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Labor market institutions and the business cycle: The role of unemployment fears*

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Abstract

We study the effects of labor market institutions (LMIs) in a general equilibrium model with search and matching frictions, endogenous separations, nominal rigidities, and uninsurable unemployment risk. By contrasting the US and EA, which are characterized by different degrees of employment protection and unemployment insurance schemes, we show that these LMIs have important implications for the transmission of standard aggregate demand and (even more so) supply shocks. In particular, if US unemployment benefits were increased during recessions to the levels typically observed in the EA, fluctuations in employment could be significantly reduced, bringing the outcomes close to the case of full unemployment insurance assumed by representative agent models. Similar effects can be obtained by subsidizing wages or introducing partial employment protection during recessions, especially if these are driven by changes in aggregate productivity.

JEL: D52, E21, E24, E32, J64, J68

Keywords: labor market institutions, search and matching, heterogeneous agents, unemployment risk, general equilibrium

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1 Introduction

Both unemployment and fear thereof are crucial factors affecting household spending at individual level (Den Haan et al., 2018). They can have particularly large implications for aggregate demand fluctuations if inequality is high and a large fraction of households hold little assets (Krueger et al., 2016). These considerations came once again to the center of policy debate when many economies facing the COVID-19 pandemic started to massively use various labor market policies to shield workers and firms from the effects of lockdowns and other social distancing measures.

A number of empirical papers have stressed the stabilizing role of labor market institutions in mitigating the consequences of unemployment risk, see, e.g. recent macroeconomic studies by Abbritti and Weber (2018) and Gnocchi et al. (2015), or microdata-based analyses by Kolsrud et al. (2018) and Ganong and Noel (2019). Following theoretical advances by Mortensen and Pissarides (1994), a growing body of researchers have implemented search and matching frictions into general equilibrium models to study the impact of labor market rigidities on business cycles, see, e.g. Gertler and Trigari (2009), Krusell et al. (2010), Ravenna and Walsh (2011) or Christiano et al. (2016). Motivated by large diversity not only across the world, but also among European economies, some of these studies examined the role of LMIs, such as labor protection legislation, unemployment benefits, wage bargaining frictions, or wage and working time flexibility, see also, among others, Thomas and Zanetti (2009), Christoffel et al. (2009), Campolmi and Faia (2011), Cacciatore and Fiori (2016), Balleer et al. (2016), Kolasa et al. (2021). One of the findings was that restrictive employment protection lowers the volatility of output and unemployment, at the same time raising the variability of wages and inflation, while higher unemployment benefits tend to have the opposite implications.

The common feature of this line of the theoretical literature is that, to ensure computational tractability, it typically assumes complete markets, at least conditional on aggregate shocks, or uses the large family assumption, meaning that unemployment risk is fully insurable. As a result, these papers cannot take fully into account the potentially significant impact of LMIs on unemployment fears and the associated precautionary behavior of households – a channel that may have important consequences for aggregate demand and hence business cycle fluctuations.

In this paper we study the role of LMIs in a general equilibrium model with search and matching frictions and uninsurable unemployment risk. Our theoretical framework is similar to Krause and

Lubik (2007), into which we additionally incorporate endogenous separations and a range of labor market policies, such as (potentially time-varying) unemployment benefits, employment protection in form of firing costs, and wage subsidies. We first show that the role of incomplete markets and precautionary motives in propagation of standard aggregate demand and supply shocks is substantial. In particular, the reaction of employment in our benchmark model with incomplete markets is more than two times larger than in the same model that assumes full insurance.

We next use the model to analyze the business cycle implications of LMIs. Following much of the literature, we focus our analysis around the differences between labor market characteristics and policies in the US and EA, the latter featuring lower labor market flows, higher average unemployment rate, higher unemployment insurance, and stronger employment protection legislation (see, e.g., OECD, 2020). We show that LMIs significantly affect the transmission of standard aggregate demand shocks, and even more so aggregate productivity shocks. To demonstrate it, we run a couple of counterfactual experiments in which LMIs in the US are assumed to dynamically adjust to adverse shocks. One of the findings is that, if US unemployment benefits were increased during recessions to the levels typically observed in the EA, fluctuations in employment could be significantly reduced, bringing the outcomes close to the case of full unemployment insurance assumed by representative agent models. We also show that similar effects can be obtained by increasing firing costs or subsidizing wages during supply side-driven recessions.

Apart from papers already cited, our paper is related to the recent and growing literature examining the effects of incomplete markets on business cycles, also revisiting the role of stabilization policies in the presence of nominal rigidities, see the so-called HANK (heterogeneous agent New Keynesian) literature represented e.g. by Kaplan et al. (2018), Auclert (2019), Bayer et al. (2019), Ravn and Sterk (2021). Some of papers in this stream focus on labor markets (see, e.g., Gornemann et al., 2016; McKay and Reis, 2016; Den Haan et al., 2018; Kekre, 2021), sometimes imposing a zero-liquidity constraint for tractability (Challe, 2020; Ravn and Sterk, 2021). All of them stress the aggregate demand implications of uninsurable changes in labor market status. We add to this literature by incorporating endogenous separations and a range of LMIs, allowing us to capture directly how they affect time-variation in unemployment risk and macroeconomic fluctuations.

The rest of this paper is organized as follows. Section two presents the model. Section three discusses its calibration variants, highlighting the distinctive features of labor market flows and institutions in the EA and US. Section four presents our main results, including the role of labor market institutions and precautionary motives in transmitting standard demand and supply shocks. Section five concludes.

2 Model

2.1 Environment

Time is infinite and divided into discrete periods indexed by t. The model economy is populated by four types of agents: households, retailers, firms and government (composed of fiscal and monetary authorities). There are three markets, for nominal assets, goods and labor.

2.2 Households

There is a continuum of households of measure one, who face uninsurable idiosyncratic shocks to their labor market status, driven by endogenously evolving job-finding rate f_t and separation rate s_t. After the realization of aggregate shocks is revealed at the beginning of period, first hiring and then separations take place, and a just-separated household cannot be engaged within the same period. Labor supply is exogenous and normalized to unity. Each household earns real gross wage w_t if employed or receives a benefit equal to $\mu_t w_t$ if unemployed, where $\mu_t \in (0, 1)$ is the (potentially time-varying) replacement rate. Labor income is taxed at a linear rate τ_t.[1]

Agents value consumption streams c_t and the associated instantaneous utility function $u(c_t)$ is strictly increasing, strictly concave, and satisfies the Inada conditions. Future utility streams are discounted with factor β_t, which we allow to fluctuate exogenously around its steady state value of $\beta_{ss} \in (0, 1)$. Time variation in the discount factor allows us to introduce a simple form of a demand-type shock in our model economy. In addition to the budget constraint, household optimization is subject to an exogenous borrowing limit $\bar{b} \geq 0$.

