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Labor Market Institutions, Productivity, and the Business Cycle: An Application to Italy

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Abstract

This paper studies the effect of labor market institutions on the cyclicality of labor productivity and aggregate fluctuations in Italy. It uses a New Keynesian model with labor market frictions and labor effort when two wage bargaining settings (efficient Nash and right-to-manage) interact with three types of hiring costs. We focus on three sets of labor market deregulation modeled as a fall in wage rigidity, hiring costs, and the bargaining power of workers. We show that, when labor effort varies, reforms trigger procyclical productivity under efficient bargaining, and countercyclical productivity under right-to-manage bargaining. Reforms also have different effects on cyclical moments. Second, we estimate the model with Bayesian techniques and find that productivity is mainly driven by technology shocks.

Keywords: Labor market institutions, labor productivity, business cycles, hiring costs, effort.

JEL codes: E24, E32, C51, C52.

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1 Introduction

Euro area labor markets are characterized by high firing costs, long-duration of unemployment spells, inflexible wages, and generous unemployment benefit systems. This is unlike other regions in the world. Elsby et al. (2013), for instance, document large differences in cyclical and long run labor market flows across countries. Compared to European economies, the US labor market exhibits higher unemployment inflow and outflow (flow) rates. The leading explanation in the literature underlines the role of labor market institutions (LMIs) in explaining cross-country differences in labor market dynamics (see, e.g., Blanchard and Wolfers 2000; Bentolila et al. 2012; Jung and Kuhn 2014; Langot and Pizzo 2019).[1]

When it comes to Italy more specifically, the country finds itself in stark contrast with OECD countries, since its labor market is characterized by high hiring and firing costs, very low labor market flow rates, and high bargaining power of workers (e.g., Boeri and Jimeno, 2005; Botero et al., 2004). It has a two-tier bargaining mechanism, with a dominant sectoral tier and a supplementary decentralized tier in which bargaining is carried out at the firm level, leading to substantial downward real wage rigidity (e.g., Devicienti et al., 2007, Devicienti et al., 2018).[2] Training costs represent a large share of hiring costs in Italy once the cost of unfair dismissal is excluded as we see in Del Boca and Rota (1998). In the last two decades, Italy adopted numerous labor market reforms aimed among others at weakening firing costs for permanent contracts, offering flexible temporary contracts to firms, and increasing job-matching efficiency (Pinelli et al., 2017). Labor productivity has declined in Italy since the early 2000s, and real wages have grown faster than labor productivity since Italy joined the Euro area as shown in Garcia-Macia (2020). Over the period 1996Q1-2018Q4, the correlation between the cyclical components of labor productivity and output is equal to 0.43 (see section 3).

The aim of this paper is to analyze how labor market deregulation (i.e., reduction in real wage rigidity, hiring cost, and bargaining power of workers) affects the cyclicality of Italian labor productivity and aggregate fluctuations. Previous studies theoretically show that labor market policies can crucially affect the short-run responses of labor market outcomes to shocks and aggregate fluctuations (e.g., Christoffel et al. 2009; Abbritti and Mueller 2013). Abbritti and Weber (2010) distinguish between unemployment rigidities and real wage rigidities. Unemployment rigidities capture institutions that limit the flows in and out of unemployment, such as hiring costs, EPL, and matching technology. Real wage rigidities capture institutions that influence the responsiveness of real wages to economic activity such as collective wage bargaining settings. They show that unemployment rigidities make it costly for firms to hire/fire new workers, reduce unemployment volatility, and increase inflation volatility. In contrast, real wage rigidities limit wage adjustments and create incentives for firms to react to shocks using the hiring margin, thereby decreasing inflation volatility, and increasing

[1] "LMIs", "labor market reforms", and "labor market policies" are used interchangeably throughout this paper.

[2] The main goals of the sectoral contracts are to protect real wages and to set common economic and normative conditions nationwide. Decentralized or firm-level bargaining offers performance and productivity-related wage increases and is limited only to large firms.

unemployment volatility (e.g., Zanetti 2011, Abbritti and Mueller 2013). Abbritti and Weber (2018) empirically show that the effects of trade unions depend on the shocks hitting the economy. However, these studies do not incorporate labor effort and focus mainly on the effects of LMIs on inflation and unemployment dynamics or the transmission of monetary policy decisions. Theoretical studies that embed labor market frictions and labor effort to study the interplay between labor market policies and the cyclicality of labor productivity are scant (see Barnichon 2010 and Galí and Van Rens 2021 for the US). The main challenge is that labor effort cannot be observed directly but many indirect measures suggest that it is procyclical in many countries including Italy (Dossche et al. 2022). Gnocchi et al. (2015) empirically show that wage bargaining reforms increase the volatility of unemployment and trigger procyclical labor productivity while employment protection reforms increase the volatility of employment and generate countercyclical labor productivity.[3] We contribute to this literature by studying theoretically and empirically to what extent labor market policies influence the cyclicality of Italian labor productivity and aggregate fluctuations.

The contribution of this paper is twofold. First, it analyzes how labor market reforms influence the cyclicality of Italian labor productivity and cyclical moments under the interaction of two distinct wage bargaining mechanisms (efficient Nash [EB] and right-to-manage [RTM]), and three functional types of hiring costs in a New Keynesian model characterized by search and matching frictions in the labor market, labor effort and nominal rigidities in the goods market.[4] The interaction between distinct wage bargaining mechanisms and different types of hiring costs enables us to model both flow and wage restrictions and is crucial for determining cyclical moments and for shaping differently the cyclicality of labor productivity and its correlation with real wage (Fabiani et al., 2010; Gnocchi et al. 2015). Indeed, Gnocchi et al. 2015 find that flow restrictions (hiring costs) affect employment while wage restrictions mostly affect the volatility of real wages and unemployment. We distinguish between pre-match hiring costs and post-match hiring costs. The former includes recruitment and advertising costs before a match is formed while the latter includes training costs for new hires (Yashiv 2007, Faccini and Yashiv 2022). We then calibrate the resulting model to match the long run features of the Italian labor market under the assumption that labor effort is procyclical.[5] Following Dossche et al. (2022), we vary the labor effort parameter and simulate how labor market deregulation affects the reactions of labor market outcomes, the cyclicality of Italian labor productivity, and cyclical moments. Second, we empirically examine the relative contribution of shocks, including labor market shocks, in explaining fluctuations in Italian labor productivity by estimating the resulting model with Bayesian techniques using quarterly Italian data running from 1996Q1 to 2018Q4.

[3]See also Fonseca et al. (2009); Fonseca et al. (2010); Langot and Pizzo (2019); Nickell (1997); Nickell and Layard (1999); Nickell et al. (2003); Merkl and Schmitz (2011); Abbritti and Weber (2018). Boeri et al. (2015) provide a survey of results of empirical studies analyzing the costs of flexibility-enhancing reforms in labor markets across countries.

[4]Under the EB mechanism, workers and firms bargain over the wage and the number of hours worked simultaneously whereas, under the RTM mechanism, both parties bargain over the wage only, and firms determine unilaterally the number of hours worked in a second stage (Trigari, 2006). The latter mechanism provides a direct channel through which the wage directly affects marginal costs and inflation dynamics.

[5]See Marchetti, Nucci et al. (2001) on the procyclicality of labor effort over the business cycle in Italy.

Our results are as follows. First, we find that when labor effort varies, labor market reforms have different effects on cyclical moments. Labor market reforms generate procyclical labor productivity when we simulate the model under the interaction of the EB mechanism and all types of hiring costs. Under the RTM mechanism, reforms generate either countercyclical or weakly procyclical labor productivity. Second, regarding cyclical moments, under the EB mechanism, when we simulate our model with post-match hiring costs we find that an increase in wage rigidity and the bargaining power of workers increases unemployment volatility while a rise in hiring cost generates the reverse. When we use linear vacancy costs together with pre-match and post-match hiring costs, an increase in wage rigidity increases unemployment volatility while an increase in hiring costs and the bargaining power of workers decreases it. Regardless of the types of hiring costs, we find that reforms do not alter inflation volatility.

Under the RTM mechanism, when we consider only post-match hiring costs, we show that an increase in wage rigidity and hiring costs increases the volatility of unemployment and inflation. An increase in the bargaining power of workers does not alter the unemployment volatility and increases the inflation volatility. When we consider linear vacancy costs, an increase in wage rigidity increases the volatility of unemployment and inflation while a rise in hiring costs and the bargaining power of workers decreases the volatility of unemployment and inflation. When we simulate our model with pre-match and post-match hiring costs, an increase in wage rigidity increases unemployment volatility and reduces inflation volatility. An increase in hiring costs reduces the volatility of unemployment, and inflation. Finally, an increase in the bargaining power of workers does not alter the volatility of unemployment and increases inflation volatility.

Finally, we estimate two models which feature the EB or RTM mechanism and hiring cost function à la Sala et al. (2013) with Bayesian techniques using Italian data over the period 1996Q1-2018Q4. We choose the latter as it includes both pre-match and post-match hiring costs. We allow many shocks, including those originating in the labor market, to affect the economy and to compete as sources of aggregate fluctuations. We find that technology shocks are the main sources of fluctuations in Italian labor productivity in the short and long run. Labor market shocks are not important sources of business cycle fluctuations, consistent with previous studies in the literature (e.g., Gertler et al. 2008, Furlanetto and Groshenny 2016). We check the robustness of our results by considering two extensions. First, we re-estimate our models over the period 2000Q1-2018Q4 to account for the flattening of Italian labor productivity in the early 2000s. Second, we take advantage of data on vacancies whose availability starts in 2004Q1 and we re-estimate our models over the period 2004Q1-2018Q4 by introducing two additional labor market shocks (disturbances to job separation and hiring costs). Our sensitivity analysis confirms our results.

This paper proceeds as follows. Section 2 lays out the model environment. Section 3 presents data and discusses our calibration. Section 4 shows our counterfactual analysis on labor market institutions and macroeconomic dynamics. Section 5 presents our estimation results. Section 6 concludes.

2 Model

This section presents a New Keynesian model with labor market frictions à la Mortensen and Pissarides (1994), which allows for labor adjustment along three margins: employment, hours and effort, and wage rigidities. It features a host of nominal and real frictions (investment adjustment costs, variable capital utilization, consumption habit formation). Our economy is populated by four types of agents: households, firms (comprised of a continuum of intermediate goods producers indexed by $i \in [0,1]$ and retailers), a monetary authority, and a fiscal authority. Time is discrete and goes from zero to infinity. In what follows we explain the structure of the labor market and the problems faced by households and firms.

2.1 Labor market search and matching frictions

The matching process is described by an aggregate constant-returns-to-scale Cobb–Douglas matching function $m_t = \varepsilon_m u_t^{\gamma}(v_t)^{1-\gamma}$ which represents the aggregate flow of hires in a unit period where $m_t = \int_0^1 m_{it} di$ denotes matches, $v_t = \int_0^1 v_{it} di$ denotes aggregate vacancies, u_t aggregate unemployment, and $\gamma \in (0,1)$ denotes the matching elasticity with respect to unemployment. During each period, vacancies are filled with probability $q_t = m_t/v_t$, $\theta_t = v_t/u_t$ denotes labor market tightness and p_t denotes the job-finding rate by the unemployed. The population size is normalized to one. ε_m is the efficiency of matching vacant positions with unemployed members. We assume that in each period, a constant fraction of workers loses jobs with probability σ and new matches m_t are formed. Defining aggregate employment $n_t = \int_0^1 n_{it} di$, the law of motion for aggregate employment is given by :

$$n_{t+1} = (1-\sigma)n_t + m_t \tag{1}$$

Workers who have lost jobs in period t start searching immediately and may find one with a probability given by the current job-finding rate p_t. After matching has taken place, those who remain unmatched enter the unemployment pool and will search for a job in the next period. Aggregate unemployment as measured after period t hiring is equal to $u_t \equiv 1 - n_t$.

2.2 Households

There is a continuum of identical households of mass one. Each household is a large family, made up of a continuum of individuals of measure one. Family members are either employed or unemployed. A fraction n_t of employed members receive the real wage w_{it} from firm $i \in [0,1]$ for supplying hours h_{it} and effort e_{it} while $1 - n_t$ unemployed members receive unemployment benefits b. To avoid distributional issues, we assume that family members pool their income before allowing the head of the family to optimally choose consumption C_t.[6] Denoting $g(h_{it}, e_{it})$ the individual labor disutility of working, the family's lifetime utility

[6] See Andolfatto (1996), Merz (1995) and Langot (1995) for a decentralized market economy with unemployment insurance.

is described by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[U(C_t; C_{t-1}) - \varepsilon_{\ell,t} n_t \int_0^1 g(h_{it}, e_{it}) di \right] \tag{2}$$

where $\beta \in (0,1)$ denotes the discount factor, $\varepsilon_{\ell,t}$ is the labor supply shock. Consumption utility is further specified as $U(C_t; C_{t-1}) = \ln(C_t - \lambda_c C_{t-1})$, where $0 \leq \lambda_c < 1$ denotes the degree of external habit formation and C_{t-1} denotes aggregate consumption taken as given and not optimized by the household (Abel, 1990). Following Bils and Cho (1994), the individual period disutility of labor takes the form $g(h_{it}, e_{it}) = (\lambda_h/(1 + \sigma_h))h_{it}^{1+\sigma_h} + h_{it}(\lambda_e/(1+\sigma_e))\ e_{it}^{1+\sigma_e}$ where λ_h, λ_e, σ_h and σ_e are positive constants and denote respectively the weight on hours, effort and the curvature of labor disutility in hours and effort. The first term captures disutility from spending h_{it} hours at work while the last term reflects disutility from exerting effort.

The household owns capital stock K_t and finances investment I_t. It faces the following budget constraint:

$$C_t + \frac{B_t}{\varepsilon_t^b R_t P_t} + I_t + a(u_t^k)K_t = n_t \int_0^1 w_{it} h_{it} + b u_t + r_t^k u_t^k K_t + \frac{B_{t-1}}{P_t} + D_t + T_t \tag{3}$$

Consumption, bond purchases B_t, investment and capital utilization costs $a(u_t^k)K_t$ are financed through wage income by employed members, rental income on capital holdings, income on bond holdings, unemployed benefits b received by unemployed members, real profits D_t, and lump-sum government transfers T_t. One-period bond holding pays a nominal interest rate R_t, r_t^k denotes the rental rate on capital. As in Smets and Wouters (2007), ε_t^b denotes a risk premium shock which drives a wedge between the central bank's rate R_t and the return on assets held by the household. This shock captures disturbances originating in the financial markets. It is assumed that using the stock of capital with intensity u_t^k entails capital utilization costs $a(u_t^k)$. We assume that $u^k = 1$ in the steady-state, so $a(u^k) = 0$ and $a^{''}(1)/a^{'}(1) = \sigma_u$ determines capital utilization dynamics.

