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Are flexible working hours helpful in stabilizing unemployment?*

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Abstract

In this paper we challenge the conventional view that increasing working time flexibility limits the amplitude of unemployment fluctuations. We start by showing that hours per worker in European countries are much less procyclical than in the US, and in some economies even co-move negatively with output. This is confirmed by the results from a structural VAR model for the euro area, in which working hours increase after a contractionary monetary shock, exacerbating the upward pressure on unemployment. To understand these counterintuitive results, we develop a structural search and matching macroeconomic model with endogenous job separation. We show that this feature is key to generate countercyclical adjustments in working hours. When we augment the model with frictions in working hours adjustment and estimate it using euro area time series, we find that increasing flexibility of working time amplifies cyclical movements in unemployment.

Keywords: labor market, search and matching, job separation, working time, business cycle fluctuations

JEL classification: E24, E32, J22, J64

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1 Introduction

The worldwide contraction in aggregate demand during the global financial crisis (GFC) resulted in strong labor market adjustments in many economies, including the euro area (EA). Employment shrank in most EA countries, but the scale of this fall was far from homogeneous. While the unemployment rate jumped in Spain from 11.3% to astonishing 24.8% between 2008 and 2012, it rose more gradually in France (from 7.4% to 9.8%) or Italy (from 6.7% to 10.7%), whereas in Germany it continued the downward trend by declining from 7.4% to merely 5.4%. These diverse developments revived the debate on the role of labor market institutions (LMIs) in stabilizing the economy, including the unemployment rate, over the business cycle.

The relevance of LMIs for macroeconomic fluctuations has been confirmed by a number of empirical studies, following the seminal paper by Blanchard and Wolfers (2000), and more recently by Gnocchi et al. (2015) and Abbritti and Weber (2018). They were accompanied by theoretical advances, building mainly on the search and matching mechanism developed by Mortensen and Pissarides (1994). This line of research, which originates from the influential works of Andolfatto (1996) and den Haan et al. (2000), shows that the inclusion of labor market frictions into the New Keynesian DSGE model helps in explaining the joint dynamics of output and inflation (Walsh, 2005; Trigari, 2009; Christoffel et al., 2009). Other papers demonstrate that selected LMIs have a sizable impact on business cycle characteristics. For instance, restrictive employment protection lowers the volatility of output and unemployment, and at the same time raises the variability of wages and inflation (Thomas and Zanetti, 2009; Zanetti, 2011; Cacciatore and Fiori, 2016). The literature is also unequivocal that the level of unemployment benefits raises unemployment and output volatility, whereas it lowers wage and inflation variability (Christoffel et al., 2009; Thomas and Zanetti, 2009; Campolmi and Faia, 2011). As regards wage stickiness, its high level leads to more persistent but less volatile inflation, and at the same time less stable real sector of the economy (Krause and Lubik, 2007; Christoffel et al., 2009; Abbritti and Mueller, 2013).

The common feature of the above cited studies is that they usually focus solely on two types of labor market frictions, i.e. those affecting flows in and out of unemployment (hiring and firing costs, efficiency of matching), or influencing the adjustment of wages (wage stickiness, wage bargaining). Following the diverse labor

market adjustments in the EA, and in particular the apparent success of Germany in avoiding an increase in unemployment during the GFC, some of interest has shifted to the third margin of labor market adjustment, i.e. hours per employee. Focusing on the labor adjustment along the intensive margin seems to be crucial as fluctuations in average hours per worker account for a large portion of variation of total hours in many countries (see e.g. Ohanian and Raffo, 2012; Cacciatore et al., 2019).

The idea that flexible working hours can reduce fluctuations in unemployment over the business cycle is not new and goes back at least to Jackman and Nickell (1999). The empirical studies looking at the effects of imposing the upper limit on hours yield mixed conclusions. For example, Crepon and Kramarz (2002) show that the one-hour reduction in workweek introduced in France in 1982 resulted in employment losses of 2-4 percent. On the other hand, Chemin and Wasmer (2009) find that switching from a 39 to 35-hour workweek in France in 2000 did not lead to significant changes in employment. From a theoretical perspective, a negative impact of working time rigidity on employment is studied by Trapeznikova (2017). Using a general equilibrium model with on-the-job-search calibrated to Danish labour market, she argues that a policy which prevents firms from increasing work hours of their employees decreases their profits and labor demand. However, all these papers focus on the effects of working time flexibility on the levels rather than variability of unemployment, and consider asymmetric rigidity, i.e. only an upper bound on hours worked.

More recently, the importance of short-time work (SWT) in saving jobs and stabilizing the unemployment rate, with a prominent example of Germany during the GFC, has been highlighted by e.g. Cahuc and Carcillo (2011), Hijzen and Martin (2013) and Niedermayer and Tilly (2017). On the modeling side, Balleer et al. (2016) incorporate working time flexibility in the form of government subsidies for less productive jobs to the search and matching framework, and find that working hours flexibility reduces unemployment and output volatility. Cooper et al. (2017) estimate a search and matching model with heterogeneous multi-worker firms and short-time compensation, and argue that subsidizing short-time work prevents an increase in unemployment during recessions, but at the same time impairs the allocative efficiency of the labor market, leading to sizeable output losses. The positive impact of SWT programs on employment in other European countries was documented by

e.g. Giupponi and Landais (2018) for Italy and Cahuc et al. (2018) for France.

In this paper we add to the debate on the impact of working time flexibility on business cycle fluctuations, and in particular on cyclical movements of unemployment. We argue that, at least in Europe, flexible working hours might increase, and not decrease, fluctuations in unemployment. To convey our point, we first use the recent update of labor market data constructed by Ohanian and Raffo (2012), and show that hours per worker in Europe are much less procyclical than in the US, and in some countries they even co-move negatively with output. This means that, at least for some shocks, hours per worker in Europe increase when labor demand declines, exacerbating the upward pressure on unemployment. We support this reasoning by presenting evidence from a structural vector autoregression (VAR) model, according to which in the EA hours per worker increase in response to a contractionary monetary shock, which can be contrasted with the opposite (and more conventional) response obtained for the US. Finally, even though our focus is on typical business cycles, we also zoom on the GFC episode. We argue that the evidence on the impact of elastic working time on changes in aggregate employment in the EA is far from clear, and the favorable effects discussed in the literature might be more related to counter-cyclical government subsidies than to working time flexibility as such.

We proceed by explaining that this striking reaction of working time in the EA can be related to the behavior of the separation rates. Our starting point is the study of Elsby et al. (2013), who present evidence that movements in the separation rate are an important driver of unemployment fluctuations in Europe. To study the implications of this fact for hours per worker, we develop a theoretical framework, which extends the endogenous job separation model of den Haan et al. (2000) and Zanetti (2011) by making working time endogenous in a similar way as it was done by Trigari (2009) or Balleer et al. (2016). The model, which is calibrated using microdata from the EU Structure of Earning Survey (EU-SES), generates a positive response of hours per worker to a monetary tightening, which is consistent with VAR evidence for the EA. In contrast, when we consider a twin setup with a fixed separation rate, we obtain a fall in hours per worker after a monetary contraction.

The intuition behind these different responses is as follows. When firms are free to increase layoffs during a fall in aggregate demand, they fire least productive workers, whose working time is usually shorter. Those who stay employed want

to work longer because in times of recessions their marginal utility is high. This incentive is further strengthened by a relatively quick recovery of wages when firms start to increase hiring again, because vacancy posting is costly. In our model calibrated for the EA these effects are sufficient to more than offset the negative effect of lower aggregate demand on working time. In contrast, when job separation rates do not change over the cycle, the selection effect is shut down, the increase in marginal utility is also less dramatic as layoffs do not increase during downturns, and the vacancy cost channel is weaker since fewer jobs need to be rebuilt. As a result, the aggregate demand effect dominates and hours per employee fall.

We next show that the direction of the response of hours per worker to shocks has important implications for the impact of working time flexibility on fluctuations in key macrovariables, and in particular employment. We do it by introducing to our model with endogenous separation rigidity in working time adjustment in the spirit of Hall (2005). According to this setup, higher hours rigidity makes the reaction of unemployment to a monetary shock weaker rather than stronger. This is because, if firms need to reduce their total labor input after a contraction in aggregate demand, and the equilibrium form of reaction is to combine an increase in layoffs with longer working time, then constraining the latter margin leads to less adjustment in the former. This intuition is confirmed when we estimate an extended version of the model, which incorporates a large number of structural shocks, using the EA data. If all shocks included in the model are considered together, lower rigidity in hours adjustment has an amplifying impact on fluctuations in the unemployment rate. Overall, our results hence present a new perspective and a more skeptical view in the discussion on the benefits of increasing working time flexibility for employment stabilization in Europe.

The remainder of this paper is organized as follows. We discuss empirical evidence on the responses of hours per worker in Europe in Section 2. Section 3 presents the baseline model. Section 4 discusses the parametrization. Section 5 explains the link between cyclicality of separation rates and hours per worker. In Section 6 we presents our analysis of the effects of working time flexibility on business cycle fluctuations. Section 7 concludes and provides some additional policy discussion. The Appendix describes the EU-SES microdata and lists all the equilibrium conditions making up our theoretical model.

2 Labor market adjustments in the euro area

In this section we present empirical evidence on the cyclical behavior of hours per worker in the EA, focusing on their correlation with output over the business cycle and response to a typical monetary shock. Our aim is to set stage for a discussion on how these differences can be traced back to the different behavior of job separation rates, and how they ultimately affect the relationship between working time flexibility and unemployment dynamics. We complement this picture with a brief discussion of labor market adjustments in the EA during the GFC.