Let us denote the value functions associated with the dynamic problems of employed and unemployed agents as $W_{e,t}$ and $W_{u,t}$. Then the maximization problem of an employed household with

[1] Note that the number of hours worked by employed households is fixed and hence labor income tax is not distortionary, i.e., it has no effect on labor supply.

current real balances b_t of nominal assets can be represented by the following Bellman equation

$$W_{e,t}(b_t) = \max_{c_t, b_{t+1}} \{u(c_t) + \beta_t \mathbb{E}_t [(1 - s_{t+1}) W_{e,t+1}(b_{t+1}) + s_{t+1} W_{u,t+1}(b_{t+1})]\} \tag{1}$$

$$\text{subject to} \quad c_t + b_{t+1} = \frac{1 + i_{t-1}}{\Pi_t} b_t + (1 - \tau_t) w_t$$

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

where i_t is the nominal interest rate that is controlled by the monetary authority and $\Pi_t = P_t / P_{t-1}$ is the gross inflation rate, with P_t denoting the price of the final homogeneous good.

The maximization problem of an unemployed household can be written as

$$W_{u,t}(b_t) = \max_{c_t, b_{t+1}} \{u(c_t) + \beta_t \mathbb{E}_t [f_{t+1} (1 - s_{t+1}) W_{e,t+1}(b_{t+1}) + (1 - f_{t+1} \cdot (1 - s_{t+1})) W_{u,t+1}(b_{t+1})]\} \tag{2}$$

$$\text{subject to} \quad c_t + b_{t+1} = \frac{1 + i_{t-1}}{\Pi_t} b_t + \mu_t w_t$$

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

Note that households are heterogeneous both between and within each group because of different history of labor market status, resulting in different stocks of accumulated assets.

2.3 Retailers

Perfectly competitive retailers pack differentiated goods $y_{j,t}$ indexed by $j \in [0, 1]$ into a basket of homogeneous final goods y_t using technology described by the Dixit-Stiglitz aggregator

$$y_t = \left(\int_0^1 y_{j,t}^{1-1/\gamma} \, \mathrm{d}j \right)^{\frac{1}{1-1/\gamma}} \tag{3}$$

where $\gamma > 1$ is the elasticity of substitution between intermediate goods produced by firms. Retailers choose $\{y_{j,t}\}$ to maximize their profits

$$P_t y_t - \int_0^1 P_{j,t} y_{j,t} \, \mathrm{d}j \tag{4}$$

where $P_{j,t}$ is the price of the variety produced by firm j. The following equation describes the first-order condition of a representative retailer

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\gamma} y_t \tag{5}$$

where the aggregate price index P_t is

$$P_t = \left(\int_0^1 P_{j,t}^{1-\gamma}\,\mathrm{d}j\right)^{\frac{1}{1-\gamma}} \tag{6}$$

2.4 Firms

There is measure one of firms indexed by $j \in [0,1]$ that produce intermediate goods using a linear technology in labor. Firm j hires workers in the frictional labor market by posting vacancies $v_{j,t}$, each of which costs κ units of the final consumption good. The probability that a vacancy is filled equals q_t and fluctuates endogenously with aggregate market tightness. Proportion $\hat{s} \in (0,1)$ of existing jobs is exogenously destroyed between periods. Once new matches are formed, hence adding to the pool of potential workers, firms decide to lay off some of the staff, subject to the potentially time-varying firing cost $\Delta_t \geq 0$. For simplicity, we assume that a fraction $\hat{s}$ of newly formed matches are also destroyed, without incurring any firing cost on the firm.

As in Krause and Lubik (2007), endogenous firing is driven by workers' individual productivity a, which is i.i.d. with cdf $F(a)$ and pdf $f(a)$. Let us also denote the threshold productivity, below which firm j decides to terminate employment as $\tilde{a}_{j,t}$. The production function of firm j can then be written as

$$y_{j,t} = Z_t \bar{A}(\tilde{a}_{j,t}) n_{j,t} \tag{7}$$

where Z_t denotes exogenous aggregate productivity and

$$\bar{A}(\tilde{a}_j) = [1 - F(\tilde{a}_{j,t})]^{-1} \int_{a \geq \tilde{a}_{j,t}} a\,\mathrm{d}F(a) \tag{8}$$

is average productivity of retained workers. The law of motion for labor input is then

$$n_{j,t} = (1 - s_{j,t})\,(n_{j,t-1} + q_t v_{j,t}) \tag{9}$$

where $s_{j,t} = \hat{s} + (1-\hat{s})\, F(\tilde{a}_{j,t})$ is the total (exogenous and endogenous) separation rate.

Each worker earns real wage w_t, the cost of which can be partially subsidized by the government at rate $\tau_t^w \in [0,1)$. Subsidies are financed by tax T_t levied on firms in a lump sum fashion. Firms are monopolistically competitive and set their prices subject to quadratic price adjustment costs as in Rotemberg (1982), with its curvature controlled by $\phi \geq 0$. Future profits are discounted with real interest rate r_t that satisfies the Fisher equation

$$1 + r_t = \frac{1 + i_{t-1}}{\Pi_t} \tag{10}$$

Firm j hence solves a dynamic problem of maximizing the discounted sum of real profits $d_{j,t}$

$$F_{j,t}(n_{j,t-1}, P_{j,t-1}) = \max_{\{y_{j,t}, \tilde{a}_{j,t}, n_{j,t}, v_{j,t}, P_{j,t}\}} \mathbb{E}_t \sum_{t=0}^{\infty} \left(\prod_{s=1}^{t} \frac{1}{1+r_s} \right) d_{j,t} \tag{11}$$

where

$$d_{j,t} = \frac{P_{j,t}}{P_t} y_{j,t} - (1-\tau_t^w)\, w_t n_{j,t} - \kappa v_{j,t} - \frac{\phi}{2} \left(\frac{P_{j,t}}{P_{j,t-1}} - \Pi_{ss} \right)^2 Y_t - \Delta \frac{F(\tilde{a}_{j,t})}{1 - F(\tilde{a}_{j,t})} n_{j,t} - T_t \tag{12}$$

subject to demand schedules (**??**), production function (7) and the law of motion for employment (9).

In a symmetric equilibrium, in which all firms are identical and hence subscripts j can be omitted, the first-order conditions describing optimal decisions can be expressed as

$$1 - \phi\,(\Pi_t - \Pi_{ss})\,\Pi_t + \mathbb{E}_t \frac{1}{1+r_{t+1}} \phi\,(\Pi_{t+1} - \Pi_{ss})\,\Pi_{t+1} \frac{y_{t+1}}{y_t} = (1 - \Psi_t)\,\gamma \tag{13}$$

$$\Xi_t = \Psi_t Z_t \bar{A}(\tilde{a}_t) - (1-\tau_t^w) w_t - \Delta_t \frac{F(\tilde{a}_t)}{1-F(\tilde{a}_t)} + \mathbb{E}_t \frac{1-\hat{s}}{1+r_{t+1}} \Xi_{t+1} \tag{14}$$

$$\Xi_t = \frac{\kappa}{q_t} \tag{15}$$

$$\Xi_t = \Psi_t Z_t \left(\bar{A}(\tilde{a}_t) - \tilde{a}_t \right) - \frac{\Delta_t}{1 - F(\tilde{a}_t)} \tag{16}$$

where Ψ_t and Ξ_t are the Lagrange multipliers related to constraints (7) and (9), respectively.

