{t=0}^{+\infty}} \mathbb{E}_0 \left[\sum_{t=0}^{+\infty} \prod_{s=0}^{t} \left(\frac{1}{R_s}\right) \cdot \left(d^F_{j,t} - \kappa \cdot v^F_{j,t} - \frac{\phi}{2} \cdot \left(\frac{P^F_{j,t} - P^F_{j,t-1}}{P^F_{j,t-1}}\right)^2 \cdot N^F_t\right)\right] \tag{6}$$

subject to:

$$\begin{aligned} Y^F_{j,t} &= \left(\frac{P^F_{j,t}}{P_t}\right)^{-\gamma} \cdot Y_t \\ N^F_{j,t} &= (1-\hat{s}) \cdot N^F_{j,t-1} \quad + q_t \cdot v^F_{j,t} \\ Y^F_{j,t} &= \mathbb{E}_z z_t N^F_{j,t} \\ d^F_{j,t} &= \frac{P^F_{j,t}}{P_t} \cdot Y^F_{j,t} \quad - w_t \cdot N^F_{j,t} \quad - \Psi \end{aligned}$$

where $\left\{P_t, Y_t, N^F_t, q_t, w_t, R_t\right\}_{t=0}^{+\infty}$ are taken as given.

I consider a symmetric equilibrium in which all forward-looking firms are identical (i.e., all firm-level variables can be replaced with the corresponding aggregates). This leads to the following first-order condition at the aggregate level:

$$\begin{aligned} &(1-\gamma) \cdot \left(\frac{P^F_t}{P_t}\right)^{1-\gamma} + w_t \cdot \gamma \cdot \left(\frac{P^F_t}{P_t}\right)^{-\gamma} \\ &+\gamma \cdot \frac{\kappa}{q_t} \cdot \left(\frac{P^F_t}{P_t}\right)^{-\gamma} - \mathbb{E}_t\left[\frac{1}{R_{t+1}} \cdot \frac{\kappa \cdot (1-\hat{s}) \cdot \gamma}{q_{t+1}}\right] \cdot \left(\frac{P^F_t}{P_t}\right)^{-\gamma} \\ &= \phi \cdot \left(\Pi^F_t - 1\right) \cdot \Pi^F_t \cdot \frac{N^F_t}{N_t} - \mathbb{E}_t\left[\frac{1}{R_{t+1}} \cdot \phi \cdot \left(\Pi^F_{t+1} - 1\right) \cdot \Pi^F_{t+1} \cdot \frac{N^F_{t+1}}{Y_t}\right]. \end{aligned} \tag{7}$$

Consistency at the economy-wide level implies that:

$$N_t = \left(1-\Lambda^B\right) \cdot N^F_t + \Lambda^B \cdot N^B_t$$

$$v_t = \left(1-\Lambda^B\right) \cdot v^F_t + \Lambda^B \cdot v^B_t$$

$$P_t^{1-\gamma} = \left(1-\Lambda^B\right) \cdot \left(P^F_t\right)^{1-\gamma} + \Lambda^B \cdot \left(P^B_t\right)^{1-\gamma}$$

As in Hagedorn et al. (2019b), it is assumed that:

$$\forall_{j,t}\, d_t = \tau_{d,t}. \tag{8}$$

3.7 Government

The government consists of two branches: the central bank and a fiscal authority. The former sets the path of nominal interest rates $\{i_t\}_{t\geq 0}$ (as specified in Section 5) and the latter controls government debt B_{t+1}, the tax function $T_t(\cdot)$, and the replacement rate μ_t to balance the budget:

$$\tau_{d,t} + \int T_t\left(y\left(h,z\right)\right) d\pi_t\left(h,z,b\right) + B_{t+1} = \left(1 - N_t\right) \cdot \mu_t \cdot w_t + R_t \cdot B_t, \tag{9}$$

where $\pi_t\left(h,z,b\right)$ is the measure of consumers characterized by labor market status $h_t = h$, productivity $z_t = z$, and assets holdings $b_t = b$ in period t. The details of function $T_t(\cdot)$ are specified in Section 4.

3.8 Wage-setting

The bilateral monopoly situation faced by a worker and a firm after a successful match in the labor market requires an additional condition to determine the real wage w_t. There is a large body of literature providing different wage-setting protocols within the Diamond-Mortensen-Pissarides model. In this paper, I adopt the approach proposed by Den Haan et al. (2018) and assume that the real wage w_t satisfies the following condition:[1]

$$w_t = w_{t-1} \cdot \Pi_t^{\omega_\Pi - 1}. \tag{10}$$

where ω_Π is a parameter.[2]

[1] More precisely, Den Haan et al. (2018) specify nominal wage $\tilde{w}_t$ as:

$$\tilde{w}_t = \omega_0 \cdot \left(\frac{A_t}{\overline{A}}\right)^{\omega_A} \cdot \overline{A} \cdot \left(\frac{P_t}{\overline{P}_t}\right)^{\omega_\Pi} \cdot \overline{P}_t$$

where ω_0, ω_A, ω_Π are parameters, $\overline{A}$ is the average productivity level and A_t is the productivity level in period t. The trend of the price level is $\overline{P}_t$ and satisfies:

$$\overline{P}_t = \bar{\Pi}^t.$$

where $\bar{\Pi}$ is inflation rate in the stationary equilibrium. In the absence of productivity fluctuations we have $A_t = \overline{A} = 1$ implying equation (10) - see the Appendix for a derivation.

[2] Condition (10) can be viewed as a form of nominal wage rigidity (see the Appendix).

3.9 Market Clearing Conditions and Distribution Dynamics

Aggregate consumption C_t is given by:

$$C_t = \int c_t\left(h, z, b\right) d\pi_t\left(h, z, b\right).$$

The resource constraint for manufactured goods is:

$$C_t + \Psi = Y_t. \tag{11}$$

The market-clearing condition for government bonds reads:

$$B_{t+1} = \int b_{t+1}\left(h, z, b\right) d\pi_t\left(h, z, b\right).$$

In equilibrium, the number of filled vacancies is equal to the mass of hired workers:

$$q_t \cdot v_t = f_t \cdot \left(1 - (1 - \hat{s}) \cdot N_{t-1}\right).$$

The distribution of households across labor status, labor productivity, and asset holdings evolves according to the following law of motion:

$$\pi_{t+1}\left(\bar{e}, z', \mathcal{B}'\right) = (1 - S_{t+1}) \cdot \int_{\{b\colon b_{t+1}(\bar{e},z,b)\in\mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t\left(\bar{e}, z, b\right) \tag{12}$$

$$+ f_{t+1} \cdot \int_{\{b\colon b_{t+1}(\bar{u},z,b)\in\mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t\left(\bar{u}, z, b\right)$$

$$\pi_{t+1}\left(\bar{u}, z', \mathcal{B}'\right) = S_{t+1} \cdot \int_{\{b\colon b_{t+1}(\bar{e},z,b)\in\mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t\left(\bar{e}, z, b\right) \tag{13}$$

$$+ (1 - f_{t+1}) \cdot \int_{\{b\colon b_{t+1}(\bar{u},z,b)\in\mathcal{B}'\}} \mathbb{P}(z'|z) d\pi_t\left(\bar{u}, z, b\right)$$

where $\mathcal{B}'$ is a Borel subset of $[-\bar{b}, +\infty)$ and $\mathbb{P}(z'|z)$ is the probability of transition from state characterized with productivity z to state z'.