Observation 1. Cyclical position of hours per worker. The literature takes it for granted that hours per worker are highly procyclical, which is based on the evidence for the US economy (Cooley and Prescott, 1995). We now show that this does not necessarily apply to the EA countries. Towards this goal, we use the data constructed by Ohanian and Raffo (2012) for Austria, Finland, France, Germany, Ireland, Italy, Spain and the US. The dataset goes back to 1985 and has been recently updated to include observations through 2016. The only exception is Spain, for which data starts in 1995. Next, we calculate the correlations between detrended hours per worker and detrended output per working age population, using either a linear trend or Hodrick-Prescott filter. We consider the whole sample as well as a subsample excluding the period since the beginning of the GFC. Apart from the countries mentioned above, we also show the results for the group of six euro area economies treated as a whole, with Spain excluded due to missing data before 1995.

The first column of Table 1 shows that, for the entire sample and linearly detrended data, the cyclical position of hours per worker is very heterogeneous across the analyzed economies. For all EA countries the correlation is much lower than in the US, and in some cases the coefficient is even negative. This picture is broadly preserved if we look only at a pre-crisis period. Turning to HP-filtered data and the entire sample, for all countries but Spain the comovement between hours per worker and output is positive, but still much weaker than in the US. However, if we drop the period of the GFC and its aftermath, the correlation coefficients for the EA countries tend to drop, and their distance to the US significantly increases. It can be noted that for Germany and Italy, which are the countries where temporary

shortening of working time was heavily subsidized during the GFC, the exclusion of observations after 2007 leads to a particularly marked drop in the correlation coefficient.

Observation 2. Structural VAR simulations. The acyclicality of hours per worker in the EA means that, at least in response to some shocks, the adjustment of hours per worker goes in the opposite direction to that of output. We thereby continue the discussion by showing that monetary policy shocks can generate this kind of negative co-movement. The reason for picking this shock is that it is broadly discussed in the economic literature, and there is a large number of studies employing vector autoregressions to compute the response of the economy to this disturbance. We use a VAR[1] model containing six macrovariables: log output (measured by real GDP per labor force), the unemployment rate, log hours per worker, log real wage per head (deflated with GDP deflator), log prices (measured by GDP deflator) and the short-term interest rate. We estimate the model for the EA using quarterly time series starting in 1985:1 and ending in 2012:4. As a reference point, we also estimate the same VAR using US data over the sample 1985:1-2008:4. The end points of the data correspond to the periods when the considered economies started to experience the zero lower bound problem, which cannot be captured in a standard linear VAR model. The key macroeconomic data are taken from the Area-Wide-Model (Fagan et al., 2005) and FRED databases. As regards hours per worker, time series for individual countries are taken from Ohanian and Raffo (2012). The values for the EA are approximated with employment-weighted average for six EA member countries included in the database.

The impulse responses to a monetary policy shock, obtained using a standard Cholesky identification scheme as in Christiano et al. (1999), are depicted in Figure 1. As in most of studies employing monetary VARs, a positive innovation to the short-term interest rate leads to a persistent drop in output and the well-known price puzzle. In the euro area inflation goes up in the initial six quarters to decline afterwards, which is similar to the results in Weber et al. (2009). Turning to labor market variables, the unemployment rate persistently increases while the adjustment in real wages is very small and statistically insignificant. These observations hold

[1]The model includes a linear trend and the number of lags is set to two using the Schwarz information criterion.

true both for the US and the EA. Most importantly from this paper's perspective, hours per worker in the EA react positively, though with some delay, and their peak reaction is significantly different from zero.

Observation 3. Great Financial Crisis episode. All euro area countries have been severely affected by the GFC, which began in 2008. However, the reaction of the labor market to the contraction in economic activity differed substantially across the region. We illustrate these adjustments for four biggest EA economies, i.e. Germany, France, Italy and Spain, as well as for Ireland, which is a country affected particularly severely by the GFC and characterized by a very flexible labor market. We use the decomposition

$$\Delta y = \Delta n + \Delta h + \Delta w - \Delta ulc, \tag{1}$$

which shows that firms can react to demand (y) squeeze by adjusting employment (n), working time (h) or nominal hourly wages (w), and their decision is reflected in unit labor costs (ulc) dynamics.[2]

The results of the decomposition for Germany and Spain (see Table 2) provide support for the conventional view about the relationship between working time and employment adjustment. Hours per worker barely adjusted in Spain, and this was the country where employment fell most. In contrast, working time strongly fell in Germany and employment actually increased during the analyzed period. A strong adjustment in working time could also be observed in Italy, where the fall in employment was moderate, especially given the magnitude of output collapse. However, the table also shows that a massive fall in working time in Ireland did not prevent this country from a surge in unemployment, while France avoided a reduction in employment despite a very mild reduction in hours per worker. Perhaps more importantly, in Germany and Italy firms were encouraged to reduce working hours instead of firing employees by short-time compensation programs sponsored by the government (Cahuc and Carcillo, 2011; Balleer et al., 2016).

Summing up, we have shown that in the EA: (i) over a typical business cycle hours per worker are acyclical or even countercyclical, (ii) the response of working

[2]All variables are expressed in logs.

time to a contractionary monetary policy is positive, (iii) the macroeconomic evidence on the favorable impact of flexible working time on employment stability from the GFC episode is rather vague than obvious. Our aim for the rest of this paper is to explain these puzzling results and to show that they call into question the conventional view about the favorable impact of flexible working time on employment stability.

3 The model

To understand the empirical results from the previous section, we propose a theoretical search and matching framework, with two key ingredients. First, given our interest in the behavior of hours per worker, working time in the model is endogenous. Second, since we focus on the European labor market, where flows out of employment contribute largely to fluctuations in unemployment (see e.g. Elsby et al., 2013), the model features endogenous separations. The latter feature makes our framework distinct from most of related studies for the US economy, where, following Shimer (2012), the separation rate is usually assumed to be constant.

3.1 Households

The model economy is populated by a mass of identical households (families), each consisting of a continuum of members indexed by $j \in (0, 1)$. Family members are heterogeneous in productivity, which determines their employment status e_{jt}, hourly wages w_{jt} and hours worked h_{jt}. In particular, in each period t an endogenous fraction n_t of family members are employed ($e_{jt} = 1$) and receive real income $w_{jt}h_{jt}$ The remaining fraction of family members $1 - n_t$ are unemployed ($e_{jt} = 0$) and receive income b that is time invariant in real terms, and that can be interpreted as unemployment benefits. The nominal income associated with labor market activity of each household is therefore equal to

$$X_t = P_t \int_0^1 \Big(e_{jt} w_{jt} h_{jt} + (1 - e_{jt}) b \Big) dj, \tag{2}$$

where P_t is the aggregate price level.

As regards consumption expenditures, we assume full income insurance between employed and unemployed family members so that $c_{jt} = c_t$ for each j. The family maximizes the expected utility that depends on consumption and hours worked

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - \varrho C_{t-1})^{1-\sigma_c}}{1 - \sigma_c} - \kappa \int_0^1 e_{jt} \frac{h_{jt}^{1+\eta}}{1+\eta} dj \right) \right\}, \tag{3}$$

where $\beta \in (0, 1)$ is the discount factor, σ_c denotes the inverse of intertemporal elasticity of substitution, η is the inverse of the Frisch elasticity of labor supply, ϱ

controls the degree of an external habit motive, κ governs the reluctance towards work and C_t stands for aggregate consumption.

The timing is as follows. Each household starts period t with non-state contingent nominal bonds B_{t-1} purchased in the previous period, and yielding interest at gross nominal rate R_{t-1}. Next, the household pays lump-sum nominal tax T_t, and receives nominal dividends Ψ_t and labor income X_t, which is defined by equation (2). All these resources can be spent on consumption c_t or to purchase bonds B_t maturing next period. The budget constraint is then

$$P_t c_t + B_t + T_t \leq R_{t-1} B_{t-1} + X_t + \Psi_t. \tag{4}$$

A representative household maximises (3) by choosing consumption, bond-holdings and working hours, subject to (4). The first two decisions give the standard intertemporal optimality condition

$$\lambda_t = \beta \mathbb{E}_t \left\{ \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right\}, \tag{5}$$

where $\lambda_t = (c_t - \varrho C_{t-1})^{-\sigma_c}$ is the marginal utility of consumption and $\pi_t = P_t / P_{t-1}$ is price inflation. The optimization with respect to hours worked is performed at an individual level as a part of a bargaining process with firms, and will be discussed later.

3.2 Intermediate good producers

Identical intermediate goods producing firms constitute the second type of agents populating the model economy. Each firm uses labor as the only input to produce output y_t, which is then sold at real price φ_t to retailers. Workers are hired on the job market that is subject to search and matching frictions. To hire a worker, a firm must start by paying a fixed cost χ per each posted vacancy v_t. Then it finds a worker with probability q_t depending on the matching technology, which converts the total number of job seekers u_t and the total number of vacancies v_t into matches m_t

$$m_t = a v_t^{\varepsilon} u_t^{1-\varepsilon}. \tag{6}$$

Here $a > 0$ can be interpreted as matching efficiency while $\varepsilon \in (0,1)$ is the elasticity of the matching function with respect to vacancies.