Equation (13) gives rise to the standard New Keynesian Phillips Curve under the Rotemberg pricing friction. Equation (14) expresses the ex-ante value of a matched worker with yet unknown idiosyncratic productivity. The within-period gain consists of the average marginal product of labor of retained workers less the after-subsidy wage and less the expected costs of firing. Equation (15) states that, due to the assumption of free entry of vacancies, the expected future ex-ante value of a matched worker equals the effective search cost κ/q_t. Finally, equation (16) pins down the value of workers' idiosyncratic productivity below which the firm decides to terminate the match.

As in Hagedorn et al. (2019), we assume that firm profits are fully taxed. This allows us to abstract from issues related to the redistribution of profits across agents. As the latter usually go to households featuring high wealth and very low marginal propensity to consume, it is unlikely that this assumption significantly affects the dynamics of aggregate consumption, which is the main object of interest of this paper.

2.5 Labor market flows and wages

Constant returns to scale matching technology M combines vacancies v_t posted by firms with workers that are unemployed at the beginning of period $1 - n_{t-1}$. Let us define labor market tightness x_t as

$$x_t = \frac{v_t}{1 - n_{t-1}} \tag{17}$$

Then the vacancy-filling rate q_t and job-finding rate f_t satisfy

$$q_t = q(x_t) = \frac{M(1 - n_{t-1}, v_t)}{v_t} \tag{18}$$

$$f_t = f(x_t) = \frac{M(1 - n_{t-1}, v_t)}{1 - n_{t-1}} \tag{19}$$

Since there is no universal theory that would pin down wages in labor market featuring search frictions, we follow much of the literature (see, e.g., Den Haan et al., 2018) and postulate an ad hoc function

$$w_t = (w_{ss} Z_t^{\omega_z})^{1-\omega_w} \left(\frac{w_{t-1}}{\Pi_t}\right)^{\omega_w} \tag{20}$$

where $\omega_w \in [0, 1)$ and $\omega_z \in [0, 1]$ control the degree of real wage rigidity and real wage indexation to productivity, respectively, while the steady state real wage w_{ss} is set to meet our calibration targets. Naturally, we make sure that w_{ss} belongs to the bargaining set (see Hall, 2005).

2.6 Government

The government consists of fiscal and monetary authorities. The fiscal branch pays unemployment benefits to households and wage subsidies to firms. Its revenue consists of firm profits, labor income taxes, and lump sum taxes levied on firms. It can also borrow from households by issuing bonds of real value B_t. Bearing in mind that wage subsidies are fully financed with lump sum taxes on firms (i.e., $\tau_t^w w_t n_t = T_t$), the intertemporal budget constraint of the fiscal authority can be written as

$$d_t + T_t + \tau_t w_t n_t = \mu_t w_t (1 - n_t) + (1 + r_t) B_t - B_{t+1} \tag{21}$$

In the baseline specification we assume that government debt is fixed at B_{ss}.

The monetary authority sets the value of the nominal interest rate according to the following Taylor-type rule

$$i_t = i_{ss} + \phi_\Pi (\Pi_t - \Pi_{ss}) + \phi_Y \frac{y_t - y_{ss}}{y_{ss}} \tag{22}$$

where i_{ss}, y_{ss} and Π_{ss} are the values of i_t, y_t and Π_t in the stationary equilibrium, while ϕ_Π and ϕ_Y are the feedback parameters describing the central bank preferences.

2.7 Consistency conditions

The market clearing condition for manufactured goods reads

$$\int c_{e,t}(b_t) d\pi_{e,t}(b_t) + \int c_{u,t}(b_t) d\pi_{u,t}(b_t) + \kappa v_t + \frac{\phi}{2} (\Pi_t - 1)^2 y_t + \Delta_t \frac{F(\tilde{a}_t)}{1 - F(\tilde{a}_t)} n_t = y_t \tag{23}$$

where $c_{e,t}(b_t)$ and $c_{u,t}(b_t)$ are the consumption policy functions associated with dynamic problems (1) and (2) of employed and unemployed households, respectively, while by $\pi_{e,t}(b_t)$ and $\pi_{u,t}(b_t)$ we denote the measure of employed and unemployed agents with asset holdings b_t.

Denoting the asset policy functions associated with problems (1) and (2) by $b_{e,t+1}(b_t)$ and $b_{u,t+1}(b_t)$, respectively, the market clearing condition for assets is then

$$\int b_{e,t+1}(b_t)\, \mathrm{d}\pi_{e,t}(b_t) + \int b_{u,t+1}(b_t)\, \mathrm{d}\pi_{u,t}(b_t) = B_{t+1} \tag{24}$$

The law of motion of agents across states is characterized by the following two transition equations

$$\pi_{e,t+1}(\mathcal{B}) = (1 - s_{t+1}) \int_{\{b: b_{e,t+1}(b_t) \in \mathcal{B}\}} \mathrm{d}\pi_{e,t}(b_t) + f_{t+1} (1 - s_{t+1}) \int_{Z \times \{b: b_{u,t+1}(b_t) \in \mathcal{B}\}} \mathrm{d}\pi_{u,t}(b_t) \quad (25)$$

$$\pi_u(\mathcal{B}) = s_{t+1} \int_{\{b: b_{e,t+1}(b_t) \in \mathcal{B}\}} \mathrm{d}\pi_{e,t}(b_t) + [1 - f_{t+1} \cdot (1 - s_{t+1})] \int_{Z \times \{b: b_{u,t+1}(b_t) \in \mathcal{B}\}} \mathrm{d}\pi_{u,t}(b_t) \quad (26)$$

where $\mathcal{B}$ is a Borel subset of $[-\bar{b}, +\infty)$. Obviously, the total measure of households equals one

$$\int \mathrm{d}\pi_{e,t}(b_t) + \int \mathrm{d}\pi_{u,t}(b_t) = 1 \quad (27)$$

2.8 Equilibrium

We are now in a position to define the equilibrium of the model as follows

Definition. *Equilibrium is a sequence of endogenous variables* $\{x_t\}$, $\{i_t\}$, $\{s_t\}$, $\{\tilde{a}_t\}$, $\{n_t\}$, $\{v_t\}$, $\{d_t\}$, $\{P_t\}$, $\{r_t\}$, $\{w_t\}$, $\{\tau_t\}$, *value functions* $\{W_{u,t}\}$, $\{W_{e,t}\}$, $\{F_t\}$, *policy functions* $\{c_{e,t}\}$, $\{c_{u,t}\}$, $\{b_{e,t+1}\}$, $\{b_{u,t+1}\}$, *and measures* $\{\pi_{e,t+1}\}$, $\{\pi_{u,t+1}\}$, *such that, given* $\{B_{t+1}\}$, $\{\tau_t^w\}$, $\{\mu_t\}$, $\{\Delta_t\}$, $\{Z_t\}$, $\{\beta_t\}$ *and initial values* B_0, n_0, P_0, $\pi_{e,0}$, $\pi_{u,0}$*:*

(a) Value functions $W_{u,t}$, $W_{e,t}$ *and the associated policy functions solve the household maximization problems (1) and (2),*

(b) Value function F_t *solves firm's maximization problem,*

(c) Real wage w_t *is given by equation (20),*

(d) The law of motion for labor employed by firms 9 is consistent with the law of motion of households across the individual states 25-26,

(e) Measures $\pi_{e,t+1}$, $\pi_{u,t+1}$ *satisfy the dynamic system described by equations (25)-(26),*

(f) The government budget constraint given by equation (21) holds and the central bank follows rule (22),

(g) Asset and goods market clearing conditions (23)-(24) hold.