Letting ε_t^i denote a shock to the investment-specific technology, the aggregate capital stock evolves according to the law of motion :

$$K_{t+1} = (1-\delta)K_t + \varepsilon_t^i F(I_t, I_{t-1}) \tag{4}$$

where δ denotes the rate of capital depreciation, $F(I_t, I_{t-1}) = \left[1 - \frac{\kappa_i}{2}\left(I_t/I_{t-1} - 1\right)^2\right] I_t$ represents investment adjustment costs, and κ_i denotes the size of these adjustment costs (Christiano et al., 2005). We assume that, in steady state, $F = F^{'} = 0$, and $F^{''} = \kappa_i > 0$.

The family representative chooses C_t and K_{t+1} to maximize the utility (2) subject to the budget constraint (3) and the law of motion for capital (4). Letting Λ_t denote the Lagrange multiplier on (3), the optimality conditions for consumption, bonds, investment, capital holdings, and capital utilization are respectively:

$$\Lambda_t = 1/(C_t - \lambda_c C_{t-1}) \tag{5}$$

$$1 = \varepsilon_t^b R_t E_t \left[\beta_{t,t+1}/\Pi_{t+1}\right] \tag{6}$$

$$1 = q_t^k \varepsilon_t^i F_{1t} + E_t \left[\beta_{t,t+1} q_{t+1}^k \varepsilon_{t+1}^i F_{2t+1}\right] \tag{7}$$

$$q_t^k = E_t \left\{\beta_{t,t+1} \left[r_{t+1}^k u_{t+1}^k - a(u_{t+1}^k) + (1-\delta) q_{t+1}^k\right]\right\} \tag{8}$$

$$r_t^k = a'(u_t^k) \tag{9}$$

Equation (5) states that the Lagrange multiplier on the budget constraint is equal to the marginal utility of consumption. Equation (6) denotes the household's Euler equation that describes the intertemporal consumption decisions and where $\beta_{t-1,t} = \beta\Lambda_t/\Lambda_{t-1}$ denotes the stochastic discount factor, $\Pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate. Equation (7) describes the marginal value of investment should be equal to the replacement cost of installed capital in units of consumption goods where F_{it} denotes the derivative of the function F(.) with respect to its i^{th} argument, and q_t^k denotes the household's shadow price of physical capital. Equation (8) shows that the value of installed capital depends on its expected future value taking into account the depreciation rate and the expected future return as captured by the rental rate times the expected rate of capital utilization. Equation (9) equates the cost of higher capital utilization with the rental price of capital services.

2.3 Intermediate goods

Intermediate goods firms hire workers in a frictional labor market and rent capital services in a perfectly competitive market. They manufacture homogeneous intermediate goods and sell them to retailers in a perfectly competitive market. There is a continuum of producers of unit measure selling homogeneous goods at competitive prices φ_t. Firm i produces output according to the following technology $Y_{it} = \varepsilon_t^a (k_{it}^s)^\alpha (l_{it}^s)^{1-\alpha}$ where ε_t^a is an exogenous technology shock to all firms, l_{it}^s are labor services, k_{it}^s are capital services and α is the share of capital services in production. Labor services are the product of employment, hours per worker, and effort per hour; capital services are given by the product of capital stock and capital utilization rate:

$$l_{it}^s = n_{it} h_{it} e_{it} \tag{10}$$

$$k_{it}^s = u_t^k K_{it} \tag{11}$$

Firms maximize the discounted value of future profits. Firms adjust employment by varying the extensive margin (number of workers) and the intensive margin (hours, effort per hour). The firm takes as given the number of workers currently employed, and its employment decision concerns the number of vacancies that it posts in the current period v_{it}. Firms open as many vacancies as necessary to employ the desired number of workers next period and face quadratic hiring costs or labor adjustment costs $\frac{\kappa}{2} x_{it}^2 n_{it}$ where κ determines the output share of the hiring costs and $x_{it} = m_{it}/n_{it}$ is the hiring rate as in Gertler and Trigari (2009). Firms also need to decide on the size of the capital service that they need for production. The problem of the firm with n_{it} currently employed workers consists of choosing capital and vacancies to maximize:

$$V^F(n_{it}) = \max \varphi_t Y_{it} - w_{it}h_{it}n_{it} - r_t^k k_{it}^s - \frac{\kappa}{2}x_{it}^2 n_{it} - \Phi n_{it} + E_t\beta_{t,t+1}V^F(n_{it+1}) \tag{12}$$

where φ_t is the relative price of intermediate goods and Φ denotes job-related overhead costs independent of the number of hours per worker. The maximization takes place subject to the production function, the law of motion for aggregate productivity, and the job transition function that links the future number of filled jobs to the current stock of filled jobs plus net hiring:

$$n_{it+1} = (1-\sigma)n_{it} + m_{it} \tag{13}$$

By choosing vacancies, the intermediate firm directly controls the total number of hires $m_{it} = q_t v_{it}$ since it knows the vacancy filling rate q_t. Letting J_{it}^F denote the Lagrange multiplier on the firm employment dynamics, optimization with respect to k_i^s, m_{it}, n_{it+1} implies respectively

$$r_t^k = \varphi_t \alpha \frac{Y_{it}}{k_t^s} \tag{14}$$

$$J_{it}^F = \kappa x_{it} \tag{15}$$

$$J_{it}^F = E_t\beta_{t,t+1}\left[(1-\alpha)\varphi_{t+1}\frac{Y_{it+1}}{n_{it+1}} - w_{it+1}h_{it+1} - \frac{\kappa}{2}x_{it+1}^2 - \Phi + (1-\sigma)J_{it+1}^F\right] \tag{16}$$

Equation (14) states that the marginal product of capital equals the real return rate. Equation (15) shows that the marginal hiring cost (κx_{it}) is equal to the shadow value of employment. Equation (16) states that the shadow value of employment to the firm is equal to the expected profits, i.e. the expected marginal product of employment minus expected wage cost minus expected hiring costs plus the continuation value of employment. By substituting (15) into (16), we obtain the following job creation condition (JCC):

$$\kappa x_{it} = E_t\beta_{t,t+1}\left[(1-\alpha)\varphi_{t+1}\frac{Y_{it+1}}{n_{it+1}} - w_{it+1}h_{it+1} - \frac{\kappa}{2}x_{it+1}^2 - \Phi + (1-\sigma)\kappa x_{it+1}\right] \tag{17}$$

Equation (17) states that the cost of hiring an additional worker equals the marginal benefit that the additional worker brings into the firm. In the online appendix, we show the optimal conditions for the JCC for the cases of the linear vacancy costs functional type (Mortensen and Pissarides, 1994) and the quadratic hiring costs functional type à la Sala et al. (2013).

Effort. Every period, when a firm and a worker meet, they must decide on the allocation of hours and effort to satisfy demand. It is assumed that both parties bargain the hours/effort decision jointly by minimizing labor disutility $g(h_{it}, e_{it})$ subject to production, yielding the following optimal allocation:

$$e_{it} = e_0 h_{it}^{\frac{\sigma_h}{1+\sigma_e}} \tag{18}$$

where $e_0 = \left(\frac{1+\sigma_e}{\sigma_e}\frac{\lambda_h}{\lambda_e}\right)^{\frac{1}{1+\sigma_e}}$. Equilibrium effort is therefore an increasing and convex function of hours worked. As shown by Barnichon (2010), changes in hours can proxy for changes in effort and the firm production function can now be rewritten as:

$$Y_{it} = y_0 \varepsilon_t^a (n_{it} h_{it}^{\phi})^{1-\alpha} (k_{it}^s)^{\alpha} \tag{19}$$

where $y_0 = e_0^{1-\alpha}$ and $\phi = 1 + \frac{\sigma_h}{1+\sigma_e}$. The elasticity of output to hours worked is thus $\phi(1-\alpha)$. The production function displays short-run increasing returns to hours when $\phi(1-\alpha) > 1$. When facing higher demand, firms respond by increasing hours and effort, which in turn raises output per hour (measured labor productivity). To obtain procyclical labor productivity in reaction to demand shocks, we need either the marginal product of hours and effort $(1-\alpha)$ or the effort elasticity to hours $\sigma_h/(1+\sigma_e)$ is sufficiently high as in Lewis et al. (2019).

Firm's match surplus. The marginal value to the firm of hiring an additional worker $J_{it}^F = \partial V_{it}^F / \partial n_{it}$ taking x_{it} as given yields:

$$J_{it}^F = (1-\alpha)\varphi_t \frac{Y_{it}}{n_{it}} - w_{it} h_{it} - \frac{\kappa}{2} x_{it}^2 - \Phi + (1-\sigma) E_t \beta_{t,t+1} J_{it+1}^F \tag{20}$$

The marginal value of employment to the firm is equal to the current period profits, i.e., the marginal revenue product of employment net of wage costs, hiring costs, and overhead costs plus its continuation value.

Worker's match surplus. Similarly, we define the marginal value of being employed and unemployed for the worker. The marginal value of employment at the firm i is:

$$W_{it}^E = w_{it} h_{it} - \varepsilon_t^{\ell} \frac{g(h_{it}, e_{it})}{\Lambda_t} + E_t \beta_{t,t+1} \left[(1-\sigma) W_{it+1}^E + \sigma W_{t+1}^U\right] \tag{21}$$

which states that the marginal value of employment for a worker is given by the real wage bill net of the disutility of work plus the expected-discounted value from being either employed or unemployed in the following period. The marginal value of unemployment, W_t^U, is given by

$$W_t^U = b + E_t \beta_{t,t+1} \left[p_{t+1}(1-\sigma) W_{x,t+1} + (1 - p_{t+1}(1-\sigma)) W_{t+1}^U\right] \tag{22}$$

where $E_t W_{x,t+1} = \int_0^1 W_{it+1}^E \frac{x_{it+1} n_{it+1}}{x_{t+1} n_{t+1}} di$ is the average value of working next period conditional on being a new worker in t, $x_{it+1} n_{it+1}$ is total new workers at firm i in the next period and $x_{t+1} n_{t+1}$ is total new workers at $t+1$. Equation (22) states that the marginal value of unemployment is equal to unemployment benefits plus the expected discounted value from remaining unemployed or becoming employed. The worker's match surplus W_{it}^H, $W_{it}^E - W_t^U$, is:

$$W_{it}^H = w_{it}h_{it} - \varepsilon_t^{\ell}\frac{g(h_{it}, e_{it})}{\Lambda_t} - b + E_t\beta_{t,t+1}\left[(1-\sigma)W_{it+1}^H - p_{t+1}(1-\sigma)W_{x,t+1}^H\right] \tag{23}$$

where $W_{x,t}^H = W_{x,t} - W_t^U$.[7]

2.4 Retailers and Price Setting

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers purchase intermediate goods from firms and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods. Retail goods are then used for consumption, government spending, and investment. Note that the relative price of intermediate goods φ_t coincides with the real marginal cost faced by the retailers. Let Y_{it} denote the quantity of output sold by the retailer i. Final goods can be expressed as an aggregate of individual retail goods:

$$Y_t = \left[\int_0^1 Y_{it}^{\frac{\epsilon_t^p - 1}{\epsilon_t^p}} di\right]^{\frac{\epsilon_t^p}{\epsilon_t^p - 1}} \tag{24}$$

where $\epsilon^p > 1$ is the demand elasticity and ϵ_t is an exogenous process for the demand elasticity that translates into exogenous variations in the price markup. The final good is sold at its unit price $P_t = \left[\int_0^1 P_{it}^{1-\epsilon_t^p}\right]^{\frac{1}{1-\epsilon_t^p}}$. The resulting demand for each intermediate good depends on its relative price and aggregate demand:

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\epsilon_t^p} Y_t \tag{25}$$

We assume price stickiness à la Calvo (1983), meaning that in any given period a random fraction of retailers χ cannot reset their price. The problem of the retailers is to choose P_{it} to maximize

$$\max E_t \sum_{s=0}^{\infty} \chi^s \beta_{t,t+s}\left[\frac{P_{it}}{P_{t+s}} - \varphi_{t+s}\right] Y_{it+s} \tag{26}$$

subject to the demand function (25). The optimal pricing decision is given by:

$$\sum_{s=0}^{\infty} \chi^s E_t \left\{\beta_{t,t+s} Y_{it+s}\left[\frac{P_t^*}{P_{t+s}} - \mu_t\varphi_{t+s}\right\}\right. = 0 \tag{27}$$

where P_t^* is the optimal price chosen by all price-setters. This implies that forward-looking firms choose the optimal price such that the time-varying markup $\mu_t = \frac{\epsilon_t^p}{\epsilon_t^p - 1}$. Since price-setters are randomly selected, the

[7] In symmetric equilibrium, $W_{it}^H = W_{x,t}^H$.

law of motion for the aggregate price level is given by:

$$P_t = \left[\chi P_{t-1}^{1-\epsilon_t^p} + (1-\chi) P_t^{*1-\epsilon_t^p}\right]^{1/(1-\epsilon_t^p)} \tag{28}$$

2.5 Hours and Wage settings

Efficient Nash Bargaining

Hours. In the Efficient Nash Bargaining (EB) hours are determined jointly by the firm and the worker to maximize the sum of the worker's surplus W_{it}^H and the firm's surplus J_{it}^F. The optimal condition for hours worked implies that the firm's real marginal cost is:

$$\varphi_t = \frac{1}{\phi(1-\alpha)^2 P_{it}} \varepsilon_{\ell,t} \frac{g_{h,t}}{\Lambda_t} \tag{29}$$

where $P_{it} \equiv \frac{Y_{it}}{n_{it} h_{it}}$ denotes the firm-level labor productivity, $g_{h,t} = \partial g(h_{it})/\partial h_{it}$ is obtained by substituting equation (19) into labor disutility $g(h_{it}, e_{it})$, resulting in $g(h_{it})$, and taking the first derivative of the latter with respect to hours. Equation (30) shows that movements in real marginal costs are driven by variations in the marginal rate of substitution between hours and consumption, adjusted for the marginal product of this worker. In other words, we can express the real marginal cost as the ratio of the marginal rate of substitution to the marginal product of this worker.[8] We provide further details on the derivations in the online appendix.