By defining labor market tightness $\theta_t = v_t/u_t$, we can express the probability of filling a vacancy as

$$q_t = \frac{m_t}{v_t} = a\theta_t^{\varepsilon-1} \tag{7}$$

and the probability of finding a job as

$$p_t = \frac{m_t}{u_t} = a\theta_t^{\varepsilon}. \tag{8}$$

After hiring workers, firms produce goods according to the technology

$$y_t = \frac{An_t}{1-G(\tilde{z}_t)} \int_{\tilde{z}_t}^{\infty} z h_t(z)^{\alpha} g(z) dz, \tag{9}$$

where $\alpha \in (0,1)$ controls the elasticity of output with respect to hours worked, $\tilde{z}_t$ stands for threshold idiosyncratic productivity dividing workers into those who stay with the firm ($z \geq \tilde{z}_t$) and those with whom the work contract is terminated ($z < \tilde{z}_t$), and A is aggregate productivity scaling factor. For idiosyncratic productivity z, we assume that it is identically and independently distributed, with cumulative and probability density functions $G(z)$ and $g(z)$, respectively. This distribution is the same for all firms and is time invariant.

The sequence of events affecting intermediate goods producing firms is as follows. At the end of period $t-1$ all firms exogenously separate with a fraction $\lambda^x \in (0,1)$ of employees. Hence, the total number of job seekers at the beginning of time t is equal to the sum of people that were unemployed in the previous period and the number of workers that have just lost their job

$$u_t = (1 - n_{t-1}) + \lambda^x n_{t-1}. \tag{10}$$

Next, firms post vacancies v_t to hire $q_t v_t$ new workers. Just before production starts, the realization of z is revealed and firms endogenously fire a fraction $G(\tilde{z}_t)$ of the least productive employees. The resulting law of motion for total employment is

$$n_t = [1 - G(\tilde{z}_t)][(1-\lambda^x)n_{t-1} + q_t v_t] \tag{11}$$

and the total real cost of production amounts to

$$tc_t = \frac{n_t}{1 - G(\tilde{z}_t)} \int_{\tilde{z}_t}^{\infty} w_t(z) h_t(z) g(z) dz + \chi v_t. \tag{12}$$

The optimization problem of the representative intermediate goods producing firm is to minimize costs (12), subject to the law of motion for employment (11) and production function (9). The first-order conditions are

$$\frac{\chi}{q_t} = \phi_t [1 - G(\tilde{z}_t)], \tag{13}$$

$$\phi_t = \frac{1}{1 - G(\tilde{z}_t)} \int_{\tilde{z}_t}^{\infty} \left[\varphi_t A z h_t(z)^{\alpha} - w_t(z) h_t(z) \right] g(z) dz + \beta (1 - \lambda^x) \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\chi}{q_{t+1}} \right\}, \tag{14}$$

$$\varphi_t A \tilde{z}_t h_t(\tilde{z}_t)^{\alpha} - w_t(\tilde{z}_t) h_t(\tilde{z}_t) + \beta (1 - \lambda^x) \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\chi}{q_{t+1}} \right\} = 0, \tag{15}$$

where ϕ_t is the Lagrange multiplier on employment law of motion (11), and can be interpreted as the value of an employment contract, while φ_t is the Lagrange multiplier on production function (9), hence represents the real marginal cost of production.

Equation (13) states that the cost and benefit of posting a vacancy must be the same. Equation (14) defines the value of an employment contract for firms. It is the average contribution of workers to profits plus the expected value of employment contract continuation. Finally, equation (15) states that the value of a contract with a worker characterized by idiosyncratic productivity at the threshold $\tilde{z}_t$ is null, i.e. firms are indifferent between keeping and firing such a worker.

3.3 Bargaining

The match surplus, which depends on idiosyncratic productivity z, is divided between firms and workers within a bargaining process. The surplus enjoyed by a firm amounts to

$$J_t(z) = \varphi_t A z h_t(z)^{\alpha} - w_t(z) h_t(z) + (1 - \lambda^x) \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[\int_{\tilde{z}_{t+1}}^{\infty} J_{t+1}(z') g(z') dz' \right] \right\}, \tag{16}$$

where z' is future realization of z. This surplus is hence equal to current sales revenue less wage compensation plus the expected value of the match in the next

period.

The surplus value of a match to a worker is

$$S_t(z) = w_t(z)h_t(z) - \frac{\kappa}{\lambda_t}\frac{h_t(z)^{1+\eta}}{1+\eta} - w_t^o + (1-\lambda^x)\beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\int_{\tilde{z}_{t+1}}^{\infty} S_{t+1}(z')g(z')dz'\right\}, \quad (17)$$

so that it consists of wage income, the utility loss associated with spending time at work, the expected value of the match in the future period, and the real value of being outside of the labor market

$$w_t^o = b + d + (1-\lambda^x)\beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}p_{t+1}\int_{\tilde{z}_{t+1}}^{\infty} S_{t+1}(z')g(z')dz'\right\}, \quad (18)$$

where d is the real and time-invariant value of home production.

During an efficient Nash bargaining process, both parties choose wage $w_t(z)$ and hours $h_t(z)$ to maximize

$$J_t(z)^{\xi}S_t(z)^{1-\xi}, \quad (19)$$

where ξ is the relative bargaining power of firms. The first-order conditions are

$$\frac{J_t(z)}{S_t(z)} = \frac{\xi}{1-\xi}, \quad (20)$$

$$\kappa h_t(z)^{\eta} = \alpha\varphi_t A_t\lambda_t z h_t(z)^{\alpha-1}. \quad (21)$$

3.4 Retailers

A continuum of monopolistically competitive retailers indexed by $i \in (0,1)$ and owned by households constitute the third group of agents populating the model economy. Each retailer i purchases homogeneous intermediate goods at the unit real price φ_t, differentiates them costlessly, and resells them at an individually set price P_{it}.

All retail goods are aggregated into a homogeneous final good Y_t according to CES technology

$$Y_t = \left(\int_0^1 Y_{it}^{1/\mu}di\right)^{\mu}, \quad (22)$$

where $\mu > 1$ is the price markup. Consequently, each retailer faces the following

downward-sloping demand for its output

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{\mu/(1-\mu)} Y_t, \tag{23}$$

and the aggregate price level is

$$P_t = \left(\int_0^1 P_{it}^{1/(1-\mu)} di\right)^{1-\mu}. \tag{24}$$

As it is standard in the New Keynesian literature, we introduce price stickiness in the form of the Calvo staggered price adjustment mechanism, so that in each period a randomly selected fraction $\delta \in (0,1)$ of retailers cannot change their prices. Each reoptimizing retailer i sets her price P_{it} to maximize

$$E_t \left\{ \sum_{s=0}^{\infty} \delta^s \beta^s \frac{\lambda_{t+s}}{\lambda_t} \left[\frac{P_{it}}{P_{t+s}} - \varphi_{t+s}\right] \left(\frac{P_{it}}{P_{t+s}}\right)^{\mu/(1-\mu)} Y_{t+s} \right\}. \tag{25}$$

The optimally reset price $\tilde{P}_t$, common to all reoptimizing retailers, satisfies

$$E_t \left\{ \sum_{s=0}^{\infty} \delta^s \beta^s \frac{\lambda_{t+s}}{\lambda_t} \left[\frac{\tilde{P}_t}{P_{t+s}} - \mu\varphi_{t+s}\right] \left(\frac{\tilde{P}_t}{P_{t+s}}\right)^{\mu/(1-\mu)} Y_{t+s} \right\} = 0. \tag{26}$$

3.5 The government

The central bank and the fiscal authority are the two government institutions in the model economy. The former sets the short-term interest rate according to a Taylor-like feedback rule

$$\log(R_t) = \phi_R \log(R_{t-1}) + (1-\phi_R)[\phi_\pi \log(\pi_t/\pi) + \phi_y \log(Y_t/Y)] + \varepsilon_{m,t}, \tag{27}$$

where $\phi_R \in (0,1)$ controls the interest smoothing motive, ϕ_π and ϕ_y determine the strength of reaction to deviations of inflation and output from their respective steady state levels, and $\varepsilon_{m,t} \overset{iid}{\sim} N(0, \sigma_m^2)$ is the monetary policy shock.

The latter sets lump-sum taxes T_t to ensure that the fiscal budget is balanced

$$P_t g + P_t(1-n_t)b = T_t, \tag{28}$$

where g is real government spending.

3.6 Market clearing

We close the model with the goods market clearing conditions, which state that the demand for the final good is equal to aggregate production of intermediate goods

$$Y_t \Delta_t = y_t \tag{29}$$

adjusted for the effect of price dispersion $\Delta_t = \int_0^1 (P_{it}/P_t)^{-\mu/(1-\mu)} di$. In turn, the total production of final goods must be equal to aggregate demand

$$Y_t = c_t + g + \chi v_t. \tag{30}$$

4 Parametrization

We calibrate the model so that it well describes the key features of the European labor market. Towards this end, we use both long-term averages of key macroeconomic proportions, estimates from the previous literature, and microdata from the European Union Structure of Earnings Survey (EU–SES). Given this paper's focus, our primary goal is to ensure that in the steady state:

i. The unemployment u and job vacancy $v/(v+n)$ rates are close to 10% and 1.5%, respectively, in line with the Eurostat data.

ii. The probabilities of finding a job p and loosing it $\lambda^x + G(\tilde{z})$ are close to 10% and 1%, respectively, in line with the estimates presented by Elsby et al. (2013).

iii. The cross-sectional standard deviations of the logs of hourly wages $\sigma(\log w(z))$ and hours worked $\sigma(\log h(z))$ are close to 0.349 and 0.190, respectively, in line with our estimates based on EU–SES (see Appendix A).