3 Calibration and solution

3.1 Functional forms

We assume that the utility function u takes the CRRA form

$$u(c) = \frac{c^{1-\theta}}{1-\theta} \tag{28}$$

where θ is the rate of relative risk aversion.

The labor market matching function M is assumed to be of a standard Cobb-Douglas type

$$M\left(1-n_{t-1}, v_t\right) = \bar{M}\left(1-n_{t-1}\right)^{\alpha} v_t^{1-\alpha}$$

where $\bar{M} > 0$ is the matching efficiency parameter and $\alpha \in (0,1)$ is the elasticity of matching function with respect to the job seekers pool.

3.2 Calibrated parameters

The time period is a quarter. The targets of our baseline model calibration are the moments characterizing the US economy over the long run. Since a major part of our analysis relies on contrasting the labor market outcomes between the United States and the Euro Area, we also use a variant of calibration that reflects selected European labor market features.

3.2.1 Baseline calibration

The model parameters can be divided into two groups. The first one contains the parameters that are set with reference to the literature, and the second group is calibrated using the model to match the moments observed in the data.

Table 1 presents the parameter values that are taken from the literature. We set the relative risk aversion coefficient $\theta = 2$, which is a standard value in the business cycle literature. By calibrating $\gamma = 11$ we match the monopolistic markup equal to 10%. We assume that the parameters associated with the Taylor rule are $\phi_Y = 0.125$ and $\phi_\Pi = 1.5$, which are standard values in the literature, and set the ratio of debt to quarterly GDP to 4. We follow Hagedorn et al. (2019) and set $\phi = 115$ to match the slope of the Phillips curve. Finally, we follow McKay and Reis (2016) and Krueger et al. (2016) and standardize the liquidity constraint $\bar{b}$ to 0.

Following Shimer (2005), we calibrate the replacement rate $\mu = 0.4$. We set the rate of exogenous separations $\hat{s} = 0.068$ as in Ramey et al. (2000) and Krause and Lubik (2007). The elasticity of matches with respect to the job seekers pool is set at a customary value of 0.5. Since most papers focusing on the US abstract from employment protection, our benchmark calibration assumes no firing cost ($\Delta = 0$). For similar reasons, we assume that there are subsidies to wages in the steady state ($\tau^w = 0$). As in Ramey et al. (2000) and Krause and Lubik (2007), we assume that idiosyncratic productivity shocks a are drawn from a log-normal distribution with mean normalized to zero. Following the procedure described in Den Haan et al., 2018, we estimate the wage rule parameters outside of the model.

Table 1: Parameters set from the literature

Parameter	Description	Value	Source
θ	Relative risk aversion	2	Standard value
γ	Elasticity of substitution between intermediate goods	11	Standard value
ϕ_Π	Taylor rule parameter (inflation)	1.5	Standard value
ϕ_Y	Taylor rule parameter (output)	0.125	Standard value
B_{ss}/Y_{ss}	Steady state debt to quarterly GDP	4	Standard value
ϕ	Price adjustment parameter	115	Hagedorn et al. (2019)
$\bar{b}$	Liquidity constraint	0	McKay and Reis (2016)
μ_{ss}	Steady state replacement rate	0.4	Shimer (2005)
$\hat{s}$	Exogenous separations	0.068	Ramey et al. (2000)
α	Elasticity of matches wrt. job seekers	0.5	Standard value
Δ_{ss}	Steady state firing cost	0	Standard value
τ^w_{ss}	Steady state wage subsidy	0	Standard value
μ_a	Mean log workers' productivity	0	Ramey et al. (2000)
ω_z	Wage indexation to productivity	0.1	Own estimates
ω_w	Real wage rigidity	0.5	Own estimates

2 explains how we calibrate the remaining parameters to match selected moments in the data. To pin down β, we use the steady state value of the annual real interest rate equal to 2.5% as the

calibration target. Since we consider a stationary equilibrium in which $\Pi = 1$, the value of i equals the real interest rate. Real wage w in the steady state is adjusted to match the unemployment rate u equal to 12%, in line with the broad measure of unemployment as in Krause and Lubik (2007). Parameter $\bar{M}$ of the matching function is calibrated at 2.53 to target the vacancy-filling rate of 0.7 as reported by Krause and Lubik (2007). Parameter κ is calibrated at 0.082 to match the relationship between wages and recruitment costs reported by Silva and Toledo (2009). The value of σ_a is adjusted to match the rate of endogenous firing $F(\tilde{a})$ equal to 3.2% as in Ramey et al. (2000).

Table 2: Parameters set to hit calibration targets

Parameter	Description	Value	Target	Target value
β_{ss}	Steady state discount factor	0.993	Real interest rate	0.025
w_{ss}	Steady state wage	0.904	Broad unemployment rate	0.12
$\bar{M}$	Match efficiency parameter	0.755	Vacancy-filling rate	0.7
κ	Cost of a vacancy	0.082	Effective vacancy cost to real wage	0.13
σ_a	Workers productivity dispersion	0.08	Endogenous firing	0.032

3.2.2 Euro Area calibration

While considering the model variant describing the EA economy, we try to keep the number of modified parameters at a minimum. This allows us to maintain a high degree of comparability to the baseline US calibration.

The EA labor market is characterized by relatively low flows, reflected in significantly lower transition probabilities of households' labor market status, see Table 3. We follow the general calibration strategy of Christoffel et al. (2009), and pin down the job-finding and vacancy-filling probabilities using the observed average fraction of unemployment spells longer than 3 months and the fraction of unfilled vacancies after 3 months, while the steady state separation rate is disciplined by the fraction of workers whose job started within the past 3 months. The resulting unemployment rate is consistent with the broad unemployment measure provided by the Eurostat in the form of overall labor market slack as a fraction of the extended labor force.