Wage Bargaining. Workers and firms bargain over the real wage w_{it} and split the surplus according to their respective time-varying bargaining weights η_t and $(1-\eta_t)$ where $\eta_t = \eta \varepsilon_t^w$. Similarly to Christoffel et al. (2009), the worker's bargaining power is exogenous and follows an AR(1) process.[9] Under Nash bargaining, the wage is chosen to maximize the joint match surplus $(W_{it}^H)^{\eta_t}\ (J_{it}^F)^{1-\eta_t}$. The optimal condition satisfies the following sharing rule:

$$\eta_t J_{it}^F = (1-\eta_t) W_{it}^H \tag{30}$$

where J_{it}^F and W_{it}^H are derived as before. Substituting the definitions of the worker's and the firm's surplus, using the sharing rule leads to the equilibrium real wage:

$$w_{it}^{Nash} h_{it} = \eta_t \left[(1-\alpha)\varphi_t \frac{Y_{it}}{n_{it}} - \Phi - \frac{\kappa}{2} x_{it}^2\right] + (1-\sigma)\kappa x_{it} \left[\eta_t - (1-\eta_t)\frac{\eta_{t+1}}{(1-\eta_{t+1})})(1-p_{t+1}\right] + (1-\eta_t)\left[b + mrs_{it}\right] \tag{31}$$

[8] As shown in Christoffel and Linzert (2010), under the EB the bargaining outcome will lie on the contract curve, i.e., the locus of tangency points of the isoprofit curve of the firm and worker's indifference curves. Hence, any change in hours will be accompanied by a corresponding change in wages.

[9] See also Faccini et al. (2013), Furlanetto and Groshenny (2016), and Langot and Pizzo (2019) among others.

where $mrs_{it} = \varepsilon_t^\ell \frac{g_{h,t}}{\Lambda_t}$. The real wage is a convex combination of two terms. The first term on the RHS reflects the surplus to the firm of hiring a new worker: the marginal product of this worker (MPL), minus overhead costs minus adjustment costs per worker. The second term on the RHS shows the continuation value of the match. The third term on the RHS reflects the reservation wage: the unemployment benefit plus the marginal rate of substitution between hours and consumption. The stronger the bargaining power of the worker, the closer the wage is to the marginal product and vice versa.

Right-to-manage bargaining

Hours. The right-to-manage (RTM) bargaining proposes that workers and firms only bargain over wages and that firms subsequently determine unilaterally the number of hours per worker in a profit-maximizing fashion. Therefore, firms take the bargained wage as given when choosing hours. The optimal number of hours chosen by firms is given by maximizing the firm's surplus with respect to hours $\partial J_{it}^F / \partial h_{it}$ taking wage as given. This leads to the following optimal condition:

$$\varphi_t \phi (1-\alpha)^2 P_{it} = w_{it} \tag{32}$$

Equation (32) states that in contrast to the Efficient Nash Bargaining, under the RTM, every additional hour of work will cost the firm the previously bargained wage.

Wage Bargaining. Workers, and firms maximize their joint surplus but they take into account that each firm sets hours worked optimally according to (32). This leads to the following optimal condition:

$$\xi_t \delta_t^w J_{it}^F = (1-\xi_t) \delta_t^f W_{it}^H \tag{33}$$

where $\delta_t^w = \partial W_{it}^H / \partial w_{it}$ is the marginal contribution of wages to the value of a job to the worker and $\delta_t^f = \partial J_{it}^f / \partial w_{it}$ is the marginal contribution of the wage to the value of a job to the firm. Replacing the definitions of the worker's and the firm's surplus, using the new sharing rule (33) results in the following wage equation:

$$\begin{aligned} w_{it}^{RTM} h_{it} = {} & \xi_t \left[(1-\alpha) \varphi_t \frac{Y_{it}}{n_{it}} - \Phi - \frac{\kappa}{2} x_{it}^2 \right] + (1-\sigma) \kappa x_{it} \left[\xi_t - (1-\eta_t) \delta_t^f \frac{\xi_t}{\eta_t \delta_t^w} \frac{\eta_{t+1} \delta_{t+1}^w}{(1-\eta_{t+1}) \delta_{t+1}^f} (1-p_{t+1}) \right] \\ & + (1-\xi_t) \left[b + mrs_{it} \right] \end{aligned} \tag{34}$$

where the effective bargaining weight is given by

$$\xi_t = \frac{\eta_t \delta_t^w}{(1-\eta_t) \delta_t^f + \eta_t \delta_t^w} \tag{35}$$

2.6 Wage Rigidity

We introduce wage rigidity à la Hall (2005) into the model in the form of a backward-looking wage norm.[10] A wage norm may arise as a result of social conventions that constrain wage adjustment. Allowing for LMIs that restrain smooth wage adjustment is very important and in line with the features of the Italian labor market (Devicienti et al., 2007). One way to model this is to assume that the real wage w_{it} is a weighted average of the Nash bargained wage w_{it}^{Nash} and the wage norm which is assumed to be the wage prevailing in the previous period:

$$w_t = \rho_w w_{t-1} + (1 - \rho_w) w_t^* \tag{36}$$

where ρ_w denotes the degree of wage rigidity in the economy, $w_t = \int_0^1 w_{it} di$ and w_t^* denotes the EB or RTM wage.

2.7 Monetary and Fiscal Policy

The central bank's monetary policy is modeled via a Taylor-type interest rate rule given by:

$$(R_t/R^*) = (R_{t-1}/R^*)^{\rho_r} \left[(\pi_t/\pi^*)^{\gamma_\pi} (Y_t/Y^*)^{\gamma_y}\right]^{1-\rho_r} \varepsilon_{R,t} \tag{37}$$

where an asterisk denotes the steady-state values of the associated variables.γ_π represents interest rate smoothing, and γ_π and γ_y govern the response of the monetary authority to deviations of output and inflation from their steady-state value. ε_t^r denotes a monetary policy shock.

The government budget constraint equates current income (bond issues plus payment of job-related overhead costs) with current expenditure (government spending, unemployment benefits, lump-sum transfer, and maturing government bonds):

$$\Phi n_t + \frac{B_t}{R_t P_t} = \frac{B_{t-1}}{P_{t-1}} + G_t + b u_t + T_t \tag{38}$$

Combining the household budget constraint (3), summed over households, with the government budget constraint (38), we obtain the aggregate accounting identity:

$$Y_t = C_t + I_t + G_t + \frac{\kappa}{2} \int_0^1 x_{it}^2 n_{it} di + a(u_t^k) K_t \tag{39}$$

The model is closed by a set of AR(1) shock processes,

$$\ln \varepsilon_t^z = \rho_z \ln \varepsilon_{t-1}^z + \epsilon_t^z \text{ with } \epsilon_t^z \sim \mathcal{N}(0, \sigma_z). \tag{40}$$

[10]Studies who previously used this wage norm include among others Krause and Lubik (2007), Christoffel and Linzert (2010), Abbritti and Weber (2010) and Leduc and Liu (2020).

where $z = \{b, \ell, i, a, g, m, p, w\}$, ρ_z denotes the persistence and σ_z is the standard deviation of innovation ϵ_t^z. We log-linearize the model around its deterministic steady state with balanced growth. The derivation of the steady state and the log-linearized system of equations are available in the online appendix.

3 Italian Data and Calibration

We calibrate the model to the Italian economy using quarterly data from 1996Q1 to 2018Q4. The beginning of the dataset is constrained by the availability of data for GDP inflation. We use the following observables for our baseline model: GDP per capita, real consumption per capita, real investment per capita, real wages per employee (real compensation of employees divided by the number of employees), inflation (quarter-on-quarter GDP deflator), nominal interest rate (3-month interest rate), unemployment rate, total employment, total hours, hours per worker and labor productivity. Data on GDP, consumption, investment real wages, and nominal interest rate are taken from Eurostat. Data on unemployment come from the Italian National Institute of Statistics (ISTAT). Finally, data on total employment, total hours worked, and hours per worker are taken from Ohanian and Raffo (2012).[11] Labor productivity is computed as the ratio of output to total hours. All data are expressed in logarithms, hp(1,600) filtered (Hodrick and Prescott, 1997) and multiplied by 100 to express them in percentage deviations. For our robustness check, we use data on the vacancy rate from ISTAT. More details can be found in the appendix A.

Using the HP filter detrended data, we document that the correlation between labor productivity and output is equal to 0.43, in stark contrast with the Euro area (Lewis et al., 2019).[12] Tables 1 and 2 summarize the Italian stylized facts and cyclical moments generated by our simulation. In the wake of the Great Recession (GR), Italy has introduced reforms aimed at reducing hiring and firing costs (Pinelli et al., 2017). It has also gradually shifted from its centrally collective bargaining to a more decentralized bargaining (D'Amuri and Giorgiantonio, 2015).[13]

[11] Ohanian and Raffo (2012) construct data on aggregate hours worked spanning the period 1960-2010 for a sample of 14 OECD countries. It is extended until 2019 by Dossche et al. (2022).

[12] Our results are robust across different filterings such as the Bandpass filter (Christiano and Fitzgerald, 2003) and the fourth difference filters. The Hamilton filter (Hamilton, 2018) predicts countercyclical labor productivity.

[13] These authors show that firm-level bargaining is associated with innovative managerial practices and a great share of firms is willing to sign contracts that enable both greater flexibility in labor utilization and higher wages or employment guarantees for workers.

Table 1: Changes in LMIs and Business Cycle Fluctuations under EB mechanism.

	Variables	Data	Labor market deregulation		
			Wage rigidity	Hiring costs	Bargaining power
Hiring cost - GT	Corr(LP,Y)	0.43	0.31	0.03	0.19
	σ_n/σ_y	0.49	1.02	0.03	0.19
	σ_{hpw}/σ_y	0.42	0.62	0.70	0.64
	σ_u/σ_y	4.25	5.91	9.64	7.43
	σ_π/σ_y	0.36	0.36	0.36	0.36
Vacancy cost	Corr(LP,Y)	0.43	0.65	0.64	0.65
	σ_n/σ_y	0.49	0.04	0.14	0.12
	σ_{hpw}/σ_y	0.42	0.74	0.72	0.72
	σ_u/σ_y	4.25	0.42	1.34	1.08
	σ_π/σ_y	0.36	0.36	0.37	0.37
Hiring cost - SST	Corr(LP,Y)	0.43	0.40	0.12	0.28
	σ_n/σ_y	0.49	0.63	0.93	0.71
	σ_{hpw}/σ_y	0.42	0.64	0.69	0.65
	σ_u/σ_y	4.25	4.90	8.78	6.71
	σ_π/σ_y	0.36	0.36	0.37	0.37

Table 2: Changes in LMIs and Business Cycle Fluctuations under RTM mechanism.

	Variables	Data	Labor market deregulation		
			Wage rigidity	Hiring costs	Bargaining power
Hiring cost - GT	Corr(LP,Y)	0.43	0.20	-0.33	-0.08
	σ_n/σ_y	0.49	0.52	1.12	0.21
	σ_{hpw}/σ_y	0.42	0.65	0.49	0.91
	σ_u/σ_y	4.25	4.88	10.53	1.94
	σ_π/σ_y	0.36	0.15	0.28	0.22
Vacancy cost	Corr(LP,Y)	0.43	-0.42	-0.15	-0.19
	σ_n/σ_y	0.49	0.02	0.09	0.03
	σ_{hpw}/σ_y	0.42	1.13	1.08	1.09
	σ_u/σ_y	4.25	0.21	0.86	0.29
	σ_π/σ_y	0.36	0.15	0.26	0.25
Hiring cost - SST	Corr(LP,Y)	0.43	0.08	0.12	0.16
	σ_n/σ_y	0.49	0.29	0.43	0.15
	σ_{hpw}/σ_y	0.42	0.95	0.85	0.93
	σ_u/σ_y	4.25	2.76	4.01	1.38
	σ_π/σ_y	0.36	0.30	0.31	0.26

3.1 Italian Calibration

The calibration of the model is summarized in Table 3. Note that this calibration also forms the basis for the priors in the Bayesian estimation exercise in Section 4. The discount factor β is set to 0.9926 so that the steady-state annualized real interest rate is equal to 3%; the capital depreciation rate δ is set to 0.025 to target a 10% annual depreciation rate of capital, the habit formation λ_c to 0.7 and the investment adjustment cost parameter to 4.5 (Forni et al., 2010). We set the capital share α to 0.3; the elasticity of demand for retail goods ϵ^p to 5 in order to target a steady-state gross price mark-up equal to 1.25 (Annicchiarico et al., 2013). The capital utilization rate κ_u is set to 0.5 (Lewis et al., 2019). We normalize the steady state utilization rate u_t^k to unity. The value of the elasticity of labor disutility to hours worked, $1/\sigma_h$, is a source of controversy in the literature. We set σ_h to unity. Our calibration lies between the values favored by the macro literature which are usually greater than 1 (Di Pace and Villa, 2016), and microeconometric estimates, which tend to be smaller than 1 (Keane and Rogerson, 2012). The elasticity of labor disutility to effort, σ_e, is calibrated to a value within the range found for Italy (see Marchetti et al. 2001; Marchetti and Nucci 2005).[14] We set σ_e to 0.1 in our baseline to match the cyclicality of labor productivity and we obtain the value of short-run returns to hours in production (ϕ) equal to 1.9, marginally above the estimate for the Euro area (Lewis et al., 2019). We normalize steady-state hours h and effort e to unity and we back out the weights on hours and effort in labor disutility λ_h and λ_e from steady-state conditions.

Turning to the labor market, we set the steady-state unemployment rate to 9.6% which is the average unemployment rate in our sample period. We set the quarterly job separation rate σ to 2.5% to match a yearly job destruction rate of 10% for Italy (Tealdi, 2019). This value is in line with evidence presented for OECD countries presented by Hobijn and Şahin (2009). This implies that the quarterly job-finding rate p is equal to 22%, in line with Peracchi et al. (2004). We target a probability of finding a worker when having opened a vacancy of $q = 0.7$, in line with evidence for the Euro area (Christoffel et al., 2009). We set the elasticity of the matches with respect to unemployment γ to 0.5, a midpoint value in line with Petrongolo and Pissarides (2001). We also set the bargaining power of the worker ξ to 0.5. The cost of hiring a worker κ is set to target total hiring costs equal to 1% of output, a value that is consistent with Gertler and Trigari (2009) and Faccini and Yashiv (2022). The value of the job-related overhead cost Φ is backed out from the steady state conditions. We set the degree of real wage rigidity ρ_w to 0.65 in line with the evidence for Italy presented by Devicienti et al. (2007). We set the Calvo price stickiness parameter χ to 0.66, which amounts to an average price duration of three quarters (Pietrunti, 2017).

Steady-state output is normalized to unity. Steady-state inflation is set to zero. We set the replacement rate b/wh to 0.35 (Pappa et al., 2015). The government share in output G/Y is equal to 0.2 which is the average in our sample. The share of private consumption to output is obtained as a residual. The monetary policy follows a standard Taylor rule with a long-run response to inflation of $\gamma_\pi = 1.31$, with a long-run response to the output gap of $\gamma_y = 0.125$ and an interest rate smoothing parameter $\rho_R = 0.85$ as in (Christoffel et al., 2009). We calibrate the shock processes to productivity, investment, and labor supply using estimates by Orsi et al. (2014). We calibrate the shock processes to the risk premium, monetary policy, and government spending using estimates in Acocella et al. (2020).