Finally, I standardize the mass of households to unity:

$$\int d\pi_t\left(h, z, b\right) = 1. \tag{14}$$

3.10 Equilibrium

The equilibrium of the model is defined as follows:

Definition. *Given an initial government debt level* B_0*, initial distribution* π_0*, exogenous sequences* $\{B_{t+1},\ \mu_t,\ i_t\}_{t\geq 0}$*, an equilibrium is: paths of prices* $\{R_t,\ \Pi_t,\ w_t\}_{t\geq 0}$*, sequences* $\{Y_t,\ q_t,\ f_t,\ N_t,\ v_t,\ d_t, \tau_{d,t},\ T_t,\ S_t,\ C_t\}_{t\geq 0}$*, individual policy and value functions* $\{c_t\ (h,\ z,\ b)\}_{t\geq 0}$*,* $\{b_{t+1}\ (h,\ z,\ b)\}_{t\geq 0}$*,* $\{V_t\ (h,\ z,\ b)\}_{t\geq 0}$*, distributions of households* $\{\pi_t\ (h,\ z,\ b)\}_{t\geq 0}$ *such that: households, retailers and producers optimize, government budget constraint holds, wage-setting rule, consistency and market clearing conditions hold.*

4 Calibration

The period in the model is a quarter. I calibrate two versions: one representing the Polish economy during a period of high unemployment (1995–2009) and another reflecting the period of low unemployment (2010–2024). To isolate the impact of labor market conditions on the transmission of monetary policy, I assume that only the calibration targets related to the labor market differ between these two models. This results in three groups of parameters. The first group consists of parameters that influence labor market moments and, by definition, vary between the two versions. The second group includes parameters that do not target labor market moments but still differ between the models so that certain calibration targets are the same for both variants of the model. Finally, the third group comprises parameters that remain identical in both versions, ensuring consistency in aspects unrelated to labor market.

Let us begin with the first group of parameters, which includes the steady-state values of the real wage w, replacement ratio μ, vacancy posting cost κ, separation rate $\hat{s}$, matching efficiency A, and the steady state tax scheme T. The values of w are set to match the average labor income shares in the subperiods 1995-2009 and 2010-2024, as reported by Gradzewicz et al., 2024. The replacement ratios μ for the periods 1995-2009 and 2010-2024 are computed directly using data on average wages and unemployment benefits.[3] Importantly, when computing the value of μ for the subperiod 2010-2024, I account for the 2010 reform, which introduced unemployment benefits that decrease after 90 days following job loss.[4] The calibration targets for vacancy posting costs κ, separation rates $\hat{s}$ and matching efficiencies A for the periods 1995-2009 and 2010-2024 include average unemployment rates, job-finding rates (as reported by the Labor Force Survey), and labor market tightnesses. The number of vacancies used to compute labor market tightness is proxied by the indicator reported by BIEC.[5] Finally, labor income tax schemes T_t are approximated using the following function proposed by Feldstein (1969):

[3]The source of the former is the Social Insurance Institution (ZUS) and of the latter is https://wskazniki.gofin.pl/9,127,4353,1,zasilek-dla-bezrobotnych.html.

[4]In particular, I apply the properties of the geometric distribution when calculating the mean unemployment benefit.

[5]See the BOP indicator reported by BIEC: http://biec.org.

Table 1: Parameters targeting labor market conditions in subperiods 1995-2009 and 2010-2024

Parameter	Description	Value		Target	Value	
		$95-09$	$10-24$		$95-09$	$10-24$
w	Real wage in stationary equilibrium	0.56	0.54	Labor share	0.56	0.54
μ	Replacement rate in stationary equilibrium	0.22	0.18	Empirical equivalent of μ	0.22	0.18
κ	Vacancy posting cost	31.2	12.6	Unemployment rate	14.0%	6.1%
$\hat{s}$	Separation rate	0.017	0.011	Labor market tightness	0.035	0.192
A	Matching efficiency	0.49	0.32	Job-finding rate	0.092	0.142
τ	Parameter affecting the average after-tax income	0.94	0.96	Tax scheme	–	–
ι	Parameter affecting tax progressivity	0.011	0.005	Tax scheme	–	–

$$T_t(y) = 1 - \tau_t \cdot y^{-\iota} \tag{15}$$

where the parameter ι measures the progressivity of the taxation scheme. Specifically, I set τ (i.e., the steady state value of τ_t) and ι to approximate the tax schemes characterized by tax thresholds and the corresponding tax rates, while accounting for tax reforms that modified these thresholds over the years.[6] Table 1 summarizes this part of the calibration exercise.

Let us now consider the parameters with identical calibration targets (i.e., groups two and three described at the beginning of this section). The coefficient of relative risk aversion σ, is set to 2, a standard value in the literature. To approximate the AR(1) process governing labor productivity with a discrete-state-space Markov chain, I use the Rouwenhorst algorithm. The estimates of the AR(1) moments - autocorrelation ρ_z and the variance of the idiosyncratic shock σ_z^2 - are based on

[6] In 1995–1996 the tax rates for the corresponding thresholds were equal to 21%, 33% and 45%. In 1997 they were equal to 20%, 32% and 44%. Between 1998 and 2008 those rates amounted to 19%, 30% and 40%. Between 2009-2019, there were two thresholds with rates 18% i 32% that changed to 17% and 32% in years 2019-2022 and were equal to 12% and 32% in years 2022-2024. Moreover, the most significant change to the amount of income that is free of tax took place in 2022.

the quarterly counterparts of the annual estimates from Kolasa (2017) and are set to 0.97 and 0.008, respectively. The elasticity of the matching technology, denoted by α, is set to 0.5, following the standard value from Pissarides and Petrongolo (2001). The elasticity of substitution between varieties, γ, is set to 6, which implies a markup of 20%, as in Bielecki et al. (2022). The parameter ϕ, which affects the price-adjustment cost, is set to 300, following Hagedorn et al. (2019b). The mass of backward-looking firms, Λ^B, is set to 0.38. This value is derived from the formula in Gali and Gertler (1999) using data on: i) the proportion of Polish firms that do not reset their prices in a given period (72.5%, as reported by Macias and Makarski (2013)), and ii) the backward-looking parameter related to past inflation in the hybrid NKPC curve, estimated by Łyziak (2019) at 0.347.[7] The OLS estimation allows for determining the value of $\omega_\Pi = 0.58$ in equation (10).[8] To match the data on wealth inequality, I assume that there two groups of households of equal size: the first group features $\beta = \beta^H$ (more patient consumers), and the second group exhibits $\beta = \beta^L$ (impatient workers). I set β^H to match the annual real interest rate of 2.64% (see Bielecki et al., 2023), and the distance between β^H and β^L is calibrated to capture the Gini index of wealth inequality (HFCS data in 2017) in the model featuring low unemployment. Following Hagedorn et al. (2019a), Ψ is set such that steady state operating profits are equal to 0. The steady-state level of real government debt $\bar{B}$ is set to match the debt-to-GDP ratio of 47.5%. Finally, the steady-state level of gross inflation is set to 1, so the nominal interest rate equals to $R - 1$ in the stationary equilibrium, and the parameter associated with a liquidity constraint $\bar{b}$ is standardized to 0 (see McKay and Reis, 2016). Given that the calibration of β^H, Ψ and $\bar{B}$ depends on endogenous moments generated by the model, their values are different for both variants (i.e., high vs. low unemployment) - i.e., they belong to the second group discussed in the first paragraph of this section.