Table 3: Euro Area labor market targets

Variable	Description	Value	Justification	Memo: US value
n	Employment rate	0.8	Eurostat: labor market slack	0.88
s	Overall separation rate	0.05	Fraction of workers in new job positions	0.1
f	Job finding probability	0.2	Unemployment spells longer than 3 months	0.81
q	Job filling probability	0.7	Unfilled vacancies after 3 months	0.7

We keep the majority of other parameters identical to the US case, including the steady state discount factor, the fraction of exogenous separations, the effective vacancy cost to real wage ratio, and the workers' productivity dispersion. What drives the differing labor market outcomes between the US and EA are the institutions, and we summarize this part of our calibration choices in Table 4.

Table 4: Labor market institutions: EA vs US

Parameter	Description	Value EA	Value US
Δ_{ss}	Steady state firing cost	0.0225	0
μ_{ss}	Steady state replacement rate	0.5	0.4
$\bar{M}$	Match efficiency parameter	0.384	0.755
w_{ss}	Steady state wage	0.908	0.904
r_{ss}	Steady state real interest rate (annualized)	0.015	0.025

Compared to the US, the steady state firing cost in the EA is positive and the steady state replacement rate of unemployment benefits is higher. Additionally, the matching efficiency parameter in EA is substantially lower, which supports a much lower labor market tightness observed in this economic region. As a result, while the steady state wages are almost identical in the EA and US, the longer average duration of unemployment spells in the former increases the precautionary motive (despite the existence of more protective labor market institutions) and drives down the average real interest rate.

3.3 Model solution

The stationary equilibrium of the model is solved by combining collocation and endogenous grid methods. To solve the dynamic model under aggregate risk, we employ a variant of the algorithm originally proposed in Reiter (2009), with the use of the modified toolboxes developed by

A. McKay and S. Graves.[2] Specifically, our version of the Reiter's algorithm inherits the structure proposed by S. Graves and implements the collocation method based on the codes by A. McKay. The most significant modification when compared to their algorithms involves adding endogenous unemployment risk faced by households.

4 Results

We now use our model to analyze the role of labor market institutions in macroeconomic stability. We proceed in the following steps. First, by comparing the reactions to standard supply and demand disturbances in our baseline model with incomplete markets and in its full insurance variant, we highlight the propagation mechanism of shocks that operates through precautionary motives. Second, by comparing the impulse response functions under two alternative calibrations, we articulate the differences in adjustments in the US and the EA – two regions featuring distinct design of labor market institutions. Third, we study a hypothetical scenario under which the EA labor market institutions (firing costs and higher unemployment benefits) are embedded into the model calibrated to match the US economy. Fourth, we analyze the role of wage subsidies in mitigating the dire consequences of large negative shocks.

4.1 Comparison to the full-insurance benchmark

Before using the model to tease out the impact of labor market institutions, we briefly discuss the role of market incompleteness in driving our results, and in particular lack of perfect insurance against idiosyncratic unemployment risk. To this end, we compare the reaction of the US economy described by our benchmark model with heterogeneous agents to its full-insurance version. The latter can be obtained by setting the replacement rate of unemployment benefits $\mu = 1 - \tau$ so that the after-tax labor income is exactly the same for both employed and unemployed. In order not to mix up the cyclical consequences of market incompleteness with broader general equilibrium effects that would necessarily arise if agents were entirely isolated from idiosyncratic risk, we begin the counterfactual simulation from the steady state featuring labor income risk. This source of uncertainty is subsequently switched off, while keeping the remaining features of the economy intact, yielding the "pure" effects of removing idiosyncratic income uncertainty.

[2]See the codes attached to McKay and Reis (2016) and Graves (2017), respectively.

Figure 1: Incomplete vs complete markets

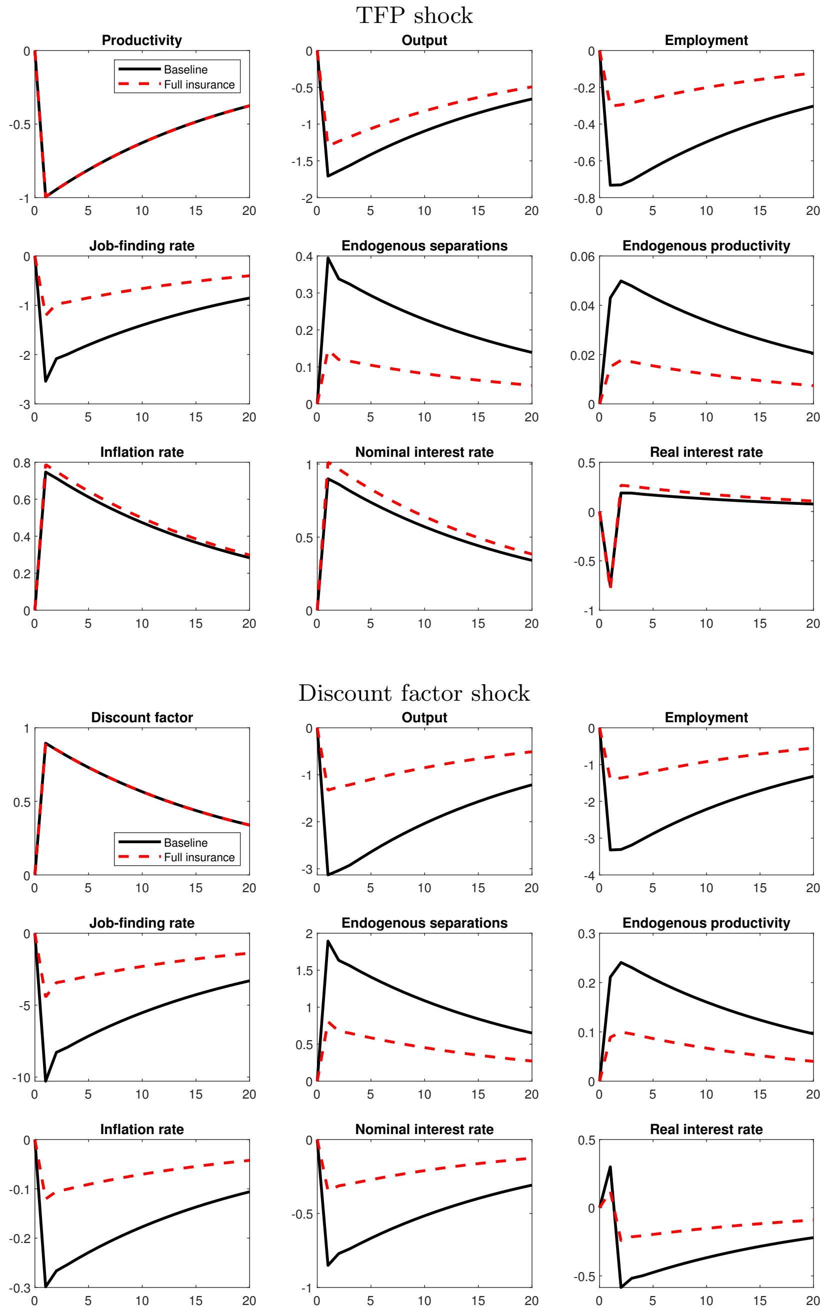


Figure 1 displays the results. The propagation of shocks through incomplete markets and precautionary motives is substantial and exhibits a similar degree of amplification for both productivity and demand shocks.[3] Specifically, the drop in employment driven by either lower productivity or

[3]Note that a relatively small distance between the output responses for the productivity shock can be attributed to the fact that this shock is a common and significant component directly affecting total product both in the model featuring complete and incomplete insurance markets.

lower demand in the economy with incomplete markets is almost 2.5 times larger on impact than the analogous reaction implied by the model with full insurance.

