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ABSTRACT

A Tractable HANK (THANK) model with three agents, incomplete markets, unemployment and sticky prices and wages, is used to analyze the dynamics, welfare and distributional effects of Ramsey-optimal unemployment insurance (UI) policies. First, the optimal transition from a steady state that replicates several empirical regularities of the European labor market to the Ramsey steady state is analyzed. In the long run, the vacancy creation motive dominates, as the replacement rate falls, lowering the unemployment rate. In the short run however, the insurance motive dominates until unemployment falls enough to generate larger welfare gains from a lower unemployment rate. Over the business cycle around the Ramsey- optimal steady state, we find that the optimal changes in the replacement rate depend (i) on the nature of the shock and (ii) on the presence of price and wage rigidities. After productivity shocks, the vacancy creation motive dominates. After separation shocks, the planner has almost no traction over vacancy creations. Only the insurance and aggregate demand stabilization motives remain, and both point to a counter-cyclical UI policy.

KEYWORDS

Unemployment, Borrowing constraints, Incomplete markets, Unemployment Insurance.

JEL

D52, E21, E62, J64, J65.

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Stéphane Auray[†] Aurélien Eyquem[‡]

April 5, 2022

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1 Introduction

Unemployment remains a major issue in most developed economies, especially in the event of large economic downturns. The dynamics of the labor market during the recent Great Recession was particularly important in determining the dynamics of aggregate variables. The same should be true for the macroeconomic dynamics resulting from the Covid-19 pandemic episode and the associated lockdown policies. In face of unemployment risk, how should unemployment insurance be designed? What should be its level, should it vary along the business cycle, and if so how and by how much? On the one hand, many contributions on the subject either assume full risk-sharing among a large family, in the spirit of Merz (1995) or Andolfatto (1996), but in this case there is no income risk to insure in the first place. On the other hand, the Baily-Chetty literature recently summarized by Landais, Michaillat, and Saez (2018) does not incorporate important macroeconomic and labor-market assumptions such as sticky prices or wages and thus neglects the potential importance of monetary policy in shaping unemployment risk. Last, we are unaware of any contribution contrasting the optimal transition path towards an optimal steady state level of UI benefits, which happens to feature contrasting dynamics in the short run and in the long run.

We analyze the design, macroeconomic effects and redistributive properties of optimal unemployment insurance (UI) benefits in a model with incomplete markets, unemployment risk, sticky prices and wage rigidity. A recent and dense macroeconomic literature burgeoned to incorporate microeconomic heterogeneity and risk in tractable macroeconomic environment featuring otherwise standard New Keynesian features such as sticky prices.[1] Some of these contributions specifically focus on fiscal policy.[2] But to the best of our knowledge, only Kekre (2021) investigates the effects of an extension in UI benefits in a HANK model, with a focus on the key role of the zero lower bound. However, as opposed to the present paper, his approach is positive more than normative.

The model is a simplified heterogeneous-agent model based on Ravn and Sterk (2017) with unemployment risk to investigate the design of (Ramsey) optimal UI policies. It considers a zero-liquidity economy, imperfect insurance, sticky prices and wages, and search and matching frictions on the labor market. It also features a UI system where unemployed workers receive a fraction of the equilibrium real wage. The key policy instrument is this fraction, the replacement rate, in addition to the nominal interest rate that captures the potency of monetary policy. The UI system is financed using distortionary taxes on labor income, paid by employed workers. The main interest of the zero-liquidity limit is that the distribution of wealth is degenerate and the model boils down to only three types of agents while preserving strong effects of unemployment

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[1] Among many others, see Gornemann, Kuester, and Nakajima (2016), Kaplan, Moll, and Violante (2018), Auclert (2019), Bhandari et al. (2021) for environment with non-degenerate wealth distributions, and Bilbiie (2018), Ravn and Sterk (2021), Challe (2019) for more tractable environments.

[2] See Challe and Ragot (2011), Albertini et al. (2021), Auclert, Rognlie, and Straub (2018), Bayer, Born, and Luetticke (2020) or Hagedorn, Manovskii, and Mitman (2019).

risk on the aggregate dynamics through precautionary savings.[3] As such, it offers an explicit relation between unemployment dynamics, unemployment risk and aggregate demand, with feedback general equilibrium effects through sticky prices and wages.