[14] Dossche, Gazzani and Lewis (2022) use a large value $\sigma_e(350)$ for the constant-effort model and a low value of $\sigma_e(0.2)$ for the variable-effort model.

Table 3: Calibrated parameters

Parameter		Values	Target/Reference
Discount factor	β	0.9926	3% risk free rate p.a
Production function parameter	α	0.3	Annicchiarico et al. (2013)
Capital depreciation rate	δ	0.025	10% depreciation rate p.a
Elasticity of substitution in goods	ϵ	5	Annicchiarico et al. (2013)
Returns to hours in labor disutility	σ_h	1	Keane and Rogerson (2012)
Weight on hours in labor disutility	λ_h	0.11	backed out from steady state
Weight on effort in labor disutility	λ_e	0.21	backed out from steady state
Match elasticity	γ	0.5	Petrongolo and Pissarides (2001)
Worker's bargaining weight	η	0.5	Petrongolo and Pissarides (2001)
Separation rate	σ	0.025	Tealdi (2019)
Hiring cost	κ	$\kappa v/Y = 1\%$	Gertler and Trigari (2009)
Replacement rate	$b/(wh)$	0.35	Pappa, Sajedi and Vella (2015)
Job-related overhead costs	Φ	-0.06	backed out from steady state
Steady-state unemployment rate	u	9.6%	Data
Steady-state job finding rate	p	0.22	Peracchi, Viviano et al. (2004)
Steady-state vacancy filling rate	q	0.7	various studies
Government spending share	G/Y	0.20	Data

4 Labor Market Institutions and Macroeconomic Dynamics

LMIs are complex to measure, multi-faceted, and are usually defined using numerous indices.[15] For this reason, we introduce some modeling assumptions that enable us to map labor market frictions with Italian labor market rigidities. We distinguish between two types of labor market rigidities as in Abbritti and Weber (2010). First, we model unemployment rigidities through parameters that capture hiring costs and labor market flows. These parameters drive incentives for job creation and job destruction in our economy. Second, we introduce real wage rigidities through (i) the EB and RTM mechanisms which characterize distinct degrees of centralization and coordination in the collective bargaining process; (ii) a wage stickiness parameter that captures the degree of real wage adjustment in Italy; and (iii) the bargaining power parameter that captures the strength of unions in our economy. We conduct counterfactuals on key parameters capturing labor market deregulation in wage rigidity, hiring costs, and the bargaining power of workers. We allow for the interaction of labor market rigidities in our simulation, which is crucial for determining macroeconomic outcomes (see, e.g., Messina et al. 2010; Fabiani et al. 2010).

[15] In the data, Gnocchi et al. (2015) build proxies of wage bargaining, the strength of unions, and employment protection institutions from a combination of several indices.

We use the calibrated version of the model for counterfactual analysis. To identify the impact of labor market reforms, we vary the parameter characterizing the selected labor market policy and we let the steady state be affected by parameter changes and the propagation of all shocks.[16] We prefer the calibrated over the estimated version of the model for two main reasons: First, the calibrated version involves changing only one parameter at a time. Second, the calibrated model is parsimoniously parameterized which makes it easier to explain the changes in dynamics triggered by the counterfactuals. We account for various labor market reforms as discussed in the literature.[17]

4.1 Structural Reforms in the Labor Market and Model Dynamics

In the following, we conduct counterfactuals on key parameters that characterize labor market deregulation in wage rigidity, hiring costs, and the bargaining power of workers when our baseline model is simulated under the interaction of the EB and RTM mechanisms and hiring costs à la Gertler and Trigari (2009). We present the responses of selected variables in reaction to the demand shock (monetary policy) and the technology shock.[18]

Figure (1) shows the responses of selected variables to an expansionary monetary policy shock under the EB and RTM mechanisms and various degrees of wage rigidity. The baseline response is always shown as a blue solid line. The red solid line shows the reactions of variables when real wages are negotiated every two quarters ($\rho_w = 0.5$) while the black dashed line displays the case of fully flexible real wages ($\rho_w = 0$). All other parameters remain at their values in the baseline. Figure (1a) exhibits the responses of selected variables under the EB mechanism. An expansionary monetary policy shock triggers a fall in the nominal interest rate and a rise in output and inflation. Producing more output requires more factor inputs. Since employment and capital stock are predetermined, firms react by increasing hours and effort in the short run which then boosts labor productivity. Higher hours and effort lead firms to post more vacancies and hire additional workers. Hence, real wages and employment increase while unemployment falls. The increase in real wages is higher on impact under the case of the fully flexible real wage. This triggers a shift in the adjustment from the intensive to the extensive margin occasioning large increases in employment and vacancies and falls in hours, effort, and unemployment. The rise in real wages does not affect inflation under the EB mechanism. Figure (1b) shows the responses of selected variables under the RTM mechanism. Here, changes in real wages directly affect inflation. Moreover, labor productivity is now countercyclical

[16] Following Christoffel et al. (2009), we simulate a version of our model that does not include the wage bargaining shock. This is equivalent to muting the wage bargaining shock by setting its variance equal to zero in a model with the wage bargaining shock.

[17] In the literature, there exist various ways to model labor market reforms. E.g., a reduction in wage rigidity (Christoffel and Linzert 2010), a decrease in hiring costs (Christoffel et al. 2009, Barnichon 2010), a decline in the bargaining power of workers (Blanchard and Giavazzi 2003; Lombardi, Riggi and Viviano 2020; Carluccio and Bas 2015), an increase in job-finding and separation rates (Abbritti and Mueller 2013), a fall in firing costs (Zanetti 2011, Cacciatore and Fiori 2016).

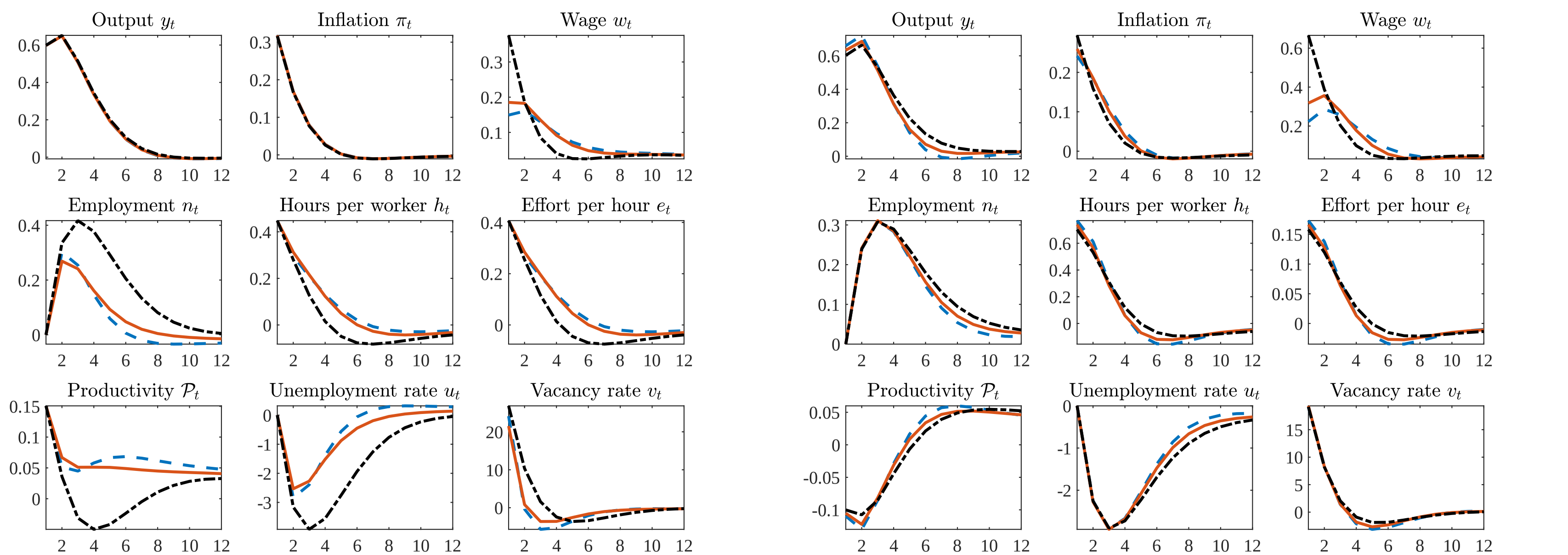
[18] We have the impulse responses in reaction to all shocks included in the simulation. For the sake of exposition, we only show the responses to the monetary policy shock and the technology shock.

conditional on the demand shock regardless of the degree of wage rigidity. Though the responses of the remaining variables are similar to the EB mechanism, the shock affects labor market dynamics differently.

Figure (2) shows the responses of selected variables to an expansionary technology shock under the EB and RTM mechanisms and various degrees of wage rigidity. Figure (2a) exhibits the responses of selected variables under the EB mechanism. An exogenous improvement in the firm's production technology increases output and drops inflation. Though production increases, aggregate demand cannot follow in the short run since prices are sticky. Hence, to meet their demand in the short run, firms temporarily reduce hours and effort and labor productivity responds in a procyclical fashion. Since the marginal worker is more productive, real wages increase and firms post more vacancies to hire additional workers and unemployment falls. The rise in real wages is higher under the case of the fully flexible real wage which generates significant differences in the responses of labor market variables. The response of labor productivity is always procyclical regardless of the degree of wage rigidity. Figure (2b) displays the responses of selected variables under the RTM mechanism. Apart from the direct effect on inflation triggered by real wage changes, the responses of labor market variables are similar to the EB mechanism.

Figure (3) shows the responses of selected variables to an expansionary monetary policy shock under the EB and RTM mechanisms and various scenarios of unemployment rigidities. The red solid line shows the responses of variables when hiring costs (κ) are reduced to $1/3$ of their size in the baseline. The black dashed line corresponds to a scenario with higher labor market flows, higher separation σ, and higher job-finding p rates. All other parameters remain at their values in the baseline. Figure (3a) displays the responses of selected variables under the EB mechanism. A reduction in unemployment rigidities (a fall in hiring costs and an increase in labor market flows) produces almost the same responses of labor market variables and labor productivity responds in a procyclical fashion under both scenarios. Nonetheless, there are a few differences. As expected, a rise in labor market flows triggers a much larger fall in unemployment than the alternative scenarios. In contrast, a fall in hiring costs generates a larger rise in vacancies and employment (in the medium run) than the alternative scenarios. Figure (3b) exhibits the responses of selected variables under the RTM mechanism. A fall in hiring costs triggers much higher increases in hours, effort, employment, and vacancies and an important fall in unemployment than the baseline scenario. The labor market effects of a reduction in unemployment rigidities are similar to the EB mechanism. Nevertheless, we find that an increase in labor market flows results in a much higher increase in employment and a substantial drop in unemployment. Labor productivity responds always in a countercyclical fashion under all scenarios.

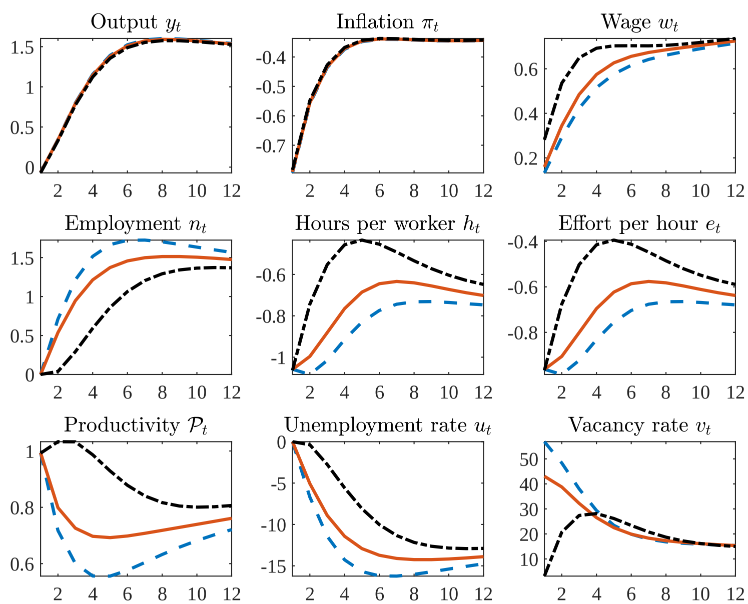
Figure (4) displays the responses of selected variables to a positive technology shock under the EB and RTM mechanisms and various degrees of unemployment rigidities. Figure (4a) presents the responses of selected variables under the EB mechanism. A fall in hiring costs triggers a larger rise in employment and vacancies, and a greater fall in hours and effort than the alternative scenario. In contrast, an increase in labor market flows triggers a larger drop in unemployment. Labor productivity increases under all scenarios.



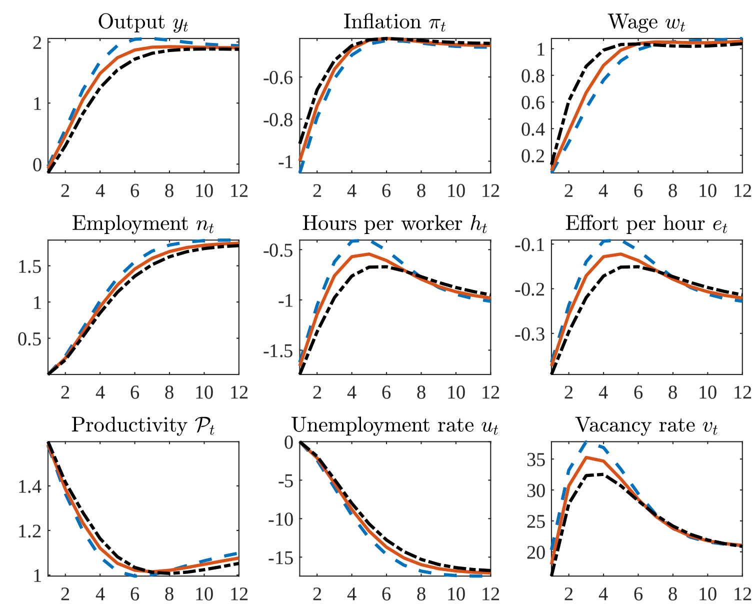
(a) **Responses to a monetary policy shock: wage rigidity-EB.**

(b) **Responses to a monetary policy shock: wage rigidity-RTM.**

Figure 1: **Impulse responses to an expansionary monetary policy shock: real wage rigidity**. Notes. Impulse responses are measured as percentage deviations from steady state. The blue dashed line marks the calibrated model. The red solid lines correspond to an intermediate degree of wage rigidity ($\rho_w = 0.5$). The black dashed line shows the case of no wage rigidity ($\rho_w = 0$).