This exercise establishes a useful reference for the simulations conducted in the next subsections, where the potential ability of the EA labor institutions to mitigate the reaction of the US economy to shocks is examined. In particular, our aim will be to evaluate the extent to which a more generous unemployment insurance scheme, higher firing costs and wage subsidies can mitigate the consequences of adverse macroeconomic shocks.

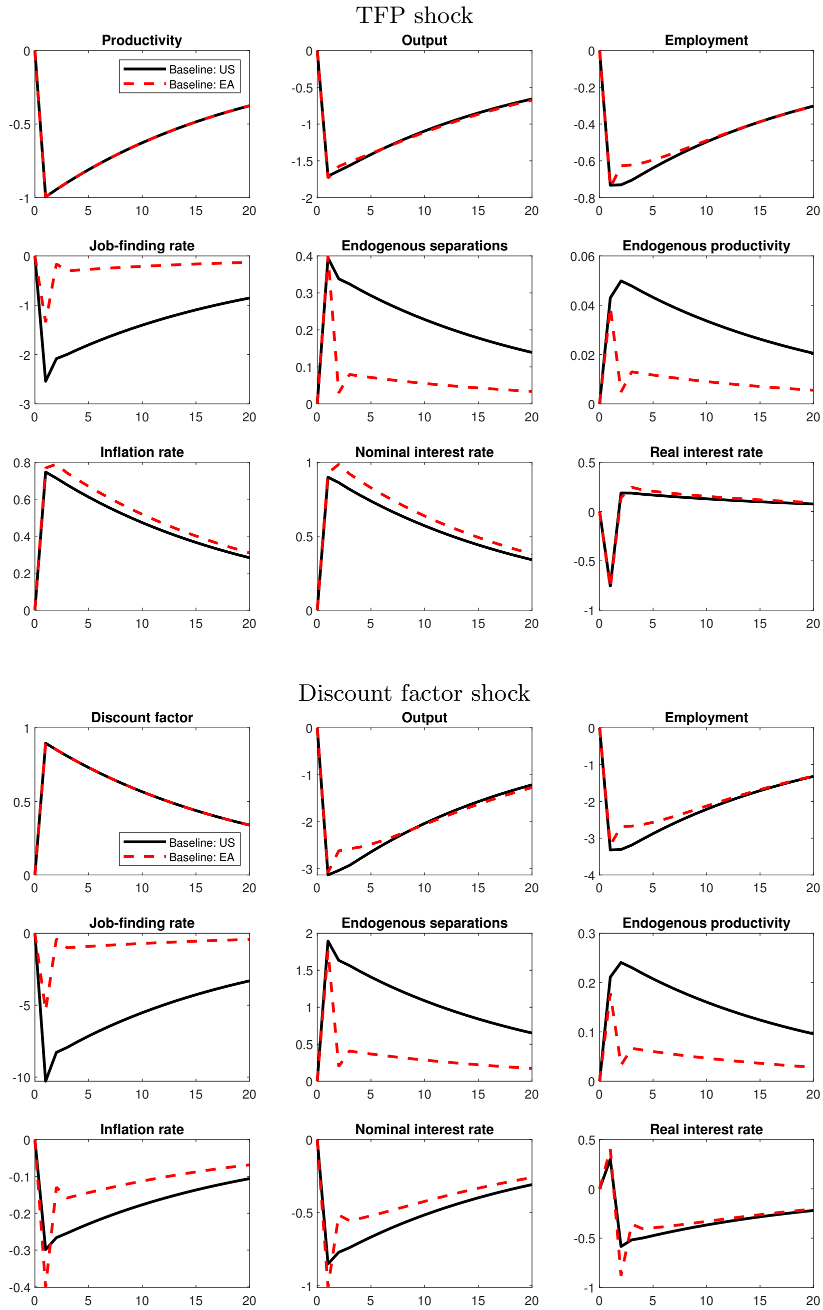
4.2 Shock transmission in the US and EA

We now compare how the transmission of the two types of shocks in our full model with uninsured unemployment risk differs between the US and EA calibration variants. The results are presented in Figure 2. The largest differences in reactions to the productivity shock pertain to labor market flows – both the drop in the job-finding rate and the rise in endogenous job-separations are less pronounced in the EA than in the US. These translate into a milder decrease in employment in the EA, which is in line with the logic underlying equation 9.

Note however that the difference in employment responses is rather small when compared to the reactions of job-finding rates and endogenous separations. This happens because both models feature different steady states and, in particular, different unemployment levels in the stationary equilibrium. This, in turn, implies that, although the reduction in the US job-finding rate in the US is larger than in the EA, its negative impact on employment is mitigated by the lower steady state unemployment level in the former economy.[4] As the rise in endogenous separations $F(\tilde{a})$ is higher in the US than in the EA, so is the increase in endogenous productivity $\bar{A}(\tilde{a})$. This effect almost entirely mitigates the negative impact of a more pronounced employment drop in the US on the US-EA output differential. As it is typically the case with transitory supply shocks, lower productivity leads to higher inflation, which increases a bit more under EA calibration compared to the US case. This together with a slightly lower fall in EA output leads to a stronger increase in this region's nominal interest rate.

[4] To isolate the impact of changes to labor flows on employment from the factors dependent on steady state differences between two economies, we conduct two counterfactual experiments in section 4.3.

Figure 2: Transmission of shocks: US vs EA



Let us turn to the effects of a discount factor shock. As a typical demand shock, it results in a drop in both inflation and output. Analogously to the analyzed responses to a TFP shock, the largest differences in reactions between EA and USA are related to labor market flows – the response of endogenous separations and job-finding rates are substantially lower in the EA than in the US. The former implies a milder increase in endogenous productivity while the latter leads to a less pronounced decrease in employment in the EA. Overall, and in contrast to the productivity shock, the impact of these developments on output does not cancel out, which results in a larger decrease in output for the US calibration.