First, the baseline version of our model is calibrated to match data about the European labor market as well as key business cycle moments. Second, (Ramsey) optimal UI policies are computed in the form of (*i*) the optimal transition from the initial steady state to the Ramsey steady state and (*ii*) the optimal response to large productivity and separation shocks around the new (Ramsey) steady state. The literature on optimal UI systems usually highlights two opposing motives for the planner when setting the replacement rate or the level of UI benefits: the insurance motive and the vacancy creation motive. In our model, an additional motive arises through the presence of sticky prices: the aggregate demand stabilization motive. The latter can be handled through monetary policy or, if monetary policy is restricted to follow a Taylor rule, by the level of UI benefits, used to sustain aggregate demand.

In the long run, an optimal reform of the UI system involves setting a *lower* replacement rate. This leads to a lower level of unemployment by raising the outside option of workers and compressing the real wage, to a lower labor income tax rate and to aggregate consumption and output gains. In addition, the composition effect by which more workers are employed and thus consume more is an important driving force of this long-run equilibrium. Further, the consumption losses of unemployed workers are more than compensated by the consumption gains of employed workers and firm owners.

In the short run however, the planner chooses to *raise* the replacement rate. On the one hand, it stimulates aggregate demand by raising directly the consumption of unemployed and indirectly (through the real wage) the consumption of employed workers, since those are hand-to-mouth. This is akin to the aggregate demand stabilization and the insurance motive. On the other hand, firm owners (firms) optimize intertemporally through the marginal value of a job filled, and create more jobs today or after a few periods, taking into account the commitment of the planner to lower future real wages permanently. The aggregate demand and insurance motives dominate until the unemployment rate falls enough for the aggregate welfare gains from a lower replacement rate to outweigh the aggregate gains from a larger replacement rate. As a consequence of those short-run dynamics, the aggregate welfare gains from the Ramsey-reform along the transition are larger than the welfare gains measured from steady state to steady state. Workers (employed or not) enjoy larger gains or suffer lower losses while firm owners experience lower gains. Finally, price and wage rigidities matter quantitatively but not qualitatively for the short-run effects of the optimal transition: price and wage stickiness call for a stronger weight put by the planner on aggregate demand and insurance in the short run, and thus for a larger initial increase in UI benefits.

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[3] A by-product of the zero-liquidity limit is that all workers end-up being hand-to-mouth: unemployed workers because they are financially constrained, and employed workers as an equilibrium result, since their demand for precautionary savings is not matched with any corresponding supply of asset in equilibrium.

Finally, the optimal responses to macroeconomic shocks hitting around the Ramsey steady state are investigated. We consider two types of large negative shocks: productivity shocks and separation shocks. Both shocks are usually seen as important drivers of the business cycle: productivity shocks are the traditional driver in the literature while separation shocks have recently been considered important contributors to the two most recent crises, namely the Great Recession (see Auray, Eyquem, and Gomme (2019) or Ravn and Sterk (2017)) and the recession related to the Covid-19 Coronavirus (see Auray and Eyquem (2020)). After productivity shocks, we find that the optimal UI policy is pro-cyclical when wages are sticky, and almost a-cyclical and muted when wages are flexible. With sticky wages, the planner has strong leverage on the unemployment rate through vacancy creations, and uses the level of UI benefits to come closer to flexible-wage allocations. This implies lowering the replacement rate by several percentage points in the event of large negative productivity shocks. After positive separation shocks, vacancies have virtually no effects on the unemployment rate since the latter is almost entirely driven by separations. The insurance and aggregate demand motives dominate and the replacement rate is counter-cyclical. Feeding the model with random productivity and separation shocks and running fully non-linear simulations reveals that most of the welfare gains from optimal policies stem from the steady-state level of the replacement rate. The net business cycle gains from optimal policies represent 1/3 of total welfare gains at most.