[7] In particular, Macias and Makarski (2013) report that the average price duration is equal to 10.9 months (3.63 quarters) which implies the price-resetting probability of 0.275 implied by the geometric distribution. . The coefficient in ii) is obtained as the average of the four medians reported in his study.

[8] In the Appendix, I demonstrate how to compute this value using data on CPI inflation and nominal wages.

Table 2: Parameters targeting identical moments in the data

Parameter	Description	Value		Target
		95 − 09	10 − 24	
σ	Relative risk aversion	2	2	Standard value in the literature
ρ_z	Persistence of productivity shock	0.97	0.97	Estimates by Kolasa (2017)
σ_z^2	Variance of productivity shock	0.008	0.008	Estimates by Kolasa (2017)
α	Elasticity of matching technology	0.5	0.5	Pissarides and Petrongolo (2001)
γ	Elasticity of substitution	6	6	Bielecki et al. (2022)
ϕ	Price adjustment cost	300	300	Hagedorn et al. (2019b)
Λ^B	Proportion of backward-looking firms	0.38	0.38	Macias and Makarski (2013), Łyziak (2019)
ω_Π	Wage rigidity	0.58	0.58	OLS estimate
β^H	Discount factor of the patient	0.972	0.979	Real interest rate of 2.64%
$\beta^H - \beta^L$	Discount factors' difference	0.03	0.03	Wealth inequality in 2017
Ψ	Fixed cost	0.38	0.43	Hagedorn et al. (2019b)
$\bar{B}$	Real government debt	1.63	1.78	Debt to GDP of 47.5%
i	Nominal interest rate in the s.s.	0.66	0.66	Gross inflation equal to 1 in the s.s.
$\bar{b}$	Liquidity constraint	0	0	McKay and Reis (2016)

5 Quantitative analysis

5.1 Marginal propensities to consume

The values of MPCs play a crucial role in the propagation of macroeconomic shocks and policies. As noted in Gross et al. (2020) and Sokolova (2023), the aggregate MPC tends to be higher during periods of high unemployment. These findings are reflected in the model studied: the average MPC in the model calibrated to align with labor market data from 1995 to 2009 is 0.13, while the MPC in the model calibrated for the period between 2010 and 2024 is 0.10.[9] The MPC among the employed remains nearly the same across both subperiods (0.096 for 1995-2009 vs. 0.091 for 2010-2024), which implies that the difference in the aggregate MPCs is primarily driven by two factors: the composition of the population in those subperiods (i.e. different unemployment rates) and the difference in the MPCs between the unemployed in the period 1995-2009 and 2010-2024.

The difference in MPCs is more pronounced among the unemployed than among employed households. The average MPC for unemployed workers is 0.36 in the 1995-2009 period and 0.30 in 2010-2024. The primary factor explaining this discrepancy can be understood by examining the differences in wealth distributions among the unemployed between these subperiods (see Figure 8 in the Appendix). In the 1995-2009 period, there is a notably higher number of liquidity-constrained households, whose MPCs are close to unity. This shift can be attributed to a larger proportion of unemployed consumers clustered around $-\bar{b}$. The key reason for this difference lies in the average unemployment spell: between 1995 and 2009, it lasted 10.9 quarters, whereas it decreased to 7 quarters in 2010-2024. This suggests that, in the model calibrated to match the 1995-2009 period, the deaccumulation of savings during times of lower income (unemployment benefits) lasts longer, increasing the likelihood of becoming liquidity constrained.[10]

[9] To calculate these values, I follow the existing literature by computing the partial-equilibrium response of household consumption to a one-time transfer equivalent to 1% of the economy's average income.

[10] Additionally, note that the aggregate supply of assets, $\bar{B}$, is lower in the economy with higher unemployment (see the calibration exercise). This further reduces households' ability to self-insure against income shocks in the high-unemployment scenario.

The compositional effect also plays a significant role in explaining the difference between average MPCs. The proportion of unemployed households with relatively high MPCs is more than twice as large in 1995-2009, which corresponds to an average unemployment rate of 14.0%, compared to just 6.1% in the 2010-2024 period.

5.2 The aggregate response to a monetary policy shock

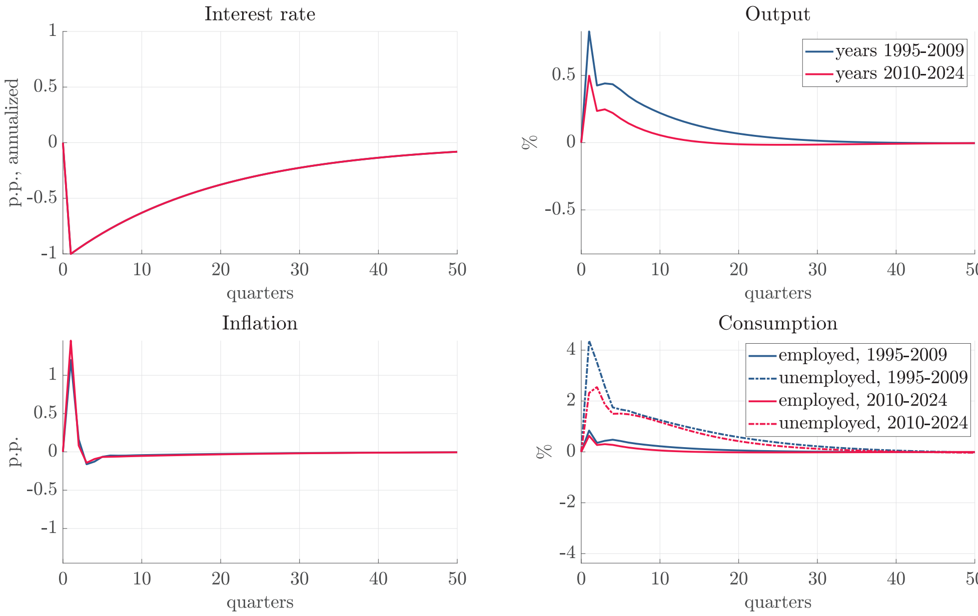
This section examines the response of key economic aggregates to an accommodative monetary policy shock. Specifically, I analyze an unexpected 1 percentage point (p.p.) drop in nominal interest rates (on an annual basis) that occurs in period 1. It is assumed that the economy is in a stationary equilibrium in period 0, and that after the shock, agents have perfect foresight regarding the future evolution of aggregate variables. Additionally, it is assumed that the autocorrelation of nominal interest rates along the transition path, denoted by ϕ_I, is 0.95.