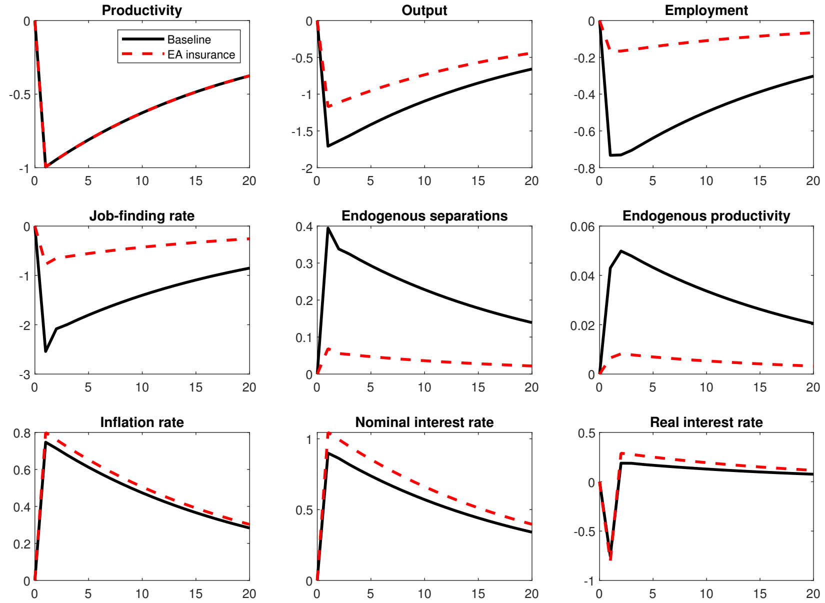
4.3 Counterfactual scenarios in the US

To preserve the comparability between the model calibrated to the US economy and its version in which some elements of the EA labor institutions setup will be embedded, we now assume that unemployment insurance μ_t and firing costs Δ_t in the US adjust to the level observed in the EA only transitorily in response to adverse macroeconomic shocks, reaching the EA level (of either μ or Δ) on impact and then decaying proportionally at the same rate as the considered adverse macroeconomic shock. By proceeding this way, we avoid a comparison of two models featuring different stationary equilibria, which would occur if also the EA average levels of either μ_t or Δ_t were changed.

Let us start with the impact of cyclically adjusting unemployment benefits, such that they reach the EU level at the maximum impact of an adverse shock. Figure 3 shows that higher unemployment insurance effectively mitigates the consequences of a drop in productivity. In particular, it reduces the fall in employment by almost four times, making it even shallower than in the model with complete markets (compare Figure 1). This can be somewhat surprising, because a rise in unemployment benefits in response to a contraction in productivity does not eliminate unemployment risk and the associated precautionary motives. It provides, however, an additional stimulus by directing transfers to the unemployed, who feature relatively high levels of marginal propensities to consume (MPC), which substantially boosts aggregate demand.

Figure 3: EA unemployment benefits in US

TFP shock



Discount factor shock

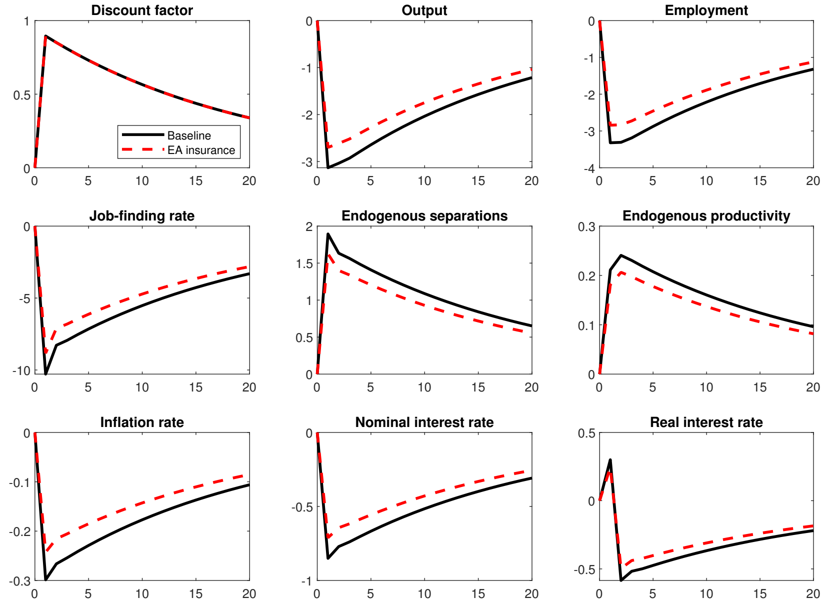
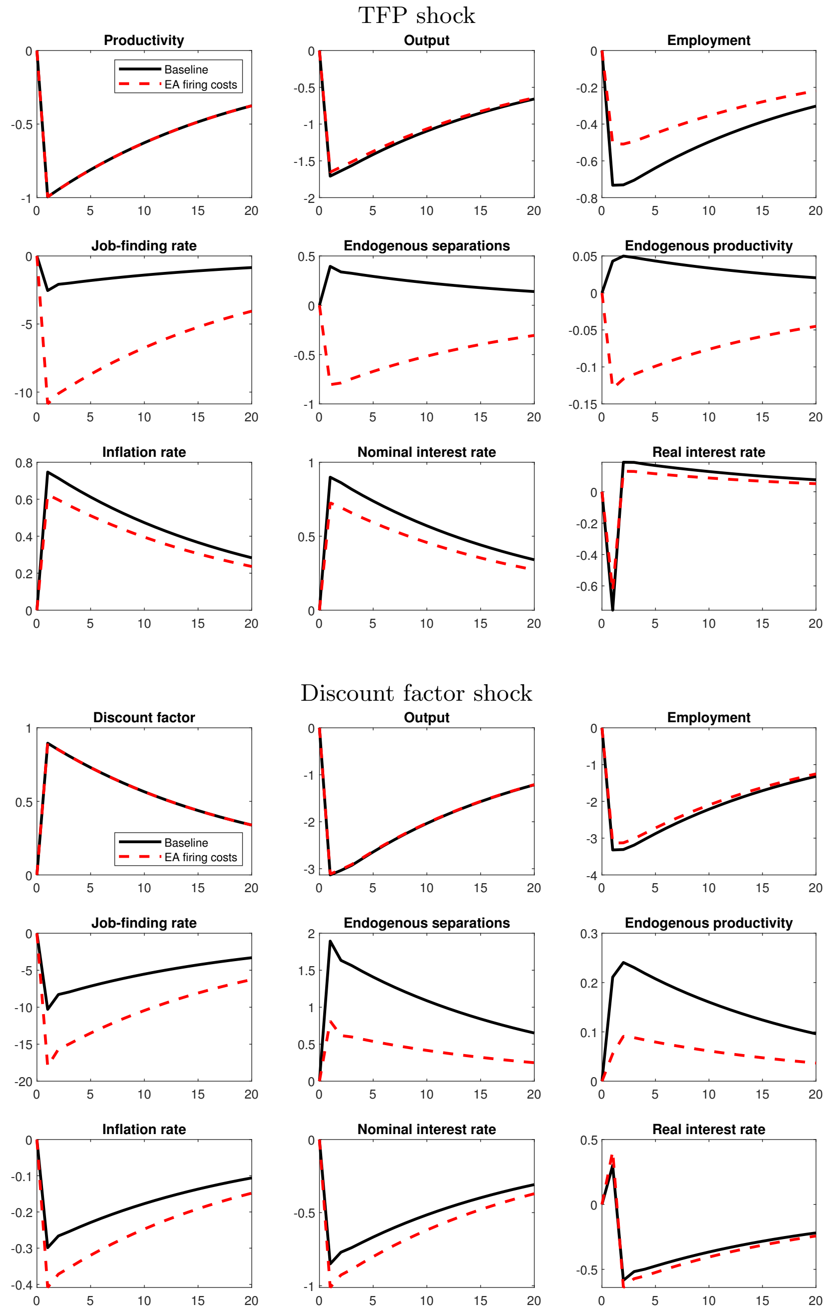


Figure 4: EA firing cost in US



Note that the difference between the US benchmark and the counterfactual is not that substantial in the case of a demand shock. This occurs because higher discount factors incentivize agents to save rather than spend. As a consequence, MPC levels fall across agents and, in particular, among the unemployed. As a result, stimulative effects of a rise in unemployment insurance are curbed.