(a) **Responses to a technology shock: wage rigidity-EB.**



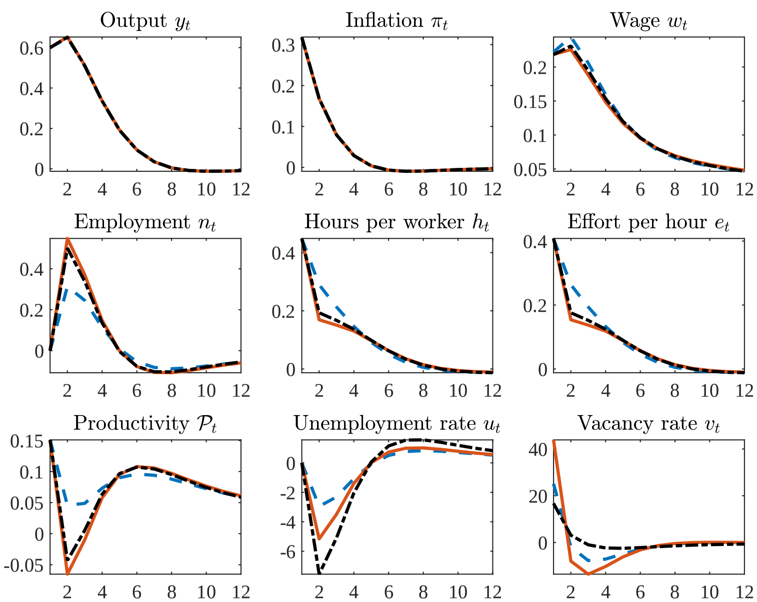
(b) **Responses to a technology shock: wage rigidity-RTM.**

Figure 2: **Impulse responses to an expansionary technology shock: real wage rigidity**. Notes. Impulse responses are measured as percentage deviation from steady state. The blue dashed line marks the calibrated model. The red solid line corresponds to an intermediate degree of RWR ($\rho_w = 0.5$). The black dashed line shows the case of no RWR ($\rho_w = 0$).

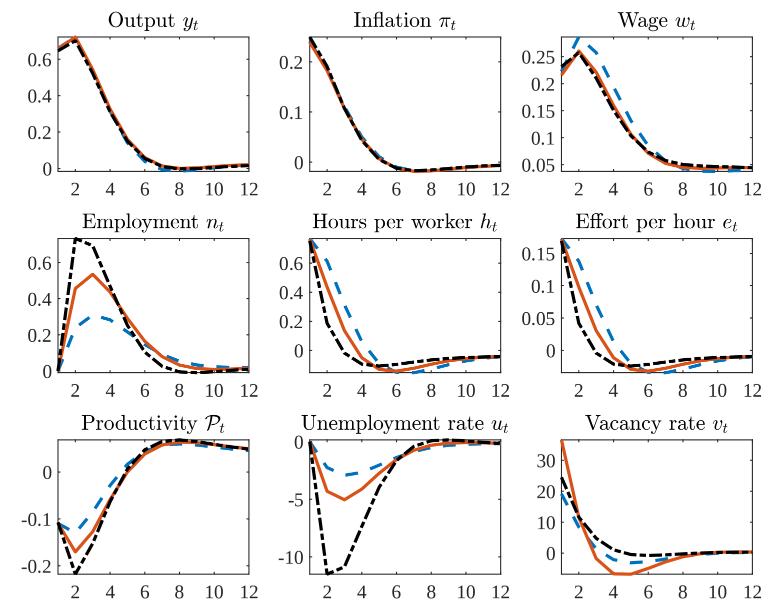
Figure (4b) presents the responses of selected variables under the RTM mechanism. Similarly, a fall in hiring costs triggers a much larger increase in vacancies than in alternative scenarios. Again, an increase in labor market flows generates a greater drop in the unemployment rate compared to alternative scenarios. Except for the direct inflation effect, the responses of the remaining labor market variables are similar to the case of the EB mechanism.

Figure (5) displays the responses of selected variables to an expansionary monetary policy shock under the EB and RTM mechanisms and various degrees of the bargaining power of workers. The blue line shows the baseline scenario where both workers and firms have the equal bargaining power of the employment match surplus ($\eta, \xi = 0.5$). The red solid line exhibits the scenario where workers enjoy an increase in their bargaining power of the match surplus ($\eta, \xi = 0.7$). The black dashed line displays the scenario where workers face a fall in their bargaining power of the match surplus ($\eta, \xi = 0.2$). The remaining parameters remain at their values in the baseline. Figure (5a) presents the responses of selected variables under the EB mechanism. A fall in the bargaining power of workers triggers a much higher fall in real wages which in turn causes a much higher increase in employment and vacancies, a small increase in hours and effort, and a larger decrease in the unemployment rate than under the alternative scenario. The response of labor productivity is procyclical under all scenarios. A higher degree of the bargaining power of workers generates opposite effects. Figure (5b) presents the responses of selected variables under the RTM mechanism. A drop in the bargaining power of workers triggers a much less rise in hours, effort, and real wages. The latter directly translates into a less significant increase in inflation and output than the alternative scenarios. The responses of the remaining labor market variables are similar to the case of the EB mechanism. Labor productivity is countercyclical under all the scenarios.

Figure (6) shows the responses of selected variables to an expansionary technology shock under the EB and RTM mechanisms and various degrees of the bargaining power of workers. Figure (6a) shows the responses of selected variables under the EB mechanism. A decline in the bargaining power of workers coupled with an improvement in the firm's production technology generates an increase in the marginal product of employment for workers which causes a moderate rise in real wages, employment, and vacancies, a larger increase in hours and effort, and a smaller drop in unemployment than under the alternative scenarios. The response of labor productivity is procyclical under all scenarios. An improvement in the bargaining power of workers has opposite effects. Figure (6b) displays the responses of selected variables under the RTM mechanism. A fall in the bargaining power of workers triggers a much lower rise in real wages than the alternative scenario in the medium run. This shifts adjustment from the intensive margin (hours and effort fall) to the extensive margin as firms post more vacancies and hire new workers, leading to a larger rise in employment and a greater fall in the unemployment rate in the medium run than the alternative scenario. The slow rise in real wages triggers a smaller fall in inflation and a smaller increase in output in the medium run. Labor productivity is strongly procyclical under all scenarios.

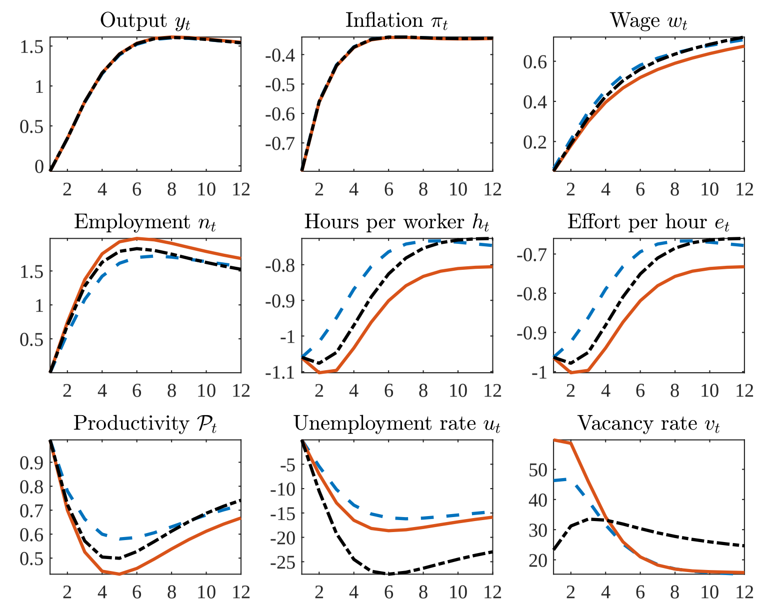


(a) **Responses to a monetary shock: unemployment rigidities-EB.**

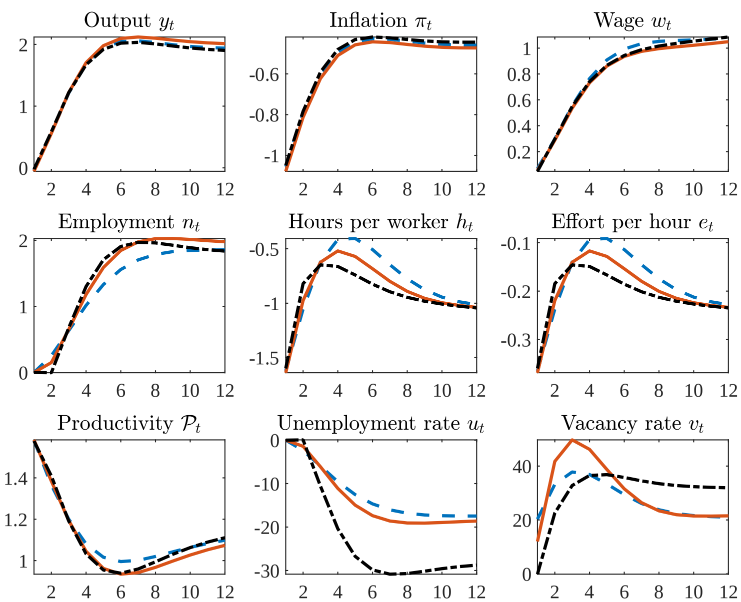


(b) **Responses to a monetary shock: unemployment rigidities-RTM.**

Figure 3: **Impulse responses to an expansionary monetary policy shock: Unemployment rigidities**. Notes. Impulse responses are measured as percentage deviation from steady state. The blue dashed line shows the baseline. The red solid line shows the case when hiring costs, κ, are $\frac{1}{3}$ of their size in the baseline. All other parameters are as in the baseline. The black dashed line corresponds to a scenario with higher separation and higher job-finding rates $\sigma = 0.06$, $u = 0.06$, $p = 0.94$. All other parameters are as in the baseline.

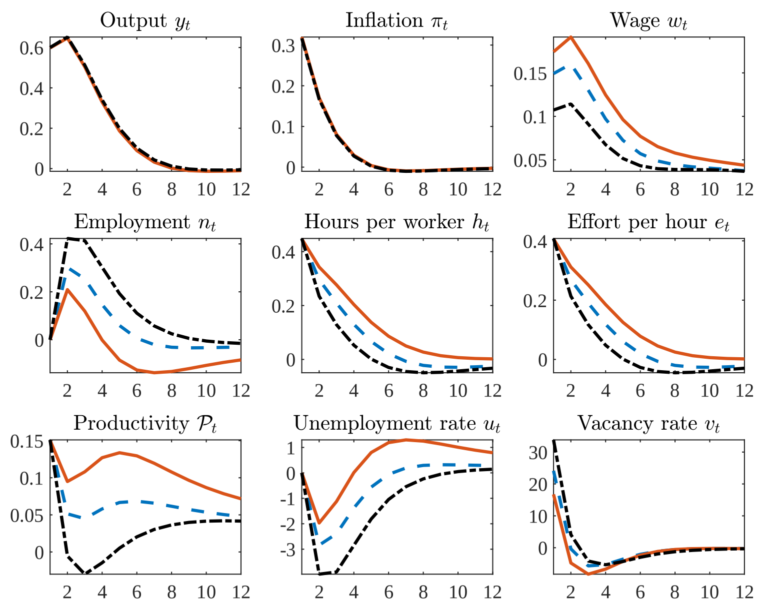


(a) **Responses to a technology shock: Unemployment rigidities-EB.**

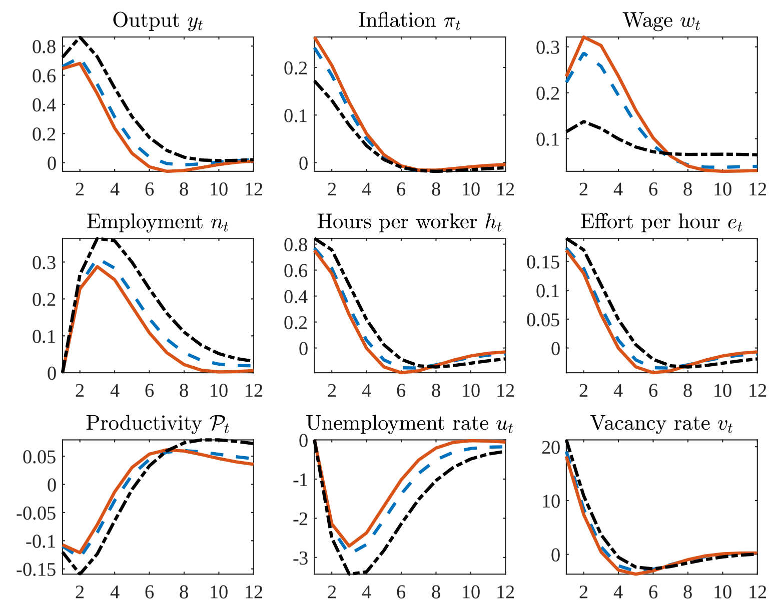


(b) **Responses to a technology shock: Unemployment rigidities-RTM.**

Figure 4: **Impulse responses to an expansionary technology shock: Unemployment rigidities**. Notes. Impulse responses are measured as percentage deviation from steady state. The blue dashed line shows the baseline. The red solid line shows the case when hiring costs, κ, are $\frac{1}{3}$ of their size in the baseline. All other parameters are as in the baseline. The black dashed line corresponds to a scenario with high separation and job-finding rates $\sigma = 0.06$, $u = 0.06$, $p = 0.94$. All other parameters are as in the baseline.