Figure 2 presents the results for the two models: one with high unemployment (1995-2009) and the other with low labor market slack (2010-2024). Monetary accommodation leads to a significantly higher output response in the former model (0.83% vs. 0.50% on impact). In contrast, the price response is more pronounced when labor market slack is low—inflation increases by 1.45% in this case on impact, compared to a 1.20% rise when unemployment is high. These results align with the textbook intuition regarding the convex AS curve: price adjustments are more substantial when labor market slack is low, while the opposite holds for output adjustments.[11]

According to the economy-wide resource constraint (equation (11)), understanding the response of output requires examining the reaction of consumption. To this end, the bottom-right panel of Figure 2 decomposes household demand and presents separate impulse responses for the consumption of employed workers and the unemployed. It is evident that while the response of employed workers' consumption is relatively similar across both model variants (0.84% when unemployment is high and 0.63% when unemployment is low), the difference is more pronounced for the unemployed: they increase their spending by 4.37% in the model calibrated to the

[11] Note that the model predicts a more persistent reaction of output than inflation, while they both adjust sluggishly according to the SVAR evidence reported by Greszta et al., 2023.

Figure 2: The effects of an accommodative monetary policy shock: main economic aggregates



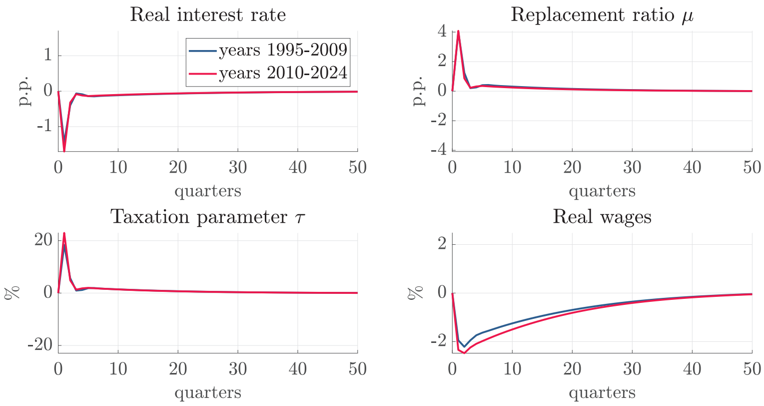
Notes: The top-left panel illustrates the exogenous change in monetary policy, which is identical across both unemployment regimes. The remaining panels depict the endogenous responses of macroeconomic variables. Responses from the model calibrated to the period 1995–2009 are shown in blue, while those corresponding to the years 2010–2024 are in red. Additionally, the bottom-right figure differentiates between the consumption of unemployed households (dashed lines) and employed households (solid lines).

1995-2009 period, compared to 2.32% in the model calibrated to 2010-2024.[12] This difference is partly driven by the fact that the unemployed in the 1995-2009 period have a higher MPC than those in the 2010-2024 period (see subsection 5.1).

To further explore the factors influencing the response of household demand, Figure 3 shows the evolution of aggregate variables that directly affect the household maximization problem (see equation (2)), which determines the optimal consumption at the individual level. First, the combined increase in inflation and decrease in nominal interest rates leads to a drop in real interest rates, which is more pronounced in the model with low unemployment (a 1.7% decrease) compared to the model calibrated for the 1995-2009 period (a 1.4% decrease). Lower real interest

[12]Note that these numbers do not sum to the aggregate output response (after weighting by the proportions of unemployed and employed households) due to the presence of the fixed cost in the resource constraint.

Figure 3: The effects of an accommodative monetary policy shock: variables affecting household maximization problem



Notes: The panels illustrate the endogenous responses of macroeconomic variables to the monetary policy change shown in the top-left panel of Figure 2. Responses from the model calibrated to the period 1995–2009 are depicted in blue, while those for the years 2010–2024 are shown in red.

rates stimulate private consumption through intertemporal substitution effects, but also reduce household demand due to a decline in interest income.

As monetary accommodation generates additional resources in the government budget - due to lower debt service costs, a reduced number of households receiving unemployment benefits, and higher corporate income tax revenues - balancing the budget requires adjustments in fiscal variables. In the numerical experiment conducted, it is assumed that the real value of public debt remains constant over time, with both τ_t and μ_t adjusting proportionally to maintain balance. This results in a 4 p.p. increase in the replacement ratio when unemployment is high (4.1 p.p. when unemployment is low), accompanied by a rise in τ_t that leads to lower tax rates T_t (see equation (15)). Lower tax rates and higher replacement ratios boost household consumption by increasing workers' disposable incomes (see the top-right and bottom-left panels in Figure 3).

Higher inflation results in lower real wages (see equation (10)), with the drop amounting to -1.9% in the model with high unemployment and -2.3% in the model with low unemployment. This decrease in real wages leads to lower labor incomes (and lower unemployment benefits), which, in turn, reduces private spending.

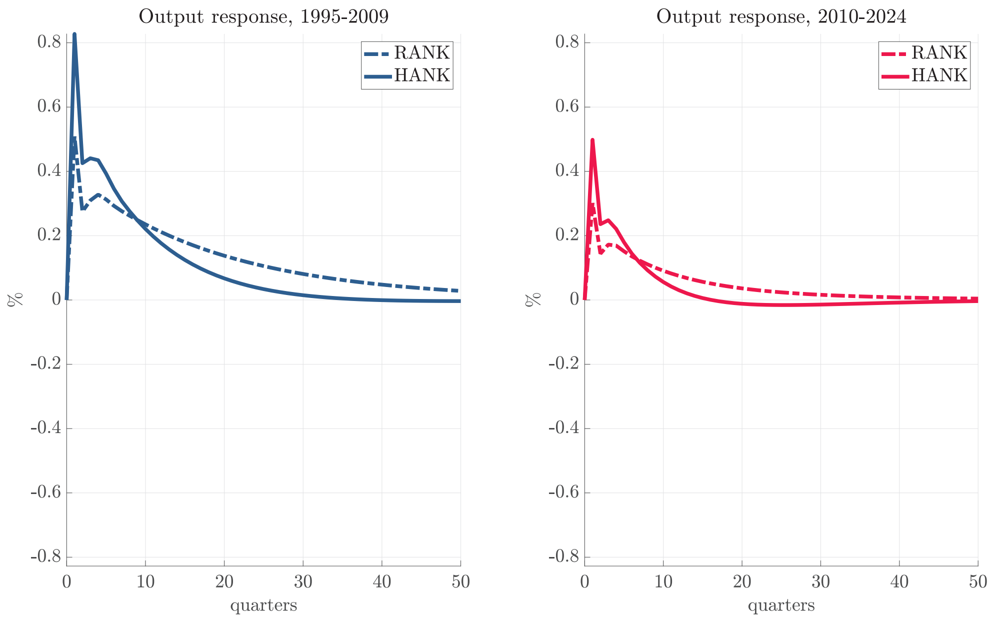
The final variable related to the household maximization problem is the job-finding rate. As shown in Figure 9 in the Appendix, the job-finding rate rises significantly in period 1, then falls below its steady-state value in period 2. Although it deviates positively from its steady-state value thereafter, this deviation is relatively small. It is important to note that the evolution of job-finding rates has two distinct effects on consumption in period 1. First, as equation (2) demonstrates, the future path of job-finding rates (i.e., for periods 2 and beyond) influences individual consumption decisions via effective separation rates (see condition (1)). Second, as indicated by the law of motion for households (see equations (12) - (13)), higher job-finding rates in period 1 alter the composition of agents in that period. Specifically, as the number of employed households rises (and the number of unemployed decreases), aggregate consumption grows because employed households tend to have higher consumption levels than the unemployed (see Figure 8 in the Appendix). The job-finding rate increases by 6.6 percentage points in period 1 in the model with low unemployment, while the corresponding figure for the model calibrated to the 1995-2009 period is 4.6 percentage points.