The impact of a transitory rise in firing costs (reaching the EA level at the peak) is displayed in Figure 4. Note that, although the employment response to a negative productivity shock is less pronounced in the counterfactual scenario than in the benchmark, the dynamics of output is barely affected. This occurs due to the behavior of labor market flows: while the rise in firing costs implies a larger drop in the job-finding rates, it also lowers the rate of endogenous separations. To put it differently, an increase in firing cost leads to labor hoarding and a decreased creation of new jobs. The overall effect of those two opposite forces on employment is positive but, given that firms limit separations, the average productivity of workers drops. As a result, the reaction of output does not differ substantially between the counterfactual and the benchmark.

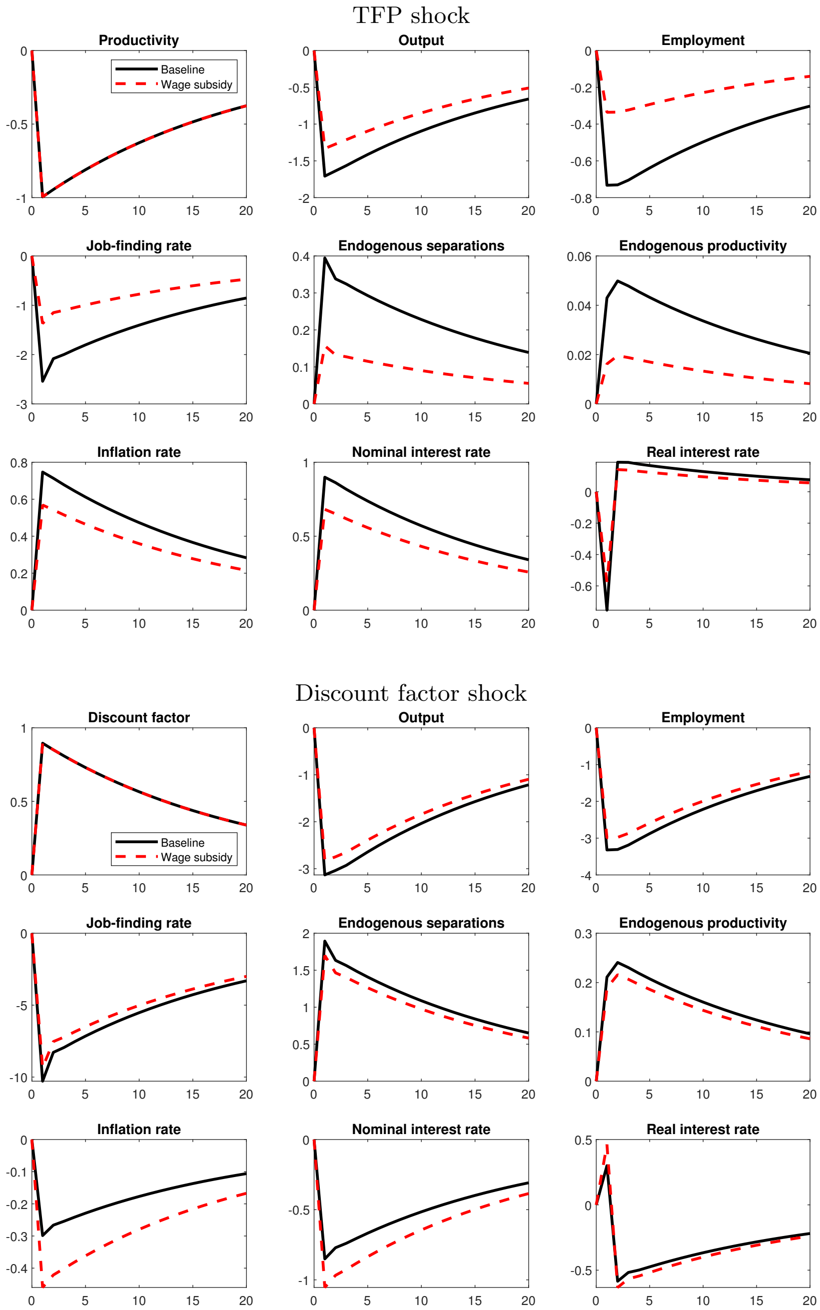
4.4 Wage subsidies

Let us now turn to the analysis of temporary wage subsidies. This type of policy was implemented in several countries (Ireland, New Zealand) in response to the COVID-19 pandemic, and should not be confused with other types of publicly financed programs preventing massive layoffs by firms during the crisis.[5]

More concretely, in this experiment we assume that, when a negative macroeconomic shock arrives, wage subsidies rise to 25% and then decay at the same pace as the underlying shock. Figure 5 shows that wage subsidies are significantly more effective in combating the adverse consequences of productivity shocks compared with demand shocks. This is because they are a particularly well-tailored instrument to mitigate the effects of the former: wage subsidies decrease the effective wage paid by firms to workers, thus absorbing the impact of lower labor productivity. This leads to a much smaller adjustment along the endogenous separations margin as it remains viable for firms to keep individuals with lower productivity employed.

[5]One example of alternative policies, particularly popular in Europe, were the short-time work schemes. Dengler and Gehrke (2021) investigate the working of this type of policy in a general equilibrium model with a no-borrowing constraint imposed for tractability.

Figure 5: Wage subsidies



5 Conclusions

The fast growing HANK literature has stressed the role of uninsurable idiosyncratic income shocks in monetary transmission and business cycle fluctuations. In this paper we have shown that unemployment risk has also important implications for the macroeconomic impact of labor market institutions. It is well understood that the presence of some of these institutions, like employment protection legislation and unemployment benefits, might have negative consequences for labor market functioning. However, especially when adjusted cyclically, they can reduce individual unemployment risk, hence stabilizing the business cycle. Our analysis suggests that these stabilization gains can be large.

HANK models are complicated objects and are typically solved by taking first-order approximation around the stationary equilibrium. In this way, the model cannot account for the effect of aggregate volatility, and hence LMIs on the means of key macroeconomic variables. We hope that further methodological advancements in this class of models will soon make such an analysis feasible.

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