Table 3 shows that the model successfully meets these targets. As we explain below, this was possible to achieve and at the same time keep the deep model parameters, which we present in Table 4, in line with the earlier studies for the EA.

Household preferences. We set the discount factor at $\beta = 0.99$, the inverse of the intertemporal elasticity of substitution at $\sigma_c = 2$, and habit formation at $\varrho = 0.7$, which are the typical values in the macro literature. The inverse of the Frisch elasticity of labor supply η is fixed at 5, which is in line with microeconometric estimates that focus on the intensive margin of fluctuations in hours (Peterman, 2016), and is key to match the targeted value of the standard deviation of hours worked to EU-SES microdata. As regards the labor disutility scaling factor κ, we calibrate its value so that in the steady state hours worked per "threshold" employee $h(\tilde{z})$ are equal to 0.33 (Christoffel et al., 2009).

Labor market. Following the endogenous separation rate literature, we assume that the distribution of individual productivity z is log-normal, i.e. $\log z \sim N(0, \sigma_z^2)$. The standard deviation σ_z is calibrated at 1.05 to match the cross-sectional dispersion of wages obtained from the EU–SES microdata, and is consistent with the

steady-state probability of endogenous separation of $G(\tilde{z}) = 0.56\%$. By calibrating the exogenous part of job separation at $\lambda^x = 0.6\%$ we obtain the total probability of losing a job that matches the target level from Table 3. The probability of finding a job is matched by setting the cost of posting a vacancy to $\chi = 0.388$. This value translates into a cost equal to 32% of average quarterly wage.

Matching. We fix the elasticity of the matching function ε at 0.5, which is in the range 0.5-0.7 of values typically applied in the literature (Christoffel et al., 2009). Following the common practice, the same value is used for the bargaining power ξ so that the steady state share of workers in the job surplus is the same as their contribution to matching (Hosios condition). The matching constant a is calculated by substituting the target values for p and θ from Table 3 to formula (8), giving 0.274. Income when unemployed b is set to 0.61, which corresponds to 51% of average wage as implied by the OECD benefits and wages statistics for the net replacement rates across the EA countries.The calibrated value of home production d represents about one-third of average market labor income.

Product market. We set the elasticity of output with respect to hours worked α to 0.7, which is close to 0.66 used by Christoffel et al. (2009). For the price setting parameters in the retail sector, we choose the standard values of $\mu = 1.1$ and $\delta = 0.75$, implying, respectively, the markup of 10% and the average duration of a price contract of 4 quarters. Both numbers are standard values assumed or estimated in DSGE models for the EA.

Government. Finally, to parametrize exogenous spending, we choose g to be equal to 0.51 so that its share in output matches the joint share of government spending and investment expenditures in the euro area GDP of 42.5%. The Taylor rule parameters ϕ_R, ϕ_π, ϕ_y are set to 0.8, 1.5 and 0.125, respectively, which are the standard values used in the literature.

5 Endogenous separation and working hours

In this part of the study, we apply the model to analyze the response of working time to a monetary tightening, with a special focus on the role of job separation process. In particular, we explain why endogenous separations might change the direction of this response and make it consistent with the VAR evidence presented in Section 2.

We start by noting that any demand-driven contraction in output results in adjustments of both labor supply and labor demand. On the one hand, during recessions households' marginal utility of consumption increases, which (for standard preferences) leads to a rise in labor supply. On the other hand, firms need to limit their production, hence require less labor. In a typical New Keynesian framework, this shift in labor demand is represented as a fall in the real marginal cost of production. The change in labor supply and demand requires adjustment in total hours worked, which occurs through two margins: extensive and intensive. The former can be further divided into two channels, hiring and firing, whereas the latter takes the form of a change in working time. Below we discuss how the adjustment along the intensive margin depends on the functioning of the two extensive margin channels.

We first consider a representative agent New Keynesian framework, in which the number of workers is fixed ($n_t = 1$), hence there is no labor market adjustment through the extensive margin. This means that total labor input adjusts solely through working time. Given that labor is the only production factor, i.e. $y_t = Ah_t^{\alpha}$, the response of working time h_t to a fall in aggregate demand has to be negative. Further, since the labor market optimality conditions imply

$$h_t = \left(\frac{\alpha}{\kappa}\varphi_t\lambda_t\right)^{\frac{1}{1-\alpha+\eta}}, \tag{31}$$

a fall in hours per worker means that the downward shift in labor demand, which is represented by a fall in the real marginal cost φ_t, dominates over the labor supply effect, which is represented by an increase in the marginal utility λ_t.

Let us switch on the first of the two extensive margin labor adjustments, i.e. hiring, and consider a standard search and matching model with exogenous separation rates. We do it by solving the model presented in section 3, in which we fix the

threshold productivity $\tilde{z}_t$ at its steady-state value.[3] Firms are thereby not involved in endogenous firing and they can affect the number of employed workers only by adjusting the rate at which they post vacancies. In this case, hours worked by an employee with individual productivity z are determined by the Nash bargaining condition (21). By integrating over all employed workers, we can derive the formula describing the average hours per worker

$$h_t = \left(\frac{\alpha}{\kappa}\varphi_t\lambda_t\right)^{\frac{1}{1-\alpha+\eta}} D, \tag{32}$$

which differs from equation (31) only by a scaling constant $D = (1 - G(\tilde{z}))^{-1} \int_{\tilde{z}}^{\infty} z^{\frac{1}{1-\alpha+\eta}} g(z)dz$. In this case, however, the reaction of hours per worker h_t^{avg} to a fall in aggregate demand y_t cannot be derived analytically. The reason is that the number of employed workers n_t is also affected by the shock, which needs to be taken into account while assessing working time (see equation (9)). We therefore need to resort to an impulse response analysis.

The dashed lines in Figure 2 present the reaction of the economy to a contractionary monetary shock generated by the model with exogenous separation. As we can see in the graph, a drop in vacancies posted by firms is not enough to sufficiently reduce total effective labor input and, despite the extensive margin adjustment, average hours per worker fall in response to a monetary tightening. As in the standard New Keynesian framework, the fall in hours per employee means that the real marginal cost decreases by more than the marginal utility rises.

We finally consider the baseline setup with endogenous separation. The average hours per worker are now given by

$$h_t = \left(\frac{\alpha}{\kappa}\varphi_t\lambda_t\right)^{\frac{1}{1-\alpha+\eta}} D_t, \tag{33}$$

where the last term $D_t = [1 - G(\tilde{z}_t)]^{-1} \int_{\tilde{z}_t}^{\infty} z^{\frac{1}{1-\alpha+\eta}} g(z)dz$ is no longer a constant. We call D_t as a composition effect, as it measures changes in average hours per worker resulting from movements in threshold productivity $\tilde{z}_t$.

The impulse responses to a monetary tightening obtained from this model variant

[3] Such a model is observationally equivalent to an alternative one with homogeneous workers, where our baseline value of exogenous separation rate λ^x is adjusted by adding to it $G(\tilde{z})$, and aggregate productivity A is appropriately rescaled.

are plotted as solid lines in Figure 2. Importantly, and in contrast to the standard New Keneysian model and a search and matching framework with constant separation rates, hours per worker barely change on impact, and their response is clearly positive afterwards. This result is partly driven by the composition effect. During recessions firms intensify firing, laying off least productive workers first. As a result, the threshold and average productivity of employed workers goes up. As working time positively depends on idiosyncratic productivity (see equation 21), an increase in average productivity raises working time h_t^{avg} of those who stay employed.

The composition effect is not the main force pushing average hours up after a contractionary monetary shock in the endogenous separation model. An increase in work intensity of those individuals who stay employed turns out to be more significant. In particular, endogenous firing amplifies the fall in output and the rise in unemployment, hence the marginal utility of consumption λ_t increases more than in the exogenous separation setup. Moreover, after the initial fall, the real marginal cost φ_t recovers at a rate that is much faster than under exogenous separation, reflecting a speedy recovery of hourly wages. To see why firms are willing to increase labor compensation faster in the model variant with endogenous separations, it is instructive to substitute the firm and worker surplus definitions (equations 16 and 17) into the wage negotiation outcome (equation 20) to obtain

$$w_t(z)h_t(z) = \xi\left(b + \frac{\kappa}{\lambda_t}\frac{h_t(z)^{1+\eta}}{1+\eta}\right) + (1-\xi)\left(\varphi_t A_t z h_t(z)^{\alpha} + (1-\lambda^x)\beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\theta_{t+1}\right\}\chi\right). \quad (34)$$

The formula shows that, other things equal, hourly wages of employed workers depend positively on expected labor market tightness θ_t. Intuitively, a tight labor market means that it is more difficult to fill a vacancy, which encourages firms to offer higher wages to incumbent workers as vacancy posting is costly ($\chi > 0$). Endogenous firing means that more vacancies will need to be posted when the economy starts recovering, and hence expected labor market tightness is higher than in the model with exogenous separations (see Figure 2). As a result, the marginal cost (representing the demand for hours supplied by employed workers) quickly reverts to the steady state.[4]

[4]The same logic can be followed while looking at a separation shock in a model with exogenous

Summing up, our simulations demonstrate that the endogenous separation channel may affect both demand and supply of labor in a way that inverts the response of hours per worker to a typical aggregate demand shock. In particular, allowing for endogenous separations allows to reproduce a positive response of working time to a contractionary monetary policy shock from the VAR model estimated for the EA as discussed in Section 2.

separation: wages (and marginal cost) go up after a positive innovation to the separation rate (Christoffel et al., 2009).