5.3 The role of uninsured idiosyncratic risk

As discussed in Section 2, incomplete markets in HANK prevent households from insuring against unemployment risk. This, along with the differences in consumption behavior between employed and unemployed individuals, motivates the numerical experiment in this subsection, which compares output responses in the baseline HANK model and in a model featuring complete insurance markets (i.e., the representative-agent New Keynesian model - RANK). Specifically, in the latter model, both unemployed and employed households operate under a consolidated budget constraint and have equal consumption levels.

Figure 4 presents the results. The left panel compares the responses of RANK and HANK in the high-unemployment regime. The output response in the baseline HANK model (0.83% on impact) is significantly reduced when the assumption of complete insurance markets is introduced, dropping to 0.51% in RANK. A similar propagation mechanism related to uninsured unemployment risk operates in the low-unemployment regime: under the representative-agent assumption, the output response decreases from 0.50% in HANK to 0.30% in RANK. These findings suggest that incomplete markets play a crucial role in the propagation of monetary policy shocks in the baseline model.

Figure 4: The output effects of the monetary accommodation: RANK vs. HANK



Notes: The left panel illustrates the response of output to the monetary policy change shown in the top-left panel of Figure 2 in the HANK model (solid line) and the RANK model (dashed line) under the high unemployment regime. The right panel presents the corresponding responses in the model with low unemployment.

Additionally, note that in the RANK model, aggregate demand - characterized by an identical aggregate MPC in both scenarios, equal to R^{-1} - remains unchanged across high- and low-unemployment regimes. This implies that the differences between the corresponding IRFs in Figure 4 stem from supply-side variations. As discussed in the introduction, these differences arise from firms' ability to hire workers, which depends on the unemployment rate.

5.4 Welfare

Let us now examine the welfare consequences of changes in policy rates. To analyze this, I apply the methodology developed by Benabou (2002), modified to account for the transitions induced by the frictional labor market. Specifically, consider the value of lifetime utility for an agent in period 1, before the job-creation process (discussed in subsection 3.3). This perspective allows me to capture the impact of the change in monetary policy in period 1 on the agent's labor market status during that period. For an agent with individual state variables $\{h, z, b\}$ in period 0, this value is given by:

$$\sum_{z'|z}\sum_{h'|h}\mathbb{P}(z'|z)\cdot\mathbb{P}(h'|h,f_1)\cdot V_1\left(h',z',b'\left(b,z\right)\right) \tag{16}$$

where $b'(b,z)$ is the asset accumulation policy in the stationary equilibrium, and $\mathbb{P}(h'|h,f_1)$ is the transition probability from labor market state h to labor market state h', given that the aggregate job-finding rate is f_1 in period 1. This setup allows us to define the consumption equivalent $\Omega_1(h,z,b)$, which solves the following equation:

$$\sum_{t=0}^{+\infty}\beta^t u\left(\Omega_1\left(h,z,b\right)\right)=\sum_{z'|z}\sum_{h'|h}\mathbb{P}(z'|z)\cdot\mathbb{P}(h'|h,f_1)\cdot V_1\left(h',z',b'\left(b,z\right)\right).$$

Similarly, one can define the consumption equivalent for an agent with individual state variables $\{h, z, b\}$ in a counterfactual scenario without aggregate shocks (i.e., in the stationary equilibrium):

$$\sum_{t=0}^{+\infty}\beta^t u\left(\Omega\left(h,z,b\right)\right)=\sum_{z'|z}\sum_{h'|h}\mathbb{P}(z'|z)\cdot\mathbb{P}(h'|h,f)\cdot V\left(h',z',b'\left(b,z\right)\right)$$

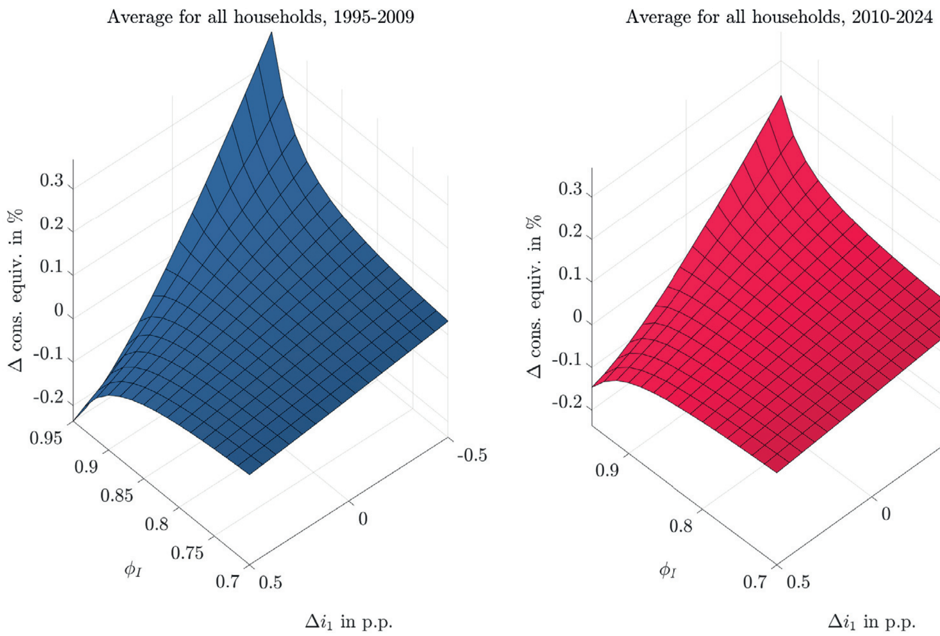
where f is the steady-state value of the job-finding rate, and V is the value function in the stationary equilibrium.

Given the definitions of $\Omega_1(h,z,b)$ and $\Omega(h,z,b)$, we can now define the aggregate change in welfare resulting from the monetary policy change in period 1:

$$\int\left[\frac{\Omega_1\left(h,z,b\right)-\Omega\left(h,z,b\right)}{\Omega\left(h,z,b\right)}\right]d\pi\left(h,z,b\right) \tag{17}$$

where π is the distribution of agents in the stationary equilibrium. Term (17) summarizes the change in lifetime consumption streams (expressed as a percentage) induced by the monetary policy change, averaged over all households. To further examine who benefits and who loses from a monetary accommodation, I also analyze expressions analogous to (17) for several subgroups of households: the unemployed, the employed, those in the bottom 20% of the consumption equivalent distribution, and those in the top 20%.