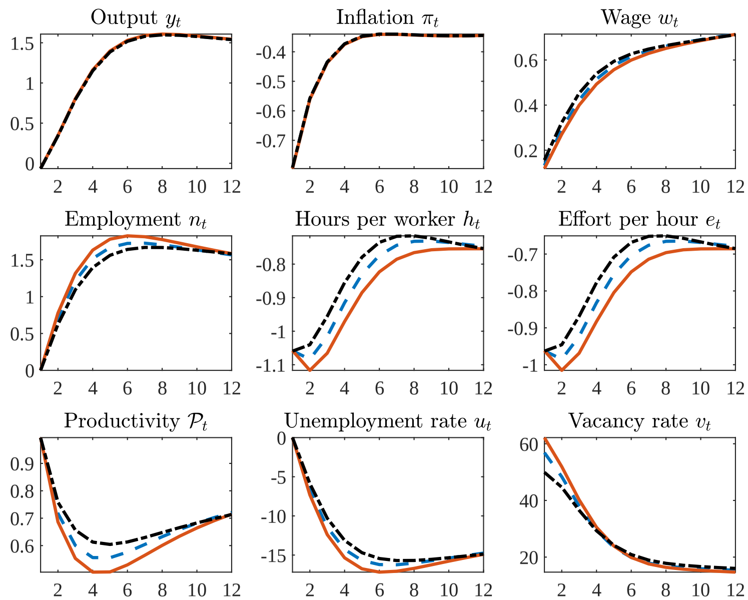


(a) **Responses to a monetary policy shock: Bargaining power-EB.**

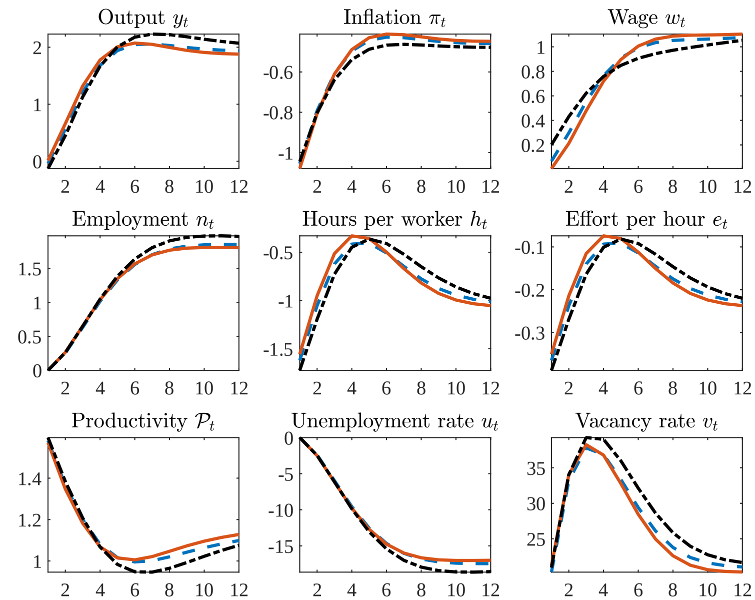


(b) **Responses to a monetary policy shock: Bargaining power-RTM.**

Figure 5: **Impulse responses to an expansionary monetary policy shock: Bargaining power**. Notes. Impulse responses are measured as percentage deviation from steady state. The blue dashed line shows the baseline. The red solid line shows a case where the worker's bargaining power, $\eta, \xi = 0.7$. All other parameters are as in the baseline. The black dashed line shows a scenario where the bargaining power of workers, $\xi = 0.2$. All other parameters are as in the baseline.



(a) **Responses to a technology shock: Bargaining power-EB.**



(b) **Responses to a technology shock: Bargaining power-RTM.**

Figure 6: **Impulse responses to an expansionary technology shock: Bargaining power**. Notes. Impulse responses measured as percentage deviation from steady state. The blue dashed line shows the baseline. The red solid line shows a case where the bargaining power of workers, $\eta, \xi = 0.7$. All other parameters are as in the baseline. The black dashed line shows a scenario where the bargaining power of workers, $\eta, \xi = 0.2$. All other parameters remain at their values in the baseline.

4.2 Labor Market Reforms and Business Cycle Moments

In this section, we analyze to what extent labor market deregulation affects the cyclicality of labor productivity and cyclical moments under the interaction of the EB and RTM mechanisms and three functional types of hiring costs. We perform a simulation exercise where we vary key parameters characterizing labor market deregulation: we vary (i) ρ_w on a grid between 0.01 and 1 to capture a continuum going from a lower to a higher degree of wage rigidity; (ii) κ on a grid between 1/4 of their steady-state size and their actual steady-state size to capture a continuum going from a fall to a rise in hiring costs; (iii) η, ξ on a grid between 0.2 and 0.7 to capture a continuum going from a fall to a rise in the bargaining power of workers. Following Dossche et al. (2022), to show the differences related to the effort margin, we also vary the value of τ on a grid between 0.1 and 5 to capture a continuum going from a variable-effort economy (red solid lines) to a constant-effort economy (blue dashed lines).

Cyclicality of labor productivity. Figure (7) displays the cyclicality of labor productivity (productivity) in reaction to labor market deregulation under the EB and RTM mechanisms and three functional types of hiring costs. Figure (7a) exhibits the cyclicality of productivity under the interaction of the EB mechanism and three functional types of hiring costs. Figure (7b) shows the cyclicality of productivity under the interaction of the RTM mechanism and three functional types of hiring costs. The first row in figures (7a)-(7b) reports the evolution of the cyclicality of productivity when we simulate our model with hiring costs à la GT. The second row shows the evolution of the cyclicality of productivity when we simulate our model with standard linear vacancy costs à la Mortensen and Pissarides (1994). The third row shows how the cyclicality of productivity evolves when we consider hiring costs à la SST. The first, second, and third columns in figures (7a)-(7b) present respectively the cyclicality of productivity by each type of labor market deregulation (wage rigidity, hiring costs and bargaining power of workers). For the sake of space, we only discuss the simulation outcomes for the variable-effort model.

Tables 1-2 compare the cyclical moments triggered by labor market regulation under the aforementioned interaction. Under the EB mechanism, when we simulate our model with the three types of hiring costs, we find that labor market policies generate procyclical productivity. In particular, when we simulate our model with hiring costs à la Sala et al. (2013), a fall in wage rigidity generates procyclical productivity (0.40) which matches well with the data. Under the RTM mechanism, when we simulate our model with the three types of hiring costs, labor market deregulation triggers either countercyclical or weakly procyclical labor productivity. More specifically, when the RTM mechanism interacts with hiring costs à la Gertler and Trigari (2009), a decrease in the degree of wage rigidity generates procyclical productivity while the remaining labor market policies trigger countercyclical productivity. When we simulate our model with linear vacancy costs, labor market deregulation generates countercyclical productivity. Finally, when we simulate our model with hiring costs à la Sala et al. (2013), labor market policies trigger weakly procyclical productivity.

Figure (8) shows the evolution of cyclical moments when our model is simulated under the interaction of the EB and RTM mechanisms and hiring costs à la GT. The rows in figures (8a)-(8b) present respectively the relative volatility of labor market outcomes (employment, hours, unemployment) and inflation. The columns in figures (8a)-(8b) display respectively the results according to each labor market policy (wage rigidity, hiring costs, and bargaining power of workers). For the sake of space, in what follows we only discuss the results of the variable-effort model. Figure (8a) shows the evolution of cyclical moments under the EB mechanism. When we simulate our model with post-match hiring costs, an increase in wage rigidity and in the bargaining power of workers increases the volatility of labor market variables (unemployment, hours, and employment). An increase in hiring costs decreases the volatility of labor market variables. Labor market policies trigger do not alter the inflation volatility but they match well the inflation volatility in the data. Figure (8b) presents the evolution of cyclical moments under the RTM mechanism. We find that an increase in wage rigidity and in hiring costs increases the volatility of unemployment, employment, and inflation. An increase in wage rigidity drops the volatility of hours while a rise in hiring costs does not alter the volatility of hours. An increase in the bargaining power of workers does not alter the volatility of unemployment and employment, reduces the volatility of hours, and increases inflation volatility. An increase in wage rigidity generates the volatility of unemployment (4.88) and inflation (0.30) which match well with the data.

Figure (9) presents the evolution of cyclical moments under the interaction of the EB and RTM mechanisms and linear vacancy costs. The rows in figures (9a)-(9b) show the volatility of labor market outcomes and inflation respectively. The columns in figures (9a)-(9b) present the results according to each labor market policy (wage rigidity, hiring costs, and bargaining power of workers) respectively. Figure (9a) presents the evolution of the cyclical moments under the EB mechanism. We show that an increase in wage rigidity increases the volatility of employment and unemployment volatility. An increase in hiring costs and in the bargaining power of workers decreases employment and unemployment volatility. LMIs do not alter the volatility of hours and inflation. Figure (9b) exhibits the dynamics of the cyclical moments under the RTM mechanism. We find that an increase in wage rigidity increases the volatility of employment and unemployment, and inflation but drops the volatility of hours. A rise in hiring costs and in the bargaining power of workers decreases the volatility of employment, unemployment, hours, and inflation.

Figure (10) displays the evolution of the cyclical moments under the interaction of the EB and RTM mechanisms and hiring costs à la Sala et al. (2013). The rows in figures (10a)-(10b) show the volatility of labor market outcomes and inflation respectively. The columns in figures (10a)-(10b) present the results according to each labor market policy (wage rigidity, hiring costs, and bargaining power of workers) respectively. Figure (10a) presents the cyclical moments under the EB mechanism. We find that an increase in wage rigidity increases the volatility of employment and unemployment. An increase in hiring costs and in the bargaining power of workers decreases the volatility of employment and unemployment. An increase in wage rigidity and in the bargaining power of workers increases the volatility of hours while a rise in hiring costs does not alter its volatility. Labor market policies do not change the volatility of inflation. Figure (10b) displays the cyclical moments under the RTM mechanism. We find that an increase in wage rigidity increases unemployment volatility but reduces the volatility of hours, unemployment, and inflation. An increase in hiring costs reduces the volatility of employment, unemployment, and inflation but rises the volatility of hours. An increase in the bargaining power of workers does not alter the volatility of employment and unemployment, reduces the volatility of hours, and increases inflation volatility.

5 The Role of Labor Market Shocks – a Bayesian Estimation

5.1 Data and Priors

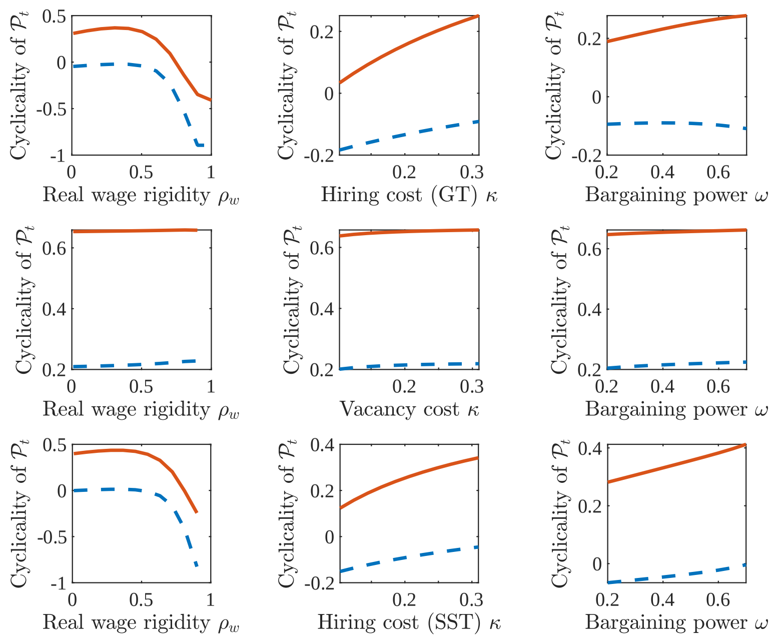
So far, we have analyzed to what extent permanent changes in LMIs affect labor market dynamics in reaction to demand and technology shocks. In this section, we examine whether shocks are important sources of fluctuations in Italian labor productivity. For this purpose, we estimate the resulting models using Bayesian techniques (see An and Schorfheide (2007) for a detailed discussion on Bayesian estimation). We estimate two models where the EB or RTM mechanism interacts with hiring costs à la Sala et al. (2013). The latter has the advantage of nesting pre-match and post-match hiring costs. We obtain the posterior distributions of parameters by combining the likelihood function from our log-linearized model and the prior distribution of parameters.[19]

Data. The model is estimated using quarterly Italian data running from 1996Q1 to 2018Q4. Our baseline model includes the following observables: real GDP per capita, real investment per capita, real consumption per capita, the nominal interest rate, inflation, wages per employee, the unemployment rate, and total hours.

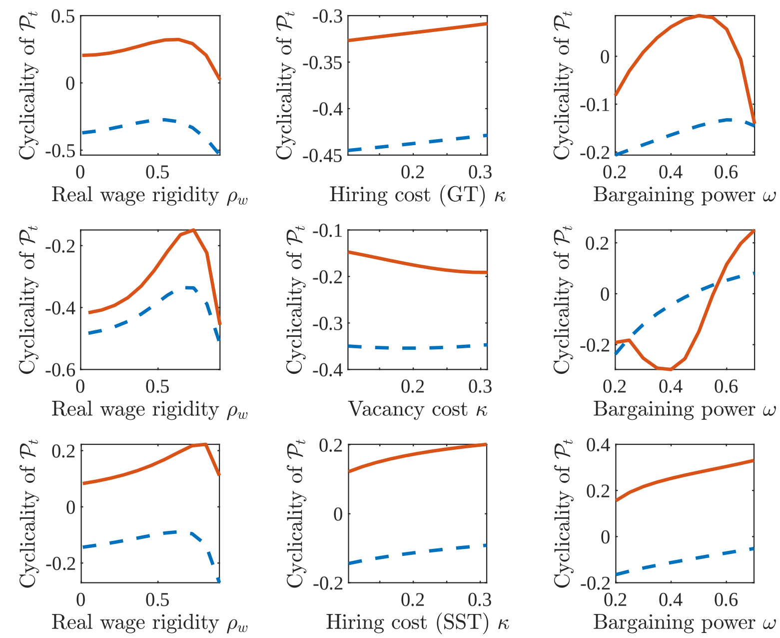
The inflation rate is measured as the quarter-to-quarter GDP deflator and the nominal interest rate is in percentage points. All variables, except the interest rate, are expressed in logs. They are then filtered using the one-sided HP filter (Stock and Watson, 1999) and multiplied by 100 to express them in percentage deviations. The estimated model includes shocks to the neutral technology, the risk premium, the investment-specific technology, the government consumption, the price markup, the labor supply, and the wage bargaining.

Priors. We keep some parameters fixed to their calibrated values before we estimate our model (see section 3.1). Our priors, summarized in Table 4, are standard (Smets and Wouters 2007, Gertler et al. 2008, Sala et al. 2013). We set the prior mean of the returns to hours parameter, ϕ, to 1.5 and we let its standard deviation account for both decreasing and increasing returns to hours in production, as in Lewis et al. (2019) for the Euro area.

[19] The posterior means are computed using two chains of the Random Walk Metropolis-Hasting (RWMH) algorithm for which we generate 300,000 draws and we discard the first half of them. We estimate our models using the Dynare toolbox version 4.5.7 (Adjemian et al., 2011).