6 The effects of working time flexibility

We are now ready to assess how working time flexibility affects business cycle fluctuations in key macrovariables. In particular, we show that acyclical or countercyclical adjustments in hours per worker call into question the beneficial influence of flexible working time on the variability of employment. This challenges one of the widely acclaimed and intuitive recommendations on labor market reforms in Europe.

6.1 Working time rigidity

We start the discussion by introducing constraints on working time adjustment to the endogenous separation model developed in the previous section. We do it by using the concept of a social norm proposed by Hall (2005). Even though the idea was originally used to describe rigidity in wage formation, its logic seems equally appealing as a way of modeling constraints in adjusting working time.[5] More specifically, we assume that hours worked by an employee with productivity z is not simply given by the outcome of Nash bargaining, but evolve instead according to the following formula

$$h_t(z) = \omega_h h_t^N(z) + (1 - \omega_h) h_{t-1}(z), \tag{35}$$

where superscript N is used to indicate the value of a variable set within the Nash bargaining process, and $\omega_h \in (0, 1)$ controls the degree of working time persistence.

Figure 3 compares the impulse responses to a contractionary monetary shock from the benchmark model, with flexible working time $\omega_h = 1$, to the economy with some degree of working time rigidity, i.e. when $\omega_h = 0.43$.[6] It turns out that when hours per worker cannot freely adjust, their peak response is smaller and delayed. The introduced rigidity also makes output contraction shallower, but the difference relative to the benchmark is not large. On the contrary, the response of wages becomes stronger, which also translates into a more pronounced reaction of inflation. Most importantly of all, however, under working time rigidity the increase in unemployment is substantially reduced. The intuition for this outcome

[5] The concept of social norms is a convenient and popular way of introducing rigidity to a bargaining process. Other popular solutions, like quadratic adjustment costs or Calvo-style rigidity, would be more difficult to implement in a framework like ours, but are unlikely to generate qualitatively different outcomes to the ones presented in this section.

[6] This value is borrowed from Bayesian estimation that will be described later on.

is straightforward. If a contraction in output is demand driven, firms need to reduce their total labor input. As we have showed in the previous section, in a model with endogenous separations, a preferable form of response is to intensify firing and lengthen working time of those who remain employed. Imposing a constraint on the adjustment along the working time margin limits the eagerness of firms to reduce employment.

It is important to note that, according to this explanation, the outcome would be reversed if the equilibrium response of working time to a monetary tightening was negative. Then, other things equal, a constraint on the intensive margin would actually imply a stronger reduction in employment, in line with the common wisdom. Clearly, the extent to which flexible working time helps reduce fluctuations in unemployment depends on the direction of the response of average hours worked or, more generally, on their cyclical correlation with aggregate demand.

6.2 Simulations with estimated DSGE model

Up until this point the discussion was somewhat limited in scope. First, we have incorporated constraints on working time adjustment, but kept wages fully flexible. This might seem to be not very realistic. Second, we have analyzed only the response of the economy to a monetary policy shock. While usually considered to be a good representative of aggregate demand disturbances, they are clearly not the only driver of business cycle fluctuations.

To address these shortcomings, we extend the analysis by using a richer variant of the model. First, we introduce wage rigidity using again the Hall (2005) concept of norms. The dynamics of real wages is

$$w_t(z) = \omega_w w_t^N(z) + (1 - \omega_w) w_{t-1}(z), \tag{36}$$

where $\omega_w \in (0, 1)$ controls the degree of wage rigidity. More importantly, we estimate the model using the following time series for the EA: GDP, the unemployment rate, hours per worker, real wage per worker, GDP deflator inflation and the short-term interest rate. The sources and sample of the data are exactly the same as for the VAR analysis described in Section 2. To enrich the stochastic structure of the model, and to avoid stochastic singularity problems, we also include six distur-

bances. In addition to an i.i.d. monetary policy shock $\epsilon_{m,t}$ already considered in the baseline setup, we allow for exogenous time variation in productivity A_t, government spending g_t, price markups μ_t, labor disutility κ_t and bargaining power ξ_t. All these additional shocks are assumed to follow independent first-order autoregressive processes, and can be considered typical disturbances used in the New Keynesian literature or their close relatives.[7] A complete list of equations that define the equilibrium in our extended model in terms of aggregate variables is presented in Appendix B.

The parameters affecting the steady state are calibrated (see Table 4), whereas the remaining ones are estimated with Bayesian methods (see Table 5). As regards prior assumptions, the distributions for the habit formation parameter ϱ, Calvo probability δ, and Taylor rule parameters ϕ_R, ϕ_π, ϕ_y are centered at the values used in the calibrated version of our baseline model. The prior means for the persistence and standard deviations of shocks are set to 0.75 and 0.01, respectively, the only exception being the monetary shock, for which we choose ten times smaller prior volatility. All these choices are standard and consistent with the previous DSGE studies focusing on the euro area economy (Smets and Wouters, 2003; Christoffel et al., 2009). It should be added, however, that our prior distributions are relatively wide so that we allow the data to have a larger impact on the posterior. As for the two parameters describing the degree of real wage and working time rigidity, i.e. ω_w and ω_h, we center them at 0.5, with fairly large standard deviations to let the data have the dominant impact on the posterior distribution.

The right panel of Table 5 demonstrates that the posterior distributions for all parameters are tighter than their prior counterparts, which indicates that the dataset is informative. The estimates seem to be economically plausible and within the range of values usually reported in the literature. Most importantly, the parameter related to hours rigidity ω_h seems to be well identified as its posterior distribution significantly deviates from the prior. Moreover, its posterior mean value amounting to 0.43 indicates substantial working time rigidity.

We conclude our discussion by presenting the effects of introducing perfect working hours flexibility in Europe using this richer setup. We do it by calculating how

[7]The bargaining power shock can be considered similar in spirit to a wage markup shock frequently used in estimated DSGE models that abstract from search and matching frictions in the labor market.

the standard deviations of key macrovariables are affected by moving from the estimated degree of rigidity in hours per worker ($\omega_h = 0.43$) to full flexibility of labor adjustment along the intensive margin ($\omega_h = 1$), keeping all other estimated parameters fixed at their posterior mean values.

The first column of Table 6 confirms the results for monetary shocks, which were discussed in the previous section. Removing working time rigidity results in larger fluctuations in hours per worker, but also in the unemployment rate. Aa regards the other variables, hourly wages and inflation become more stable, while the effect on output and the interest rate is very small. The results for other shocks show that the impact of working time flexibility on the variability of key macro-variables strongly depends on what drives the business cycle. However, one result is clear-cut: flexible working hours amplify the volatility of unemployment. This effect is particularly strong for government spending shock, whereas it is relatively small for cost-push shocks (product markups and wage bargaining power). When all shocks are taken together, the simulations imply that the introduction of full working time flexibility in Europe would exacerbate cyclical fluctuations in unemployment by 14%. As regards the effect on output, the effect would be negligible. This is consistent with the intuition explained before. If output is demand determined as in a standard New Keynesian framework, the extensive and intensive adjustments on the labor market can be considered close substitutes: constraining one type of adjustments is compensated by an offsetting change in utilization of the other, leaving total labor input roughly unchanged.

7 Conclusions

The key message of the paper is that high working time flexibility does not necessarily dampen fluctuations in unemployment, especially in the EA countries. This claim, which is in opposition to the common wisdom and previous studies, is related to the observation that hours per worker in many European countries are acyclical or even countercyclical, and hence they may move in the opposite direction to changes in employment. This means that, if firms have the ability to adjust the firing rate whenever aggregate demand decreases, they may increase layoffs during economic downturns and at the same time exploit high marginal utility of the remaining workers to increase their working time. Constraining the adjustments at the intensive margin may hence limit rather than amplify those along the extensive one.

Overall, our findings call for some caution in applauding the benefits of increasing working time flexibility as a cure to limit fluctuations in unemployment. Naturally, this does not mean that trying to save jobs during recessions by encouraging firms to shorten working time is not a good policy. However, as our analysis shows, this might be possible to achieve only by appropriate subsidies, and not simply by labor market reforms enabling firms to adjust working time more freely.

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Tables and Figures

Table 1: Cyclical position of hours per worker

	Linearly detrended		HP filtered	
	1985-2016	1985-2007	1985-2016	1985-2007
Austria	0.51	0.46	0.47	0.20
Finland	0.06	0.04	0.20	0.19
France	-0.52	-0.46	0.15	0.02
Germany	-0.22	-0.40	0.50	0.09
Ireland	0.16	-0.20	0.24	0.36
Italy	0.24	0.08	0.43	0.16
Spain	0.34	0.40	-0.06	-0.21
EA6	-0.14	-0.30	0.46	0.08
US	0.71	0.73	0.76	0.73

Notes: The table presents the correlation between hours per worker and GDP per working age population. The data are taken from an udate to Ohanian and Raffo (2012). Data for Spain starts in 1995. EA6 is an aggregate of all euro area members included in the table but for Spain. The linear trend for Austria and Italy allows for a structural break in its slope as of 2000. The smoothing parameter in the Hodrick-Prescott filter is 1600.