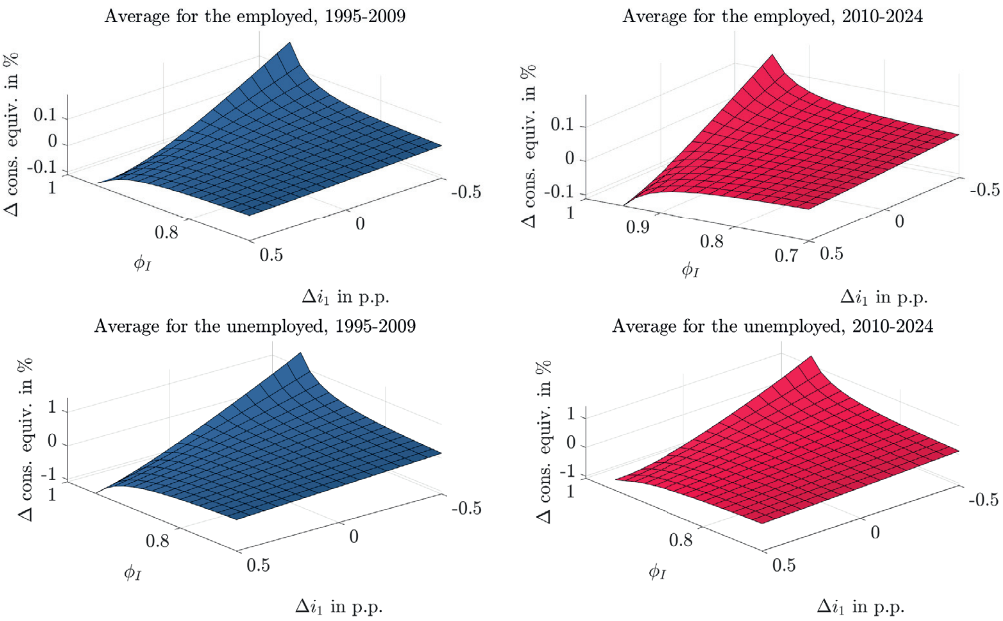
Figure 5: The welfare effects of changes to monetary policy: aggregate



Notes: The left panel illustrates the change in aggregate welfare (measured by the average consumption equivalent) driven by the monetary policy change shown in the top-left panel of Figure 2 under the high unemployment regime. Aggregate welfare changes are plotted as a function of two parameters characterizing the monetary policy shift: the size of the initial change in period 1, Δi_1, and the persistence of the change, ϕ_I. The right panel presents the corresponding changes in the model with low unemployment.

Figure (5) shows the average change in consumption equivalent driven by the monetary shock as a function of two key parameters associated with the central bank's policy: the size of the shock in period 1 (Δi_1, measured in percentage points) and the persistence of the change (ϕ_I, measuring the pace at which the nominal rate returns to its steady-state value). It also compares the model calibrated to the 1995-2009 period with the model for 2010-2024. First, note that the welfare changes are qualitatively similar for both high and low unemployment regimes, though they appear to be more pronounced in the former. For instance, a 0.5 percentage point drop in nominal rates with an autocorrelation of 0.95 leads to a 0.37% increase in welfare when unemployment is high, compared to 0.22% when unemployment is low. Second, less persistent changes in nominal rates have negligible welfare effects compared to more persistent shocks. Specifically, as noted, a 0.5 percentage point drop in interest rates in the model with high unemployment raises welfare by 0.37%

Figure 6: The welfare effects of changes to monetary policy: employed and unemployed households

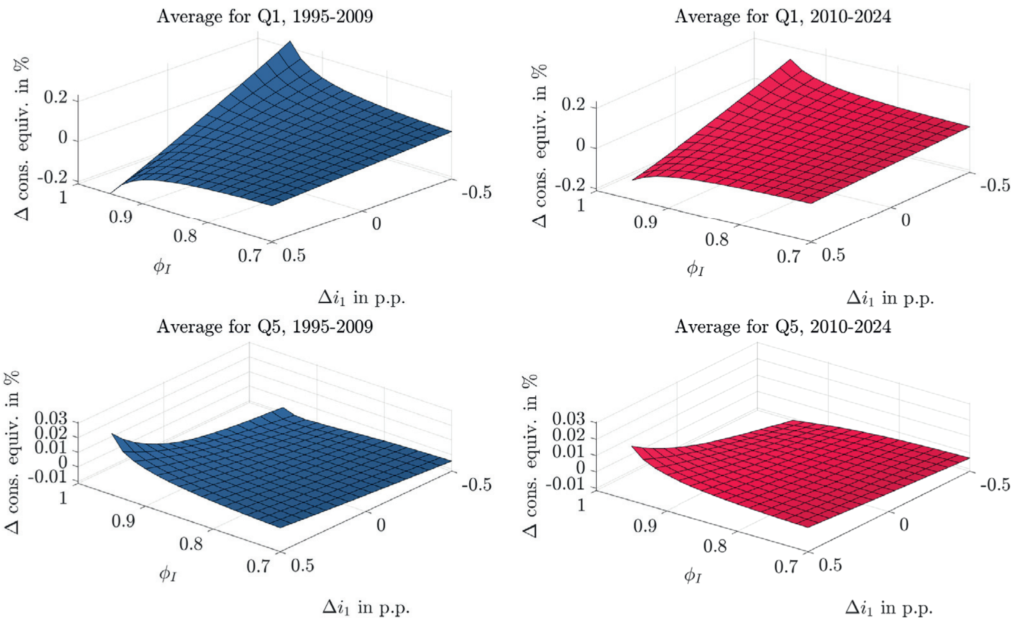


Notes: The top-left panel illustrates the change in welfare, measured by the average consumption equivalent among the employed, resulting from the monetary policy shift depicted in the top-left panel of Figure 2 under the high-unemployment regime. Welfare changes are shown as a function of two parameters characterizing the policy shift: the size of the initial change in period 1, Δi_1. The bottom-left panel presents the corresponding welfare changes for the unemployed. Similarly, the top-right and bottom-right panels display the analogous welfare changes in the low-unemployment regime for the employed and unemployed, respectively.

when the autocorrelation is 0.95, but only by 0.03% when the autocorrelation is 0.7. A similar pattern is observed when unemployment is low. Third, in both unemployment regimes, monetary policy changes have asymmetric effects: they are more pronounced in the case of accommodation than in the case of contraction. For example, when unemployment is low, a 0.5 percentage point drop in the policy rate with persistence equal to 0.95 leads to a 0.22% increase in welfare, which is considerably larger (in absolute terms) than the 0.15% decrease in welfare resulting from the corresponding contraction.