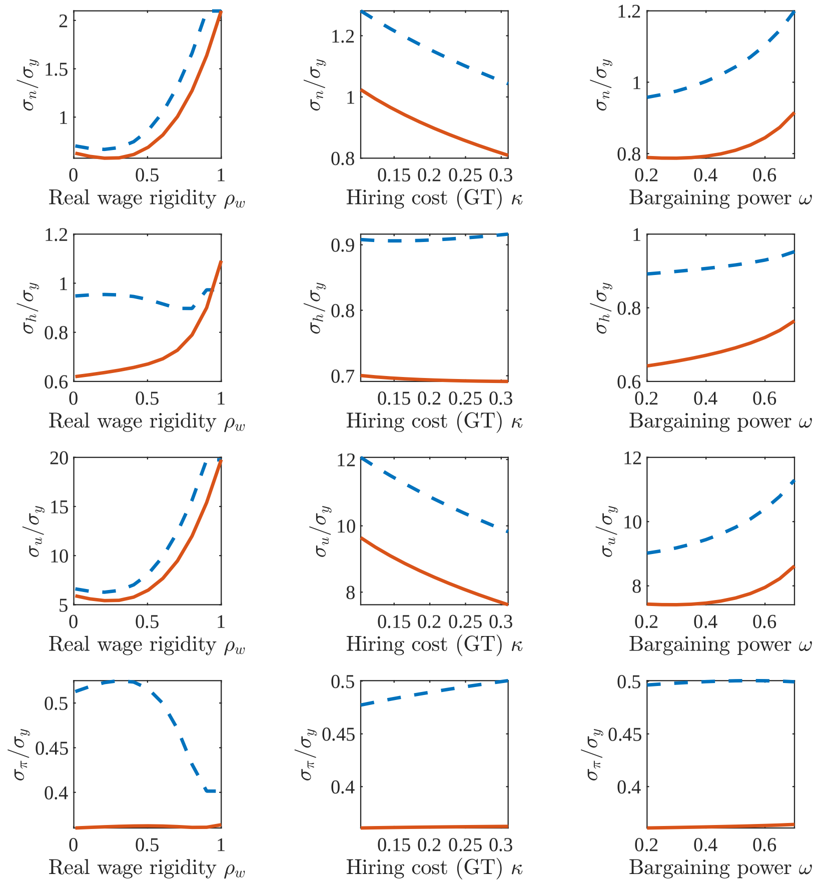


(a) **Cyclicality of labor productivity under EB and three hiring costs.**

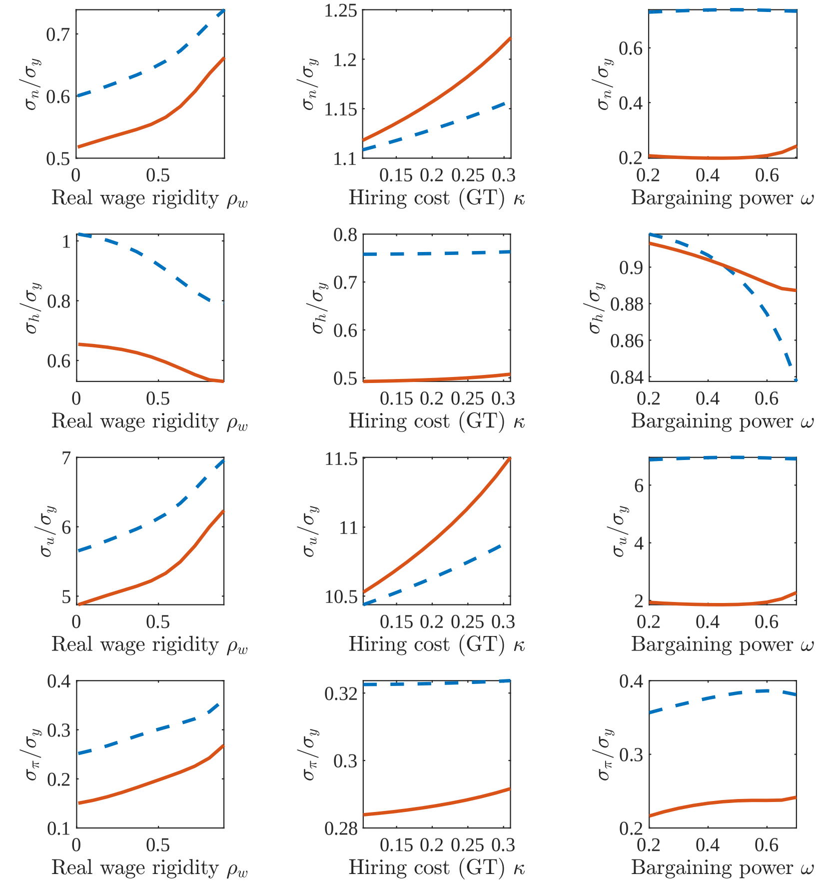


(b) **Cyclicality of Labor Productivity under RTM and three hiring costs.**

Figure 7: **Cyclicality of Labor Productivity**. The red solid lines show the variable-effort model (low τ) (the baseline), blue dashed lines show the constant-effort model (high τ).

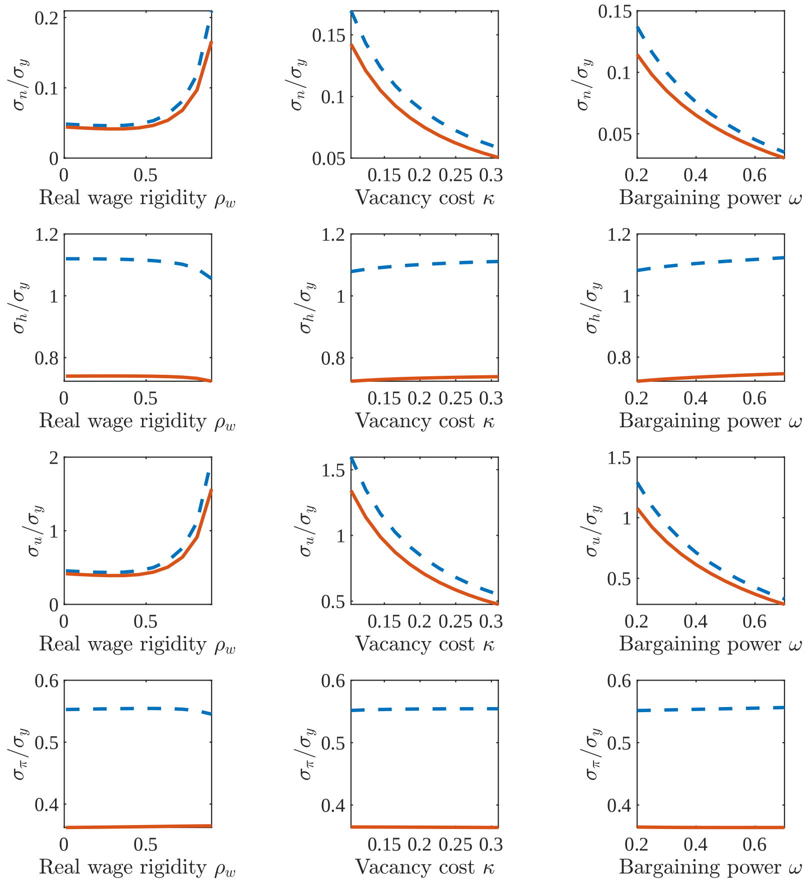


(a) **Labor market and inflation volatility under EB and Hiring costs.**

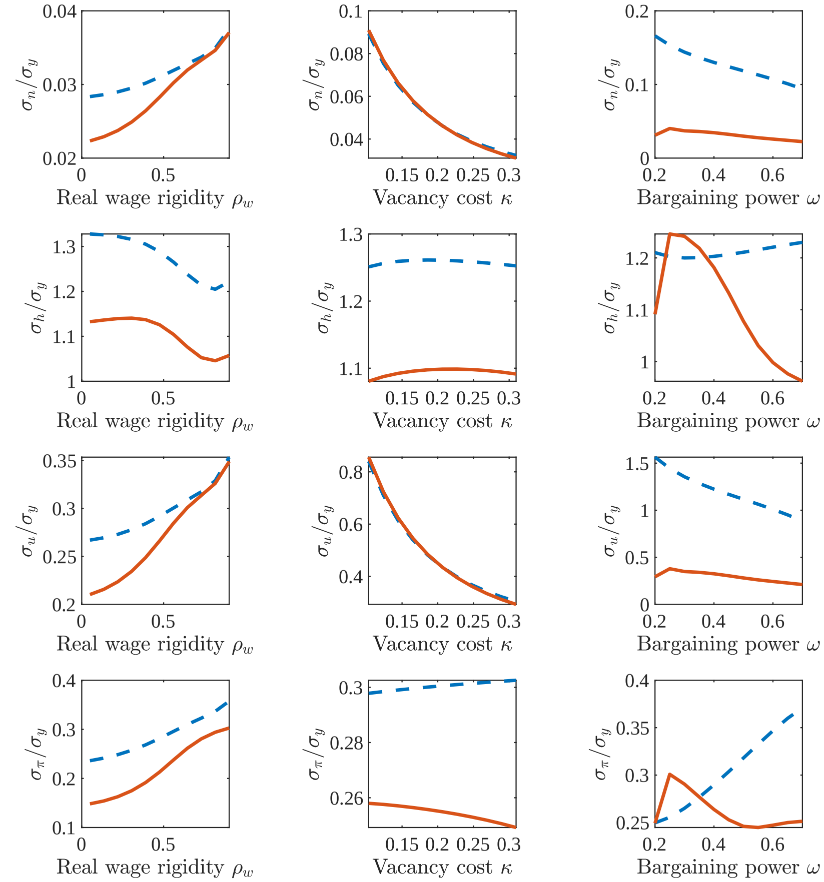


(b) **Labor market and inflation volatility under RTM and Hiring costs.**

Figure 8: Labor market and inflation volatility-hiring costs (GT). The red solid lines show the variable effort model (low τ) (the baseline), blue dashed lines show the constant-effort model (high τ).

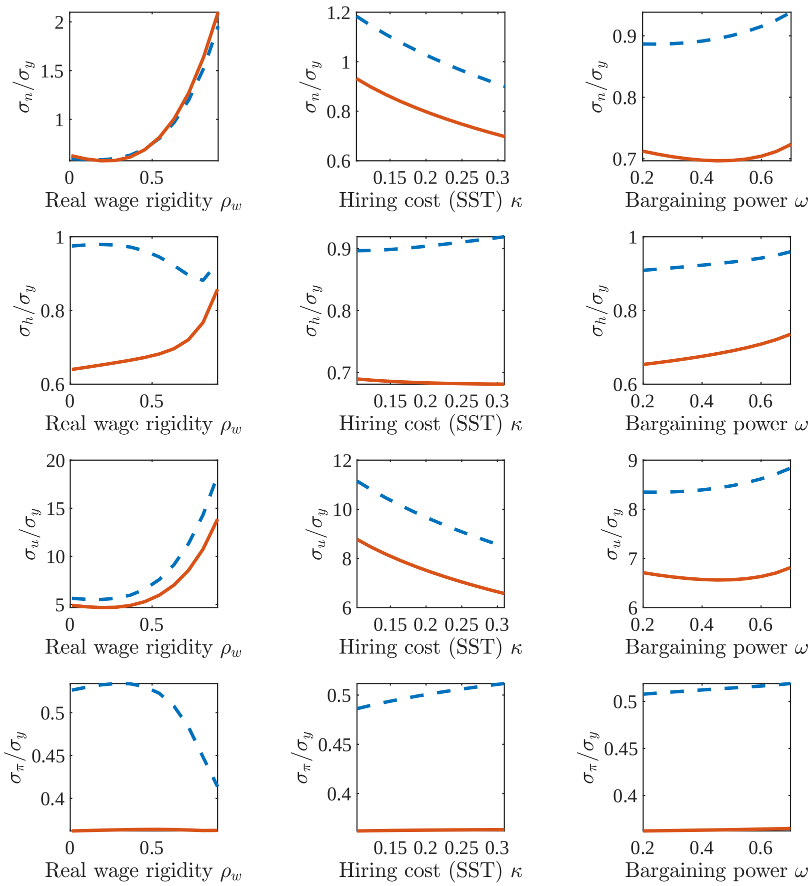


(a) **Labor market and inflation volatility under EB and vacancy costs.**

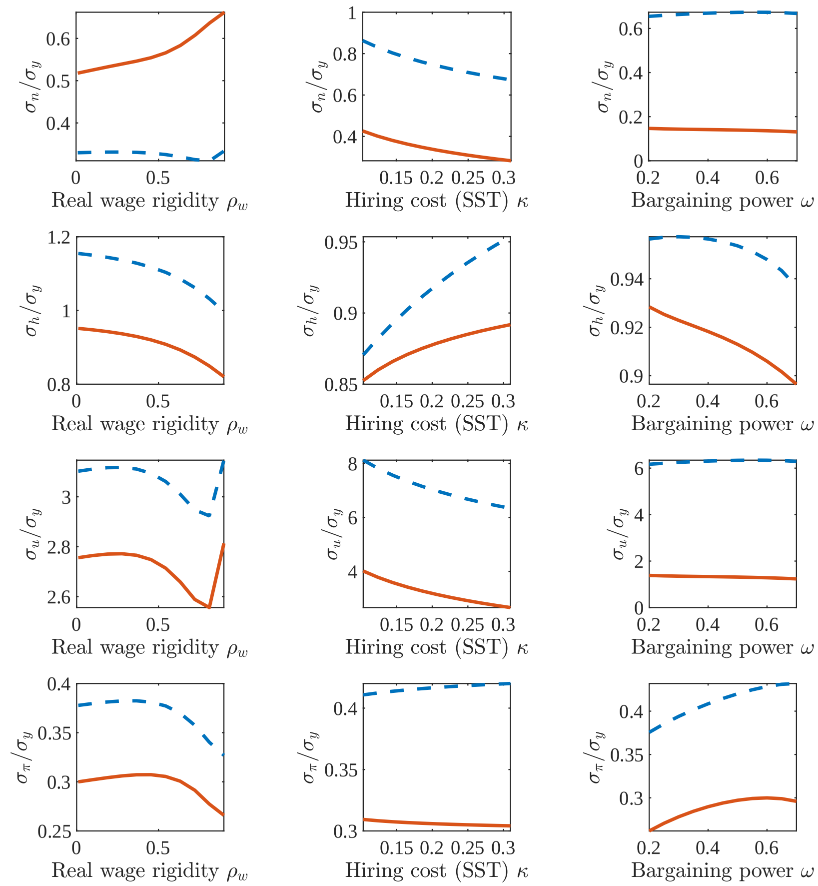


(b) **Labor market and inflation volatility under RTM and vacancy costs.**

Figure 9: Labor market and inflation volatility-vacancy costs. The red solid lines show the variable-effort model (low τ) (the baseline), blue dashed lines show the constant-effort model (high τ).