Table 2: Labor market adjustment during the period 2008-2012

	Δy	Δn	Δh	Δw	Δulc
Germany	2.3	2.9	-3.1	11.2	8.7
France	1.2	0.2	-1.2	10.8	8.6
Italy	-6.3	-2.6	-3.9	10.5	10.3
Spain	-7.6	-14.9	-0.8	6.2	-1.9
Ireland	-3.8	-13.4	-7.7	4.1	-13.2
Euro area	-1.9	-2.6	-2.9	10.8	7.2

Notes: This table presents the decomposition of output change as described by equation (1), where y is GDP, n is employment, h is working hours, w denotes nominal hourly wages, and ulc stands for unit labor costs. All variables are expressed as logs and are taken from the AMECO database.

Table 3: Steady State Ratios

	Model	**Target**	**Sources**
Unemployment rate u	0.106	0.096	Eurostat, 1998-2016
Job vacancy rate $v/(v+n)$	0.015	0.014	Eurostat, 2006-2016
Labor market tightness θ	0.131	0.131	Eurostat, 2006-2016
Probability of finding a job p	0.100	0.100	Elsby et al. (2013)
Probability of losing a job $\lambda^x + G(\tilde{z})$	0.012	0.010	Elsby et al. (2013)
St. dev. of hourly wages $\sigma(\log(w(z)))$	0.349	0.349	EU–SES, 2014
St. dev. of hours per worker $\sigma(\log(h(z)))$	0.190	0.194	EU–SES, 2014

Table 4: Calibrated parameters

Parameter	**Value**	
	Utility function	
β	0.99	Discount factor
σ_c	2	Inverse of intertemporal elasticity of substitution
κ	35	Relative weight on work effort in utility
η	5	Inverse Frisch elasticity of labor supply
ϱ	0.7	Habit formation
	Labor market	
ε	0.50	Matching elasticity
ξ	0.50	Bargaining power
a	0.274	Matching technology
χ	0.388	Cost of posting a vacancy
λ^x	0.006	Exogenous separation rate
b	0.61	Income of unemployed
d	0.38	Value of home production
	Firms	
α	0.70	Elasticity of output to hours
σ_z	1.05	Dispersion of individual productivity
μ	1.1	Price markup
δ	0.75	Calvo probability
	Government	
g	0.51	Exogenous spending
ϕ_R	0.85	Taylor rule, smoothing
ϕ_π	1.5	Taylor rule, inflation
ϕ_y	0.125	Taylor rule, output

Table 5: Bayesian estimation of extended model

Parameter	Prior distribution			Posterior distribution		
	Type	**Mean**	**St.Dev.**	**5%**	**Mean**	**95%**
Structural parameters						
ϱ	beta	0.75	0.05	0.861	0.900	0.941
δ	beta	0.67	0.05	0.902	0.923	0.943
ϕ_R	beta	0.8	0.1	0.822	0.851	0.880
ϕ_π	gamma	1.5	0.2	1.394	1.623	1.851
ϕ_y	normal	0.125	0.2	-0.001	0.034	0.067
ω_w	beta	0.5	0.1	0.047	0.056	0.071
ω_h	beta	0.5	0.1	0.338	0.430	0.519
Shocks - persistence						
ρ_A	beta	0.75	0.1	0.943	0.959	0.976
ρ_g	beta	0.75	0.1	0.927	0.949	0.971
ρ_μ	beta	0.75	0.1	0.667	0.764	0.863
ρ_ξ	beta	0.75	0.1	0.165	0.271	0.373
ρ_κ	beta	0.75	0.1	0.889	0.925	0.962
Shocks - standard deviations						
σ_A	inv. gamma	0.01	inf	0.004	0.005	0.005
σ_g	inv. gamma	0.01	inf	0.014	0.016	0.017
σ_μ	inv. gamma	0.01	inf	0.015	0.024	0.033
σ_ξ	inv. gamma	0.01	inf	0.572	0.769	0.961
σ_κ	inv. gamma	0.01	inf	0.027	0.034	0.040
σ_m	inv. gamma	0.001	inf	0.001	0.001	0.001

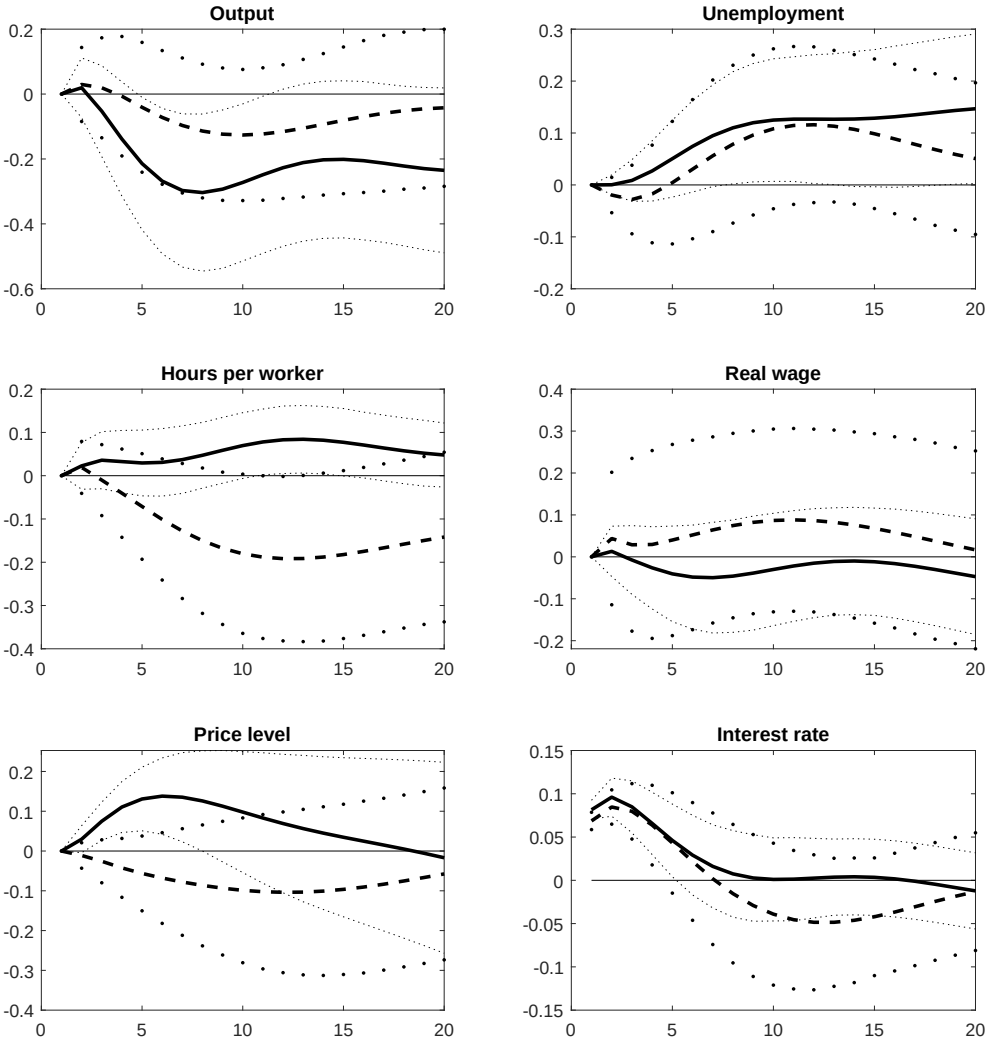
Notes: The posterior distribution is approximated using 1,000,000 draws from the random walk Metropolis-Hastings algorithm, after discarding the initial 25% draws.

Table 6: Flexible working hours and aggregate volatility

Variable \ Shock	Monetary	Productivity	Gov. spending	Markup	Labor disutility	Barg. power	All shocks
Output	1.01	0.80	1.08	1.00	1.03	1.01	1.00
Unemployment	1.05	1.10	2.00	1.01	1.11	1.01	1.14
Hours per worker	1.18	0.71	0.63	1.08	1.04	1.03	0.82
Wage per hour	0.94	0.60	0.41	0.97	1.03	1.01	0.98
Inflation	0.93	0.79	0.46	1.00	1.05	1.02	0.91
Interest rate	1.00	0.80	0.56	1.00	1.05	1.02	0.90