Let us now analyze the welfare consequences of monetary policy for employed and unemployed households. As shown in Figure 6, welfare changes are more pronounced in the high-unemployment regime than in the low-unemployment one for

Figure 7: The welfare effects of changes to monetary policy: top and bottom quintiles of the consumption equivalent distribution



Notes: The top-left panel illustrates the change in welfare, measured by the average consumption equivalent among households that belong to quintile 1 (of the distribution of consumption equivalents in the stationary equilibirum), resulting from the monetary policy shift depicted in the top-left panel of Figure 2 under the high-unemployment regime. Welfare changes are shown as a function of two parameters characterizing the policy shift: the size of the initial change in period 1, Δi_1. The bottom-left panel presents the corresponding welfare changes for quintile 5. Similarly, the top-right and bottom-right panels display the analogous welfare changes in the low-unemployment regime for quintile 1 and quintile 5, respectively.

both groups, mirroring the pattern observed for the overall population. The most striking difference, however, lies in the scale of these changes, which are nearly an order of magnitude larger for unemployed households compared to the employed. For instance, in the model calibrated for 2010-2024, a 0.5 percentage point interest rate drop with a persistence of 0.95 increases welfare by 1.3% for the unemployed but only by 0.15% for the employed. A similar magnitude of difference is observed in the high-unemployment period, where the corresponding welfare gains are 1.4% and 0.2%, respectively.

Finally, let us examine the welfare changes in the bottom and top quintiles of the household distribution based on their steady-state consumption equivalent Ω. As seen in Figure 7, and consistent with the patterns in Figures 5 and 6, welfare changes are more pronounced in the high-unemployment economy. Notably, however, welfare effects have opposite signs for quintile 1 (Q1) and quintile 5 (Q5). Specifically, households in Q5 experience a decline in welfare following monetary accommodation - a stark contrast to all previously analyzed cases. The explanation is intuitive: Q5 households typically hold substantial liquid assets, meaning that monetary accommodation reduces their interest income, thereby lowering their welfare. Additionally, in both high- and low-unemployment regimes, the absolute welfare change is significantly larger for Q1 than for Q5. For instance, in the high-unemployment regime, a 0.5 percentage point monetary accommodation with a persistence of 0.95 raises welfare by 0.24% for Q1 but decreases it by just 0.01% for Q5. This occurs because, as mentioned, Q5 households have larger liquid asset holdings, allowing them to buffer transitory monetary shocks and keep their consumption paths largely unaffected.

6 Conclusions

This paper has examined the non-linear relationship between monetary policy effects and the level of unemployment. To this end, I developed a HANK model with a frictional labor market, following the standard Diamond-Mortensen-Pissarides framework, and calibrated it to match Poland's high- and low-unemployment regimes (1995-2009 and 2010-2024, respectively). I then used the model to analyze the impact of monetary policy on economic aggregates and welfare under different unemployment conditions.

The results indicate that monetary policy has significantly larger output effects when unemployment is high, whereas price responses are more pronounced when unemployment is low. This finding aligns with standard macroeconomic intuition: when economic slack is high, adjustments to demand shocks primarily affect output, whereas when slack is low, adjustments occur mainly through prices. Additionally, by comparing the HANK model to its representative-agent counterpart, I underscore the role of uninsured unemployment and income risks in the transmission of monetary policy shocks. Lastly, I find that policy rate changes have varying welfare effects—both in magnitude and direction—depending on households' labor market status and consumption levels in the stationary equilibrium.

References

Ahlander, E., Klein, M., and Pappa, E. (2024). What flattens the supply curve? Technical report.

Aiyagari, S. R. (1994). Uninsured Idiosyncratic Risk and Aggregate Saving. *The Quarterly Journal of Economics*, 109(3):659–684.

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).

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

Benabou, R. (2002). Tax and Education Policy in a Heterogeneous-Agent Economy: What Levels of Redistribution Maximize Growth and Efficiency? *Econometrica*, 70(2):481–517.

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., Błażejowska, A., Brzoza-Brzezina, M., Kuziemska-Pawlak, K., and Szafrański, G. (2023). Estimates and projections of the natural rate of interest for Poland and the euro area. Technical report.

Bielecki, M., Brzoza-Brzezina, M., and Kolasa, M. (2022). Aging, Migration and Monetary Policy in Poland. *Gospodarka Narodowa. The Polish Journal of Economics*, (1):5–30.

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

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.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12(3):383–398.

Den Haan, W., Rendahl, P., and Riegler, M. (2018). Unemployment (Fears) and Deflationary Spirals. *Journal of the European Economic Association*, 16(5): 1281–1349.

Feldstein, M. S. (1969). The Effects on Taxation on Risk Taking. *Journal of Political Economy*, 77(5):755–764.

Gali, J. and Gertler, M. (1999). Inflation dynamics: A structural econometric analysis. *Journal of Monetary Economics*, 44(2):195–222.

Gornemann, N., Kuester, K., and Nakajima, M. (2016). Doves for the Rich, Hawks for the Poor? Distributional Consequences of Monetary Policy. International Finance Discussion Papers 1167, Board of Governors of the Federal Reserve System (U.S.).

Gradzewicz, M., Jabłonowski, J., Sasiela, M., and Żółkiewski, Z. (2024). Measuring labor share for Poland â does heterogeneity of labor compensation matter? Technical report.

Greszta, M., Humanicki, M., Kapuściński, M., Kleszcz, T., Kociecki, A., Kotłowski, J., Ledóchowski, M., Łesyk, M., Łyziak, T., Pipień, M., Popowski, P., Stanisławska, E., Szafranek, K., Szafrański, G., Ścibisz, D., Wesołowski, G., and Wróbel, E. (2023). Monetary policy transmission mechanism in Poland What do we know in 2023? Technical report.

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.

Guerrieri, V. and Lorenzoni, G. (2017). Credit Crises, Precautionary Savings, and the Liquidity Trap. *The Quarterly Journal of Economics*, 132(3):1427–1467.

Hagedorn, M., Luo, J., Manovskii, I., and Mitman, K. (2019a). Forward guidance. *Journal of Monetary Economics*, 102(C):1–23.

Hagedorn, M., Manovskii, I., and Mitman, K. (2019b). The Fiscal Multiplier. NBER Working Papers 25571, National Bureau of Economic Research, Inc.

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

Kaplan, G., Moll, B., and Violante, G. L. (2018). Monetary Policy According to HANK. *American Economic Review*, 108(3):697–743.

Kolasa, A. (2017). Life Cycle Income and Consumption Patterns in Poland. *Central European Journal of Economic Modelling and Econometrics*, 9(2):137–172.

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. and Walerych, M. (2025). Unemployment level and the non-linear effects of monetary policy in Poland. Technical report.

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.

Macias, P. and Makarski, K. (2013). Stylizowane fakty o cenach konsumenta w Polsce. Technical report.

McKay, A. and Reis, R. (2016). The Role of Automatic Stabilizers in the U.S. Business Cycle. *Econometrica*, 84:141–194.

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

Michaillat, P. and Saez, E. (2019). Optimal Public Expenditure with Inefficient Unemployment. *Review of Economic Studies*, 86(3):1301–1331.

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.

Pissarides, C. A. and Petrongolo, B. (2001). Looking into the Black Box: A Survey of the Matching Function. *Journal of Economic Literature*, 39(2):390–431.

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.

Rotemberg, J. J. (1982). Sticky Prices in the United States. *Journal of Political Economy*, 90(6):1187–1211.