(a) **Labor market and inflation volatility under EB and hiring costs.**



(b) **Labor market and inflation volatility under RTM and hiring costs.**

Figure 10: Labor market and inflation volatility-hiring costs (SST). The red solid lines show the variable-effort model (low τ) (the baseline), blue dashed lines show the constant-effort model (high τ).

Estimation results. Table 5 compares the results of our estimation for the EB and RTM models. Since most estimates are in line with the previous literature, we mainly discuss the parameters most relevant to our research question. Effort plays a crucial role in the Italian business cycle regardless of the bargaining mechanisms. We do not find substantial differences in the use of effort between the EB and RTM models. The posterior mean of the returns to hours ϕ is 1.43 for the EB model and 1.48 for the RTM model. Given these estimates and the calibrated value of σ_h, the curvature of the effort disutility function, σ_e, is equal to 1.33 for the EB model and 1.08 for the RTM model. Lewis et al. (2019) estimate a value of 1.74 for the Euro area which implies a value of 0.35 for the curvature of the effort disutility function. This outcome predicts that the Euro area business cycle features a greater use of the effort margin than Italy. This explains the strongly procyclical productivity for the Euro area compared to Italy. We find great differences in the estimate of the steady-state bargaining power between the EB and RTM models. The posterior mean of the bargaining power of workers η is equal to 0.37 for the EB model while the effective bargaining power of workers ξ is estimated at 0.34 for the RTM model. This result suggests that the bargaining power of workers has weakened in Italy and is in line with empirical evidence for Italy (see Lombardi et al. 2020). We find stark differences in the estimate of the weight on pre-match hiring costs η_q between the EB and RTM mechanisms. Recall that when $\eta_q = 0$ only training costs in new hires are present, $\eta_q = 2$ all weight is assigned to recruitment costs, and $\eta_q = 1$ there is an equal weight of the two costs. The posterior mean of η_q is 0.67 for the EB model and 0.46 for the RTM model. Our results show that post-match training costs are more important than pre-matching recruitment costs in Italy, in line with Del Boca and Rota (1998).

Finally, we document large differences in the estimates of wage stickiness ρ_w between the EB and RTM mechanisms. The posterior mean of the parameter of real wage wage adjustment is 0.22 for the EB model and 0.55 for the RTM model, thereby suggesting that the latter is in line with evidence for Italy (Devicienti et al., 2007). Table 5 compares the results of the variance decomposition of selected variables from the estimated models across different horizons. We find that the investment shock is the dominant source of business cycle fluctuations in the long run. In the short run, most of the cyclical fluctuations in labor and macroeconomic variables are driven by demand shocks (risk premium, monetary), price markup shocks, and technology shocks. Fluctuations in output are mainly driven by the risk premium shock in the short run and the investment shock in the long run. The wage bargaining shock explains a sizable share of fluctuations in employment in the short run for the EB model only but its role remains limited, in line with previous results in the literature (Sala et al., 2013,Furlanetto and Groshenny, 2016). Labor productivity is mainly driven by technology shocks in the EB and RTM models.

We have also evaluated the robustness of our empirical results by considering two extensions: the drivers of labor productivity after 2000s and the role of additional labor market shocks. Our main results are confirmed and technology shocks remain the main driving forces of labor productivity. See more details in the appendix B.

Table 4: Priors and posteriors of structural parameters: EB and RTM with hiring costs à la SST.

Parameter			EB	RTM
Structural				
Returns to hours	ϕ	N(1.5, 0.1)	1.43 [1.36, 1.51]	1.48 [1.38, 1.60]
Habit consumption	λ_c	B(0.5, 0.15)	0.45 [0.37, 0.54]	0.54 [0.46, 0.62]
Capital utilization	κ_u	B(0.3, 0.1)	0.21 [0.14, 0.27]	0.24 [0.13, 0.36]
Investment adj. costs	κ_i	G(4.5, 0.15)	4.62 [4.52, 4.74]	4.28 [4.13, 4.47]
Price stickiness	χ	G (0.66, 0.1)	0.75 [0.67, 0.83]	0.67 [0.55, 0.80]
Steady-state bargaining power	η, ξ	B(0.5, 0.2)	0.37 [0.26, 0.48]	0.34 [0.23, 0.43]
Steady-state price markup	ϵ^p	N(0.8, 0.05)	0.80 [0.76, 0.83]	0.79 [0.72, 0.86]
Weight on hiring costs	η_q	G(0.49, 1.20)	0.67 [0.51, 0.82]	0.46 [0.29, 0.66]
Wage stickiness	ρ_w	B(0.6, 0.15)	0.22 [0.17, 0.27]	0.55 [0.41, 0.68]
Inflation - Taylor rule	τ_π	N(1.5, 0.1)	1.54 [1.41, 1.67]	1.54 [1.47, 1.62]
Output gap - Taylor rule	τ_y	N(0.125, 0.05)	0.17 [0.12, 0.23]	0.18 [0.14, 0.23]
Interest rate smoothing	ρ_r	B(0.85, 0.05)	0.82 [0.80, 0.85]	0.84 [0.81, 0.87]
Autoregressive parameters				
Technology	ρ_a	B(0.5, 0.15)	0.57 [0.47, 0.67]	0.54 [0.46, 0.63]
Risk premium	ρ_b	B(0.5, 0.15)	0.28 [0.22, 0.34]	0.26 [0.19, 0.33]
Government	ρ_g	B(0.5, 0.15)	0.73 [0.66, 0.81]	0.75 [0.67, 0.84]
Bargaining	ρ_w	B(0.5, 0.15)	0.64 [0.51, 0.76]	0.41 [0.30, 0.54]
Investment	ρ_i	B(0.5, 0.15)	0.98 [0.97, 0.99]	0.96 [0.94, 0.99]
Price markup	ρ_p	B(0.5, 0.15)	0.50 [0.43, 0.56]	0.60 [0.51, 0.70]
Labor supply	ρ_h	B(0.5, 0.15)	0.60 [0.53, 0.67]	0.39 [0.24, 0.53]
Monetary	ρ_m	B(0.5, 0.15)	0.46 [0.39, 0.52]	0.49 [0.41, 0.58]
Standard deviations of innovations				
Technology	σ_a	IG(0.10, 3)	0.01 [0.012, 0.013]	0.01 [0.012, 0.013]
Risk premium	σ_m	IG(0.10, 3)	0.01 [0.012, 0.014]	0.01 [0.012, 0.014]
Government	σ_g	IG(0.10, 3)	0.02 [0.017, 0.022]	0.02 [0.018, 0.022]
Bargaining	σ_w	IG(0.10, 3)	0.02 [0.017, 0.028]	0.07 [0.022, 0.121]
Investment	σ_i	IG(0.10, 3)	0.02 [0.014, 0.021]	0.02 [0.014, 0.022]
Price markup	σ_c	IG(0.10, 3)	0.02 [0.017, 0.023]	0.02 [0.013, 0.019]
Labor supply	σ_h	IG(0.10, 3)	0.02 [0.015, 0.020]	0.03 [0.021, 0.035]
Monetary	σ_h	IG(0.01, 3)	0.001 [0.001, 0.002]	0.001 [0.001, 0.002]

Table 5: Forecast error variance decomposition.

	Horizon	Technology	Risk premium	Government	Lab. Supply	Investment	Bargaining	Price markup	Monetary
					EB model				
Output	2	13	41	3	8	5	0	12	18
	10	14	15	1	10	41	0	10	10
	LR	4	4	0	3	83	0	3	3
Inflation	2	24	16	0	15	10	0	16	20
	10	18	13	0	12	28	0	13	16
	LR	6	5	0	4	75	0	4	5
Wages	2	1	36	0	34	3	8	6	11
	10	4	30	0	32	4	12	8	11
	LR	1	6	0	6	81	2	2	2
Total hours	2	19	34	2	9	6	1	13	17
	10	10	13	1	11	41	2	12	10
	LR	7	9	1	8	59	1	9	7
Employment	2	5	0	0	7	10	26	30	22
	10	6	1	0	8	52	13	13	1
	LR	1	0	0	2	89	3	3	1
Hours per worker	2	24	42	3	7	3	1	7	13
	10	21	36	3	9	7	5	7	12
	LR	6	10	1	3	73	2	2	4
Productivity	2	98	1	0	0	0	1	0	0
	10	91	2	0	1	1	4	1	0
	LR	15	0	0	0	83	1	0	0
					RTM model				
Output	2	11	41	3	5	5	1	12	24
	10	12	15	1	6	40	1	13	13
	LR	4	5	0	2	79	0	5	4
Inflation	2	27	6	0	11	12	1	25	18
	10	18	5	0	8	36	1	17	14
	LR	7	2	0	3	75	0	7	5
Wages	2	1	32	0	42	2	5	5	13
	10	4	26	0	35	3	4	11	16
	LR	2	8	0	10	71	1	4	10
Total hours	2	20	35	3	5	5	1	11	21
	10	11	17	1	7	36	1	15	14
	LR	8	12	1	5	54	1	10	10
Employment	2	3	8	0	1	20	0	35	32
	10	5	1	0	2	64	0	19	8
	LR	1	0	0	1	91	0	5	2
Hours per worker	2	24	39	3	5	3	1	7	19
	10	20	33	2	9	8	1	10	18
	LR	10	15	1	4	55	1	5	9
Productivity	2	95	2	0	0	0	0	1	1
	10	91	2	0	1	2	0	2	2
	LR	23	15	1	4	55	1	5	9

6 Conclusion

This paper first analyzes how labor market deregulation affects the cyclicality of Italian labor productivity and cyclical moments when two distinct wage bargaining mechanisms (efficient Nash and right-to-manage bargaining) interact with three functional types of hiring costs in a New Keynesian model that features labor market frictions and labor effort. Second, it measures the role of shocks including labor market shocks, as sources of fluctuations in Italian labor productivity by estimating the resulting model with Bayesian estimation using Italian data. Depending on the interaction, our results show that when effort varies, labor market deregulation modeled as a fall in wage rigidity, hiring costs, and the bargaining power of workers can generate either procyclical or countercyclical labor productivity and have different effects on cyclical moments. We find that fluctuations in Italian labor productivity are mainly explained by technology shocks. An important yet challenging future task will be for instance to introduce automation in the current framework and to analyze how the interplay between labor market institutions and automation influences the cyclicality of labor productivity and cyclical fluctuations.

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Appendices

A Data sources

This section discusses the sources and the transformations of the data used in deriving the business cycle statistics in the text and in estimating the model with Italian quarterly data running from 1996Q1 to 2018Q3.

Our estimation includes as many shocks as observable. We use the following observables for our baseline estimation: real GDP per capita, real investment per capita, real consumption per capita, the nominal interest rate, inflation, wages per employee, the unemployment rate, and total hours worked. The inflation rate is measured as the GDP deflator and the nominal interest rate is in percentage points.

All variables, except the interest rate, are expressed in logs, filtered using the one-sided HP filter (Stock and Watson, 1999), and multiplied by 100 to express them in percentage deviations. The estimated model includes the following shocks: the technology shock, the risk premium shock, the investment-specific technology shock, the government consumption shock, the cost-push shock, the labor supply shock, and the wage bargaining shock.

Data sources. In the following, we list the time series collected and their sources.

- Population: labor force 15 years and over (thousands) from labor force - quarterly seasonally adjusted data - previous regulation (until 2020). Source: ISTAT.
- Real GDP per capita: Real Gross Domestic Product at market prices (Quarterly – Chain linked volumes (2010), million euro – Seasonally and calendar adjusted data) divided by population. Source: Eurostat ($Eurostat/namq_10_gdp/Q.CLV10_MEUR.SCA.B1GQ.IT$).

- Real Consumption per capita: Real Final consumption expenditure of households (Quarterly – Chain linked volumes (2010), million euro – Seasonally and calendar adjusted data). Source: Eurostat.
- Real Investment per capita: Real Gross fixed capital formation (Quarterly – Chain linked volumes (2010), million euro – Seasonally and calendar adjusted data).Source: Eurostat.
- Inflation: GDP deflator (GDP implicit price deflator, index 2015=100). Source: OECD, extracted from FRED. The inflation rate is computed as a quarter-on-quarter difference of the log of the GDP deflator.
- Total hours: this series comes from Ohanian and Raffo (2012) and has been recently updated by Dossche et al. (2022). The series is constructed as the product of employment and hours worked per worked divided by population.
- Real wages per employee: Quarterly Compensation of employees (Current prices, million euro, seasonally and calendar adjusted data) divided by inflation. Then, the resulting series is divided by total hours. Source: Eurostat. $(Eurostat/namq_10_gdp/Q.CP_MEUR.SCA.D1.IT$
- Nominal interest rate: Quarterly three-month rate – Euro area (EA11-1999, EA12-2001, EA13-2007, EA15-2008, EA16-2009, EA17-2011, EA18-2014, EA19-2015). Source: Eurostat. $(Eurostat/irt_st_q/Q.IRT_M3.EA)$. This is expressed in quarterly terms.
- Unemployment rate: seasonally adjusted quarterly unemployment rate aged 15 and over from labor force survey. Source: ISTAT.
- Vacancies: seasonally adjusted quarterly job vacancy rate. Source: ISTAT.
- Employment: total employment (quarterly, number of persons). Source: OECD Economic Outlook. Taken from Dossche et al. (2022).
- Hours per worker: hours worked per worker (annualized, number). Source: Eurostat Labour Force Survey. Taken from Dossche et al. (2022).
- Labor productivity: the series is the ratio between real GDP and total hours.

B Sensitivity Analysis

We now evaluate the robustness of our empirical results by considering two extensions. We report the empirical results of our sensitivity analysis in the online appendix.

B.1 Driving forces of labor productivity after 2000s.

In this first experiment, we change the sample period used for the estimation. We re-estimate our models over the period 2000Q1-2018Q4 to account for the flattening of labor productivity which occurs in the early

2000s (Diwambuena and Ravazzolo, 2022). Our results are confirmed. Technology shocks remain the main driving forces of labor productivity during this period.

B.2 Additional labor market shocks

In this second experiment, we extend our models with two additional labor market shocks (i.e. shock to the job separation rate and hiring costs). We take advantage of data on vacancies and re-estimate our models that include 9 observables and 10 shocks with data running from2004Q1 to2018Q4.[20] Data on vacancies are taken from ISTAT and are only available from 2004Q1. Our results are confirmed. Technology shocks remain the main source of fluctuations in labor productivity. We find that labor market shocks (wage bargaining and separation shocks) explain a significant share of variations in employment and vacancies.

[20] Schmitt-Grohé and Uribe (2012) show that it is possible to have more shocks than observables.