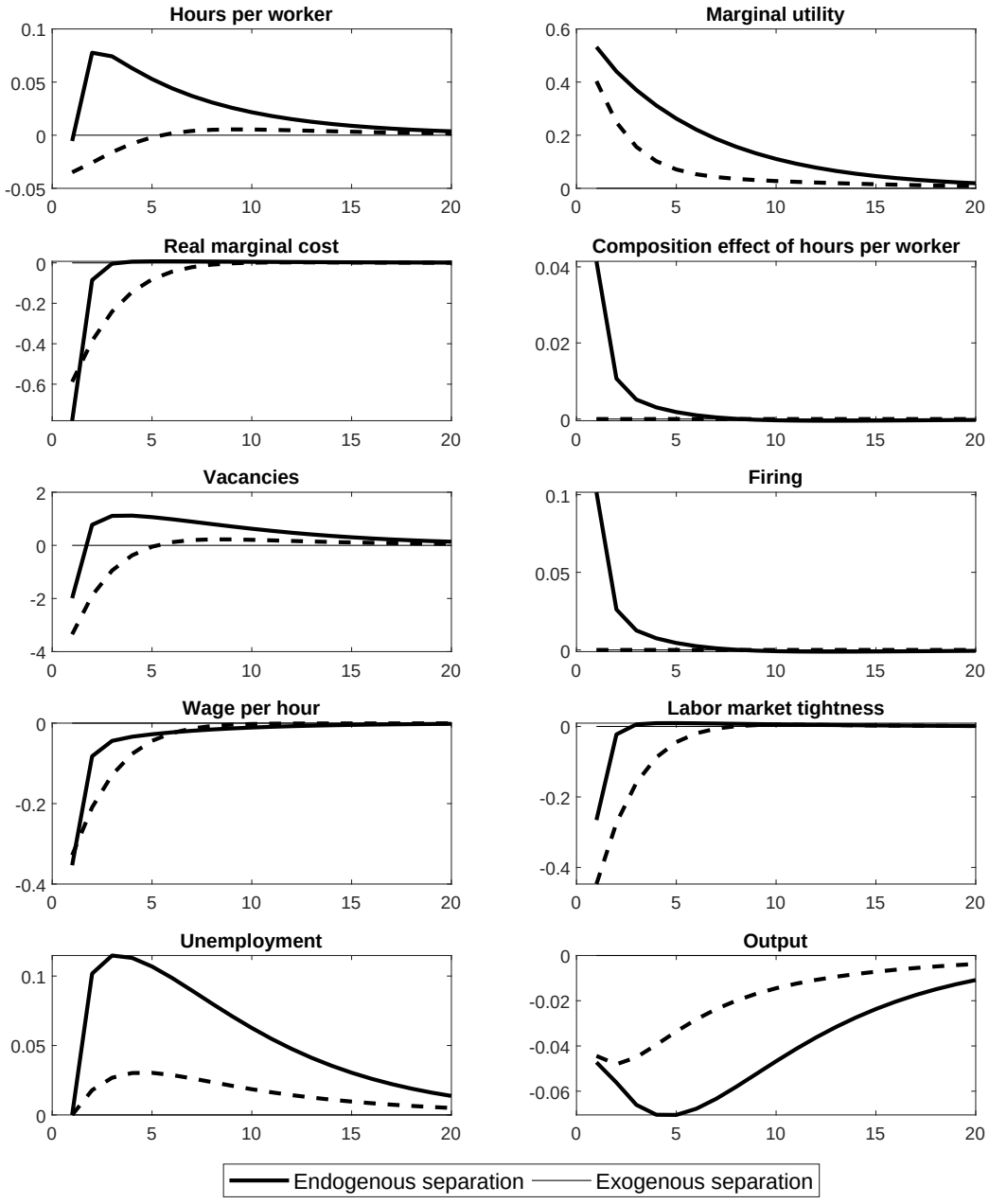
Notes: Each number is defined as the conditional standard deviation of a given macrovariable under fully flexible working hours, expressed relative to that implied by the model variant with estimated degree of working time rigidity. In both variants, all other parameters are fixed at their calibrated values or posterior means.

Figure 1: VAR impulse responses to a monetary shock



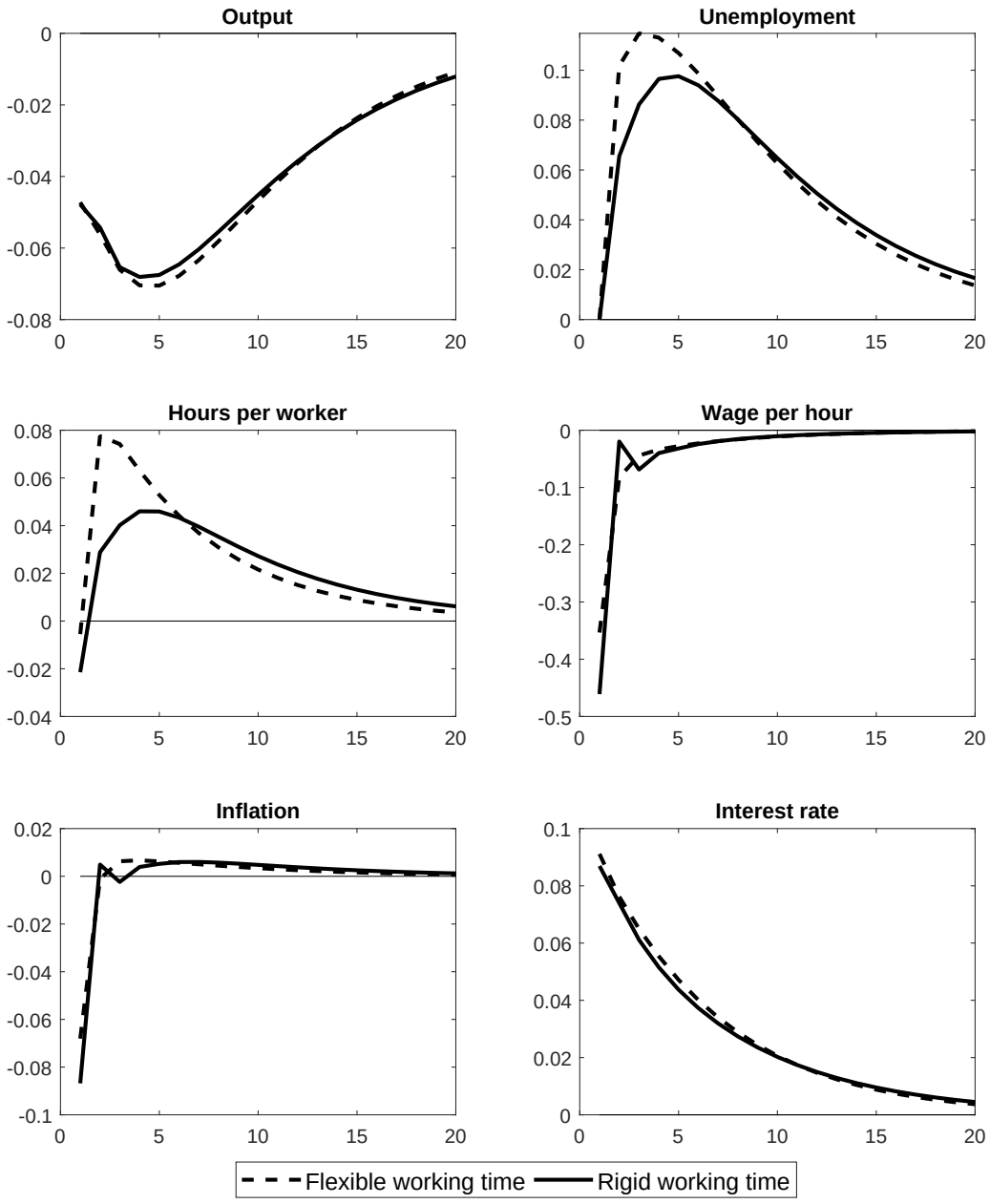
Notes: The impulse responses are presented in per cent. Solid lines - EA, dashed lines - US. Sample starts in 1985 and ends in 2012 (EA) and 2008 (US). The dotted lines indicate the region of plus/minus two standard deviations from the mean.

Figure 2: Impulse responses to a monetary shock - exogenous vs endogenous separations



Note: The impulse responses are presented in per cent deviations from the steady state.

Figure 3: Impulse responses to a monetary shock - flexible vs rigid working time



Note: The impulse responses are presented in per cent deviations from the steady state.

Appendix

A.1 Estimating cross-section dispersion of wages and hours using EU-SES microdata

To calculate the target values of cross-sectional standard deviations of hourly wages and hours worked per employee, which we target while calibrating the model, we use the microdata form the European Union Structure of Earnings Survey (EU-SES). The EU-SES is a large enterprise sample survey conducted every four years in the EU member states, the candidate countries and the EFTA members. Its goal is to provide the researchers and policy makers with the harmonized, good quality data on earnings in the European Union. Thus, the EU-SES offers a detailed and comparable information on the relationships between the level of earnings, individual characteristics of employees and their employer. The EU-SES combines the data collected from tailored questionnaires, existing surveys and administrative sources. It is usually based on a sample of employees drawn from a stratified sample of local units and includes only those employees who did receive the renumeration during the reference month (October for majority of countries).

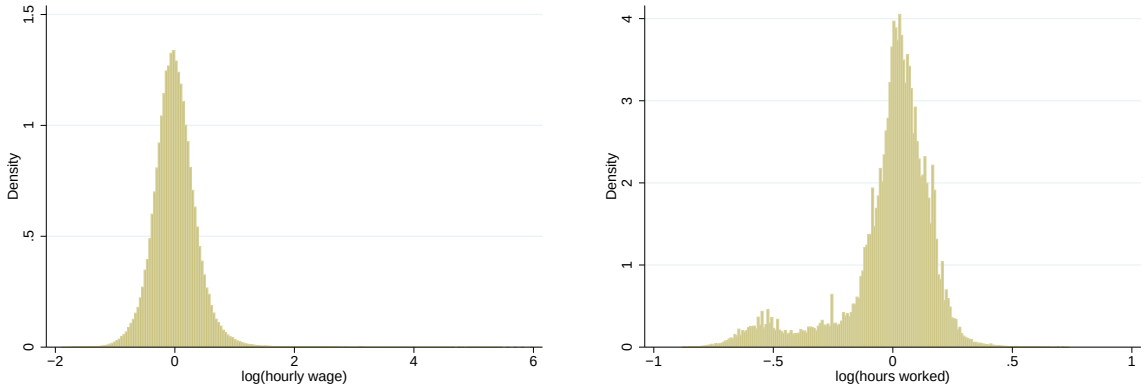
We use the EU-SES data for France, Germany, Italy and Spain and the reference year 2014, which is the last vintage available. We consider employees working in local units that are not micro-enterprises (at least 10 persons employed), operate in the areas of economic activity defined by sections B to S of NACE Rev. 2 (we exclude section O, i.e. public administration and defense; compulsory social security). Moreover, we also exclude employees working less than 75 or more than 300 hours in the reference month, as well as individuals with average gross hourly earnings of less than 5 euro. Our final dataset includes almost 1.2 million observations.