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

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

Wage rule: derivation and estimation

The assumption $A_t = \overline{A} = 1$ is applied to reformulate the wage rule from Den Haan et al. (2018) ($\tilde{w}_t$ is nominal wage and ω_A, ω_0 are parameters):

$$\tilde{w}_t = \omega_0 \cdot \left(\frac{A_t}{\overline{A}}\right)^{\omega_A} \cdot \overline{A} \cdot \left(\frac{P_t}{\overline{P}_t}\right)^{\omega_\Pi} \cdot \overline{P}_t = \omega_0 \cdot \left(\frac{P_t}{\overline{P}_t}\right)^{\omega_\Pi} \cdot \overline{P}_t$$

Rewriting:

$$\begin{aligned}\tilde{w}_t = \omega_0 \cdot \left(\frac{P_t}{\overline{P}_t}\right)^{\omega_\Pi} \cdot \overline{P}_t &= \omega_0 \cdot \left(\frac{P_0 \cdot \Pi_1 \cdot \Pi_2 \cdot \ldots \cdot \Pi_t}{P_0 \cdot \bar{\Pi}^t}\right)^{\omega_\Pi} \cdot P_0 \cdot \bar{\Pi}^t \\ &= \omega_0 \cdot \left(\frac{P_0 \cdot \Pi_1 \cdot \Pi_2 \cdot \ldots \cdot \Pi_{t-1}}{P_0 \cdot \bar{\Pi}^{t-1}}\right)^{\omega_\Pi} \cdot P_0 \cdot \bar{\Pi}^{t-1} \cdot \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\omega_\Pi} \cdot \bar{\Pi} \\ &= \tilde{w}_{t-1} \cdot \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\omega_\Pi} \cdot \bar{\Pi}\end{aligned}$$

which in the analyzed stationary equilibrium in which $\bar{\Pi} = 1$ gives:

$$\tilde{w}_t = \tilde{w}_{t-1} \cdot (\Pi_t)^{\omega_\Pi}$$

which divided by P_t yields:

$$\frac{\tilde{w}_t}{P_t} = \frac{\tilde{w}_{t-1}}{P_t} \cdot \frac{P_{t-1}}{P_{t-1}} \cdot (\Pi_t)^{\omega_\Pi} \iff w_t = w_{t-1} \cdot (\Pi_t)^{\omega_\Pi - 1}$$

which is equation (10).

To estimate parameter ω_Π I reformulate the equivalent equation which is displayed above:

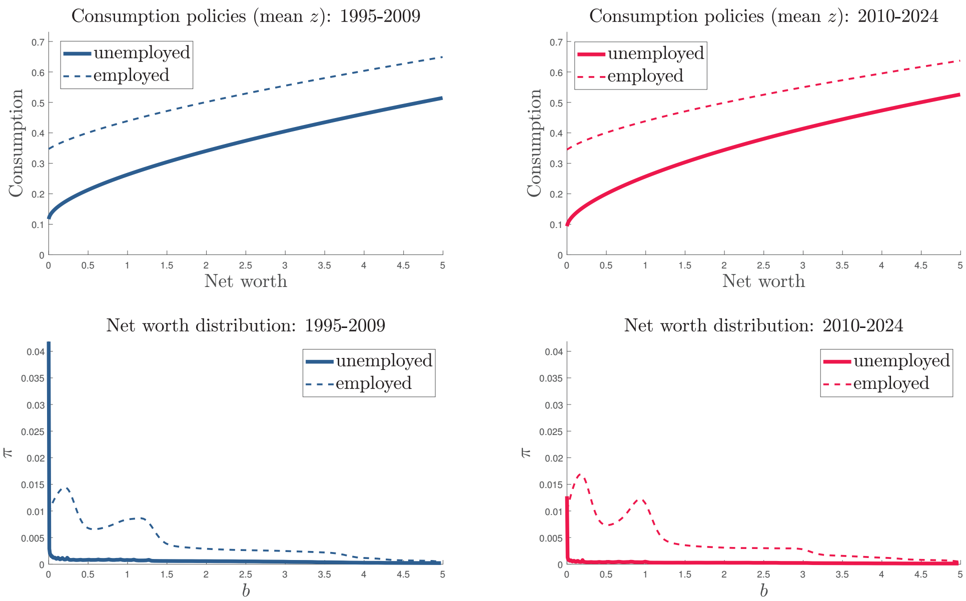
$$\tilde{w}_t = \tilde{w}_{t-1} \cdot (\Pi_t)^{\omega_\Pi}$$

$$\implies \log \tilde{w}_t - \log \tilde{w}_{t-1} = \omega_\Pi \cdot \left(\log \Pi_t - \log \bar{\Pi}\right)$$

I use the OLS to estimate the value of ω_Π.

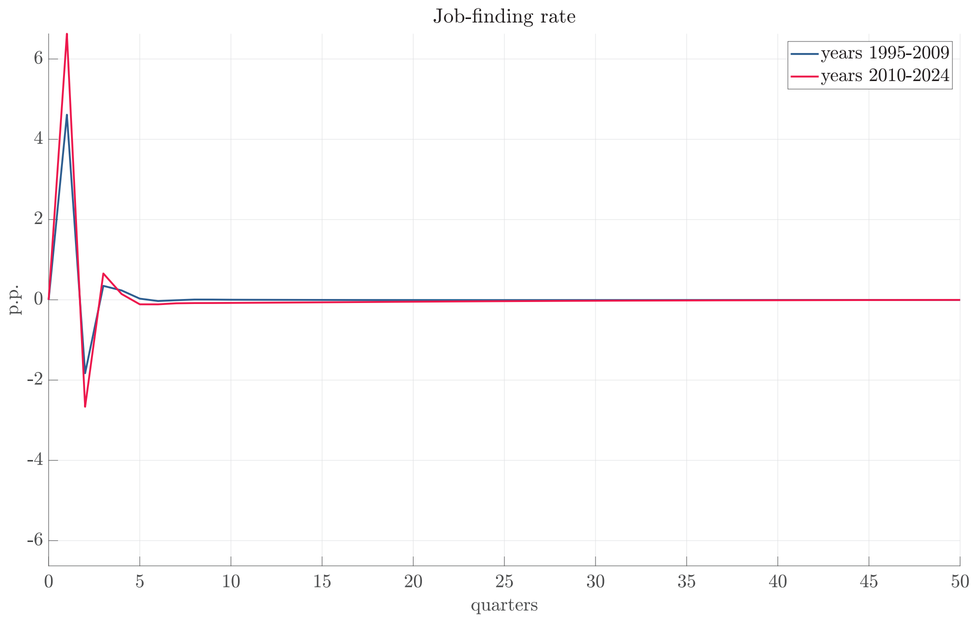
Additional figures

Figure 8: Consumption policies and wealth distributions



Notes: The top panels display the consumption policy functions for unemployed households (solid line) and employed households (dashed line). The bottom panels illustrate the net worth distributions for unemployed households (solid line) and employed households (dashed line).

Figure 9: Job-finding rate



Notes: The figure illustrates the endogenous responses of job-finding rates to the monetary policy change shown in the top-left panel of Figure 2. The response from the model calibrated to the period 1995–2009 is depicted in blue, while the one for the years 2010–2024 is shown in red.

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