We use this sample of data to regress the logarithms of average gross hourly earnings in the reference month on sex, education, age, sector and country dummies, and interaction terms between age and education. For weighting purposes, we use the grossing-up factors for employees. Our estimates of the cross-sectional standard deviation of the logs of hourly wages correspond to the standard deviations of residuals from this regression. We next run a similar regression using the number of hours actually paid during the reference month as the dependent variable. Our calibration target for the standard deviation of logs of hours per worker is calculated

as the standard deviation of log-differences between the observed numbers of hours and their predicted values.

The following two charts present the thus obtained distributions of hourly wages and hours per worker.

Figure 4: Distribution of hourly wages and hours per worker in the EA



Notes: Based on the microdata from EU–SES for France, Germany, Italy and Spain, reference year 2014.

A.2 Model equations

This appendix presents a full set of equilibrium conditions defining the model with wage and working time rigidity as described in section 6.2.

Marginal utility

$$\lambda_t = (c_t - \varrho c_{t-1})^{-\sigma_c} \tag{A.1}$$

Consumption Euler equation

$$\lambda_t = \beta \mathbb{E}_t \left\{ \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right\} \tag{A.2}$$

Labor market tightness

$$\theta_t = \frac{v_t}{u_t} \tag{A.3}$$

Probability of finding a job

$$p_t = a\theta_t^{\varepsilon} \tag{A.4}$$

Probability of filling vacancy

$$q_t = a\theta_t^{\varepsilon - 1} \tag{A.5}$$

Unemployment

$$u_t = 1 - (1 - \lambda^x) n_{t-1} \tag{A.6}$$

Employment

$$n_t = [1 - G(\tilde{z}_t)][(1 - \lambda^x) n_{t-1} + q_t v_t] \tag{A.7}$$

Aggregate production function

$$\Delta_t Y_t = \frac{A_t n_t \Omega_{2,t}^{\alpha}}{1 - G(\tilde{z}_t)} H(\tilde{z}_t) \tag{A.8}$$

Intermediate goods producing firms' optimality conditions

$$\varphi_t A_t \tilde{z}_t h_t(\tilde{z}_t)^{\alpha} = w_t(\tilde{z}_t) h_t(\tilde{z}_t) - \beta(1 - \lambda^x) \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\chi}{q_{t+1}} \right\} \tag{A.9}$$

$$\frac{\chi}{q_t} = [\varphi_t A_t \Omega_{2,t}^{\alpha} - \Omega_{3,t} \Omega_{2,t}][H(\tilde{z}_t) - (1 - G(\tilde{z}_t)) \tilde{z}^{\frac{1+\eta}{\eta - \alpha + 1}}] \tag{A.10}$$

Resource constraint

$$Y_t = c_t + g_t + \chi v_t \tag{A.11}$$

Firing probability[8]

$$G(\tilde{z}_t) = F\left(\frac{\log(\tilde{z}_t)}{\sigma_z}\right) \tag{A.12}$$

Nash threshold wage

$$w_t^N(\tilde{z}_t)h_t^N(\tilde{z}_t) = \xi_t\left(b + d + \frac{\kappa_t}{\lambda_t}\frac{h_t^N(\tilde{z}_t)^{1+\eta}}{1+\eta}\right) \tag{A.13}$$

$$+(1-\xi_t)\left(\varphi_t A_t \tilde{z}_t h_t^N(\tilde{z}_t)^{\alpha} + (1-\lambda^x)\beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\theta_{t+1}\right\}\chi\right) \tag{A.14}$$

Nash threshold hours

$$\kappa_t h_t^N(\tilde{z}_t)^{\eta-\alpha+1} = \alpha\varphi_t A_t \tilde{z}_t \lambda_t \tag{A.15}$$

Threshold wage

$$w_t(\tilde{z}_t) = \Omega_{3,t}\tilde{z}_t^{\frac{\eta}{\eta-\alpha+1}} + \Omega_{4,t}\tilde{z}_t^{\frac{-1}{\eta-\alpha+1}} \tag{A.16}$$

Threshold hours

$$h_t(\tilde{z}_t) = \Omega_{2,t}\tilde{z}_t^{\frac{1}{\eta-\alpha+1}} \tag{A.17}$$

Nominal interest rate

$$R_t = R_{t-1}^{\phi_R}\left[\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi}\left(\frac{Y_t}{Y}\right)^{\phi_y}\right]^{1-\phi_R}\exp\{\epsilon_{m,t}\}, \quad \epsilon_{m,t} \overset{iid}{\sim} N\left(0, \sigma_m^2\right) \tag{A.18}$$

Sticky price block

$$\tilde{p}_t = \mu_t\frac{\Phi_t}{\Psi_t} \tag{A.19}$$

$$\Phi_t = \lambda_t\varphi_t Y_t + \beta\delta\mathbb{E}_t\left\{\left(\frac{\pi_{t+1}}{\pi}\right)^{\frac{\mu_t}{\mu_t-1}}\Phi_{t+1}\right\} \tag{A.20}$$

$$\Psi_t = \lambda_t Y_t + \beta\delta\mathbb{E}_t\left\{\left(\frac{\pi_{t+1}}{\pi}\right)^{\frac{1}{\mu_t-1}}\Psi_{t+1}\right\} \tag{A.21}$$

$$\Delta_t = (1-\delta)\tilde{p}_t^{\frac{\mu_t}{1-\mu_t}} + \delta\pi_t^{\frac{\mu_t}{\mu_t-1}}\Delta_{t-1} \tag{A.22}$$

[8]In the following equations, F denotes the cumulative distribution function of the standard normal distribution.

$$1 = \delta \pi_t^{\frac{1}{\mu_t - 1}} + (1-\delta)\tilde{p}_t^{\frac{1}{\mu_t - 1}} \tag{A.23}$$

Auxiliary distribution functions

$$D(\tilde{z}_t) = \exp\left\{0.5\left(\sigma_z \frac{1}{\eta - \alpha + 1}\right)^2\right\}\left[1 - F\left(\frac{\log \tilde{z}_t}{\sigma_z} - \sigma_z \frac{1}{\eta - \alpha + 1}\right)\right] \tag{A.24}$$

$$H(\tilde{z}_t) = \exp\left\{0.5\left(\sigma_z \frac{\eta + 1}{\eta - \alpha + 1}\right)^2\right\}\left[1 - F\left(\frac{\log \tilde{z}_t}{\sigma_z} - \sigma_z \frac{\eta + 1}{\eta - \alpha + 1}\right)\right] \tag{A.25}$$

Auxiliary variables

$$\Omega_{1,t} = (1-\xi_t)\left((1-\lambda^x)\beta \mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\theta_{t+1}\right\}\chi\right) + \xi_t(b+d) \tag{A.26}$$

$$\Omega_{2,t} = \omega_h\left(\frac{\alpha \varphi_t A_t \lambda_t}{\kappa_t}\right)^{\frac{1}{\eta - \alpha + 1}} + (1-\omega_h)\Omega_{2,t-1} \tag{A.27}$$

$$\Omega_{3,t} = \omega_w\left(\frac{\xi_t}{1+\eta} + \frac{1-\xi_t}{\alpha}\right)\frac{\kappa_t}{\lambda_t}\left(\frac{\alpha \varphi_t A_t \lambda_t}{\kappa_t}\right)^{\frac{\eta}{\eta - \alpha + 1}} + (1-\omega_w)\Omega_{3,t-1} \tag{A.28}$$

$$\Omega_{4,t} = \omega_w \Omega_{1,t}\left(\frac{\alpha \varphi_t A_t \lambda_t}{\kappa_t}\right)^{\frac{-1}{\eta - \alpha + 1}} + (1-\omega_w)\Omega_{4,t} \tag{A.29}$$

Stochastic shocks

$$\log(A_t) = \rho_A \log(A_{t-1}) + \epsilon_{A,t}, \quad \epsilon_{A,t} \overset{iid}{\sim} N\left(0, \sigma_A^2\right) \tag{A.30}$$

$$\log(g_t) = (1-\rho_g)\log(g) + \rho_g \log(g_{t-1}) + \epsilon_{g,t}, \quad \epsilon_{g,t} \overset{iid}{\sim} N\left(0, \sigma_g^2\right) \tag{A.31}$$

$$\log(\kappa_t) = (1-\rho_\kappa)\log(\kappa) + \rho_\kappa \log(\kappa_{t-1}) + \epsilon_{\kappa,t}, \quad \epsilon_{\kappa,t} \overset{iid}{\sim} N\left(0, \sigma_\kappa^2\right) \tag{A.32}$$

$$\xi_t = (1-\rho_\xi)\,\xi + \rho_\xi \xi_{t-1} + \epsilon_{\xi,t}, \quad \epsilon_{\xi,t} \overset{iid}{\sim} N\left(0, \sigma_\xi^2\right) \tag{A.33}$$

$$\log(\mu_t) = (1-\rho_\mu)\log(\mu) + \rho_\mu \log(\mu_{t-1}) + \epsilon_{\mu,t}, \quad \epsilon_{\mu,t} \overset{iid}{\sim} N\left(0, \sigma_\mu^2\right) \tag{A.34}$$

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