Literature. In the literature, the analysis of optimal UI policies is usually considered to start with Baily (1978) and Chetty (2006). More recent studies such as Landais, Michaillat, and Saez (2018) and Mitman and Rabinovich (2015) find that optimal UI benefits should be counter-cyclical, at least in the short-run and based on US estimations/calibrations. In particular, the latter show that the trade-off faced by the Ramsey planner between the vacancy creation motive and the insurance motive can be non-monotonic after a persistent negative productivity shock. The insurance motive dominates on impact – UI benefits should rise above their steady-state value – and the vacancy creation motive dominates in the medium run. Le Grand and Ragot (2022) develop a truncation method and apply it to optimal UI policy in a model with exogenous unemployment risk that abstracts from sticky prices or search and matching frictions, and find it to be counter-cyclical. Birinci and See (2020) study the optimal UI policy over the business cycle using a model with heterogeneous agents, job-search, aggregate risk and incomplete markets. They find that replacement rates should be counter-cyclical, with longer average durations than the current US system. McKay and Reis (2021) analyze the design of optimal automatic stabilizers (and progressive taxation), but only focus on the effects of the average replacement rate on macroeconomic stabilization. In line with our results, they find that a lower steady-state replacement rate helps households better smooth consumption through precautionary savings. Den Haan, Rendahl, and Riegler (2017) show that the interaction between incomplete markets and sticky wages amplifies the effect of productivity shocks through deflationary spirals. They abstract from considering an optimal level or response of the replacement rate though. Other studies, such as Jung and Kuester (2015) and Kekre (2021) focus on crisis environments, where the crisis is either generated by productivity or discount factor shocks. While Jung and Kuester (2015) find little role for changes in the level of UI benefits in a framework with several other instruments, Kekre (2021) focuses on the (positive and large) multiplier effect of a rise in the level of unemployment benefits when agents are heterogeneous and prices are sticky.

Our paper differs from the above contributions along several dimensions. First, to the best of our knowledge, it is the first to characterize the transition resulting from an optimal reform of UI. Second, the analysis considers sticky prices and wages, allowing for a stronger role for the dynamics of aggregate demand induced by unemployment and unemployment risk. Those clearly alter the optimal dynamics of UI benefits in response to shocks. Sticky prices shift the trade-off faced by the planner towards the insurance and aggregate demand motives after separation shocks, and sticky real wages shift it towards the vacancy creation motive after productivity shocks. Third, it considers separation shocks on top of productivity shocks. Their potential role as drivers of the two most recent crises, the Great Recession and the Covid-19 recession, have been emphasized in the literature, and our results show that they have quite different dynamic implications for the dynamics of optimal UI benefits.

The paper is organized as follows. The baseline model is described and discussed in Section 2. Section 3 calibrates the model and characterizes its business cycle properties. Section 4 discusses the design of (Ramsey) optimal UI benefits policies in the steady state and characterizes the optimal transition. Section 5 analyzes the optimal responses to a large negative shock, and discusses the role of nominal rigidities. Finally, Section 6 discusses the business cycle and welfare implications of optimal UI policies and Section 7 offers some conclusions.

2 Model

The model structure borrows from Ravn and Sterk (2017) and features three types of households: employed workers, unemployed workers and firm owners. As will be clear, unemployed workers are financially constrained while employed workers hold zero assets as an equilibrium result. Firm owners receive profits, consume and hold government bonds. The rest of the model is a standard search and matching framework with (sticky) Nash-bargained wages. Finally, a government sector is introduced, that levies distortionary taxes on labor income and issues one-period bonds to finance UI benefits.

2.1 Households

The economy is populated with a unit size continuum of households: a proportion $\chi \in [0, 1]$ of workers that can either be employed or not, and a proportion $(1 - \chi)$ of firm owners receives profits from intermediate-good producers and retailers. Workers are excluded from the market of government bonds but potentially have access to a private asset to save.

Workers. There is a measure χ of workers in the household sector. Worker $i = \{e, u\}$ maximizes its lifetime log-utility:

$$\mathrm{E}_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \log \left(c_s^i \right) \right\} \tag{1}$$

where β is the common subjective discount factor and $c_t^i > 0$ the individual level of private consumption of worker i. Its budget constraint is:

$$a_t^i + c_t^i = (1 + r_{t-1})\, a_{t-1}^i + \varepsilon_t^i (1 - \tau_t)\, w_t + \left(1 - \varepsilon_t^i\right) b_t,\ a_t^i \geq 0 \tag{2}$$

where a_t^i is the individual level of private wealth and r_{t-1} its return between period $t-1$ and t. Variable $\varepsilon_t^i = \{0, 1\}$ defines the employment status of the worker: when $\varepsilon_t^i = 1$, the worker is employed at the real wage w_t; when $\varepsilon_t^i = 0$, the worker is unemployed and receives $b_t = \delta_t w_t$, where δ_t is the replacement rate of UI benefits. The wage income is taxed at the rate τ_t while UI benefits are exempted. The proportion of employed workers among workers n_t and the rate of unemployment u_t are related by

$$n_t + u_t = 1 \tag{3}$$

At the beginning of period t, an exogenous proportion s_t – following an AR(1) process subject to iid shocks – of past employment relationships are destroyed and the pool of unemployed workers within the period is $u_{t-1} + s_t n_{t-1}$. A fraction f_t of this pool becomes employed before the end of period t. The proportion of employed workers is thus given by:

$$n_t = (1 - s_t)\, n_{t-1} + f_t \left(u_{t-1} + s_t n_{t-1}\right) = (1 - \sigma_t)\, n_{t-1} + f_t \left(1 - n_{t-1}\right) \tag{4}$$

where we have used $u_t = 1 - n_t$ and defined $\sigma_t = s_t (1 - f_t)$ as the net separation rate, s_t being the gross separation rate. Alternatively, the dynamics of the unemployment rate is

$$u_t = (1 - f_t)\, u_{t-1} + \sigma_t \left(1 - u_{t-1}\right) \tag{5}$$

The matching function is:

$$m_t = \psi \left(u_{t-1} + s_t n_{t-1}\right)^{\gamma} v_t^{1-\gamma} \tag{6}$$

where ψ is a matching-efficiency parameter. It implies that the job-finding rate $f_t \in [0, 1]$ and the worker-finding rate $q_t \in [0, 1]$ are respectively:[4]

$$f_t = \psi \left(\frac{v_t}{u_{t-1} + s_t n_{t-1}} \right)^{1-\gamma} = \psi \theta_t^{1-\gamma} \text{ and } q_t = \psi \left(\frac{u_{t-1} + s_t n_{t-1}}{v_t} \right)^{\gamma} = \psi \theta_t^{-\gamma} \tag{7}$$

where $\theta_t = v_t / \left(u_{t-1} + s_t n_{t-1}\right)$ denotes the extent of labor-market tightness. From the perspective

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[4] The bounds for f_t and q_t imply in particular that $v_t \geq 0$, a constraint that might become relevant in the case of very large shocks. See Petrosky-Nadeau and Zhang (2021) for a detailed discussion.

of a currently employed workers, the Euler equation on the private asset writes:

$$\mathrm{E}_t \left\{ \beta \left(1 + r_t\right) \frac{\left(1 - \sigma_{t+1}\right) / c_{t+1}^{i=e} + \sigma_{t+1} / c_{t+1}^{i=u}}{1 / c_t^{i=e}} \right\} \leq 1 \tag{8}$$

where $\sigma_t = s_t \left(1 - f_t\right)$ is the transition probability from employment to unemployment at the end of period t, $c_t^{i=e}$ and $c_t^{i=u}$ respectively denote the individual consumption level of a worker if employed or not. The above equation holds with equality when employed worker i is not constrained financially, and with inequality when she is constrained. If the private asset is in zero net supply – which is the case in general equilibrium – employed workers hold exactly zero private assets ($a_t^{i=e} = 0$) as an equilibrium result, and Equation (8) holds with equality. As a result, the distribution of wealth is degenerate, and all employed workers share the same per-capita level of consumption

$$c_t^{i=e} = c_t^e = \left(1 - \tau_t\right) w_t \tag{9}$$

Further, given that $\sigma_t > 0$ and $u_c\left(c_{t+1}^e\right) = 1/c_{t+1}^e < u_c\left(c_{t+1}^u\right) = 1/c_{t+1}^u$ since the consumption of employed workers is larger on average than the consumption of unemployed workers, a precautionary motive arises due to the risk of unemployment. Employed workers face a potentially decreasing future consumption schedule that pushes them to save to self-insure. However, because they can not precautionary-save since the private asset is in zero net supply, the excess asset demand is entirely reflected in a lower real interest rate. From the perspective of unemployed workers, the Euler equation holds with strict inequality and writes:

$$\mathrm{E}_t \left\{ \beta \left(1 + r_t\right) \frac{\left(1 - f_{t+1}\right) / c_{t+1}^{i=u} + f_{t+1} / c_{t+1}^{i=e}}{1 / c_t^{i=u}} \right\} < 1 \tag{10}$$

which means that they are constrained, and therefore share an identical level of per-capita consumption

$$c_t^{i=u} = c_t^u = b_t = \delta_t w_t \tag{11}$$

Firm owners. The household sector also comprises $(1 - \chi)$ firm owners. Since they are not exposed to idiosyncratic risk, they hold the same amount of private assets. They invest in vacancies, own the retailers and receive the resulting profits denoted Π_t. They maximize their lifetime utility:

$$\mathrm{E}_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \frac{\left(c_s^f\right)^{1-\rho} - 1}{1 - \rho} \right\} \tag{12}$$

where c_t^f denotes their per-capita consumption level, subject to the following aggregate resource constraint:

$$a_t^f + \left(1 - \chi\right) c_t^f = \left(1 + r_{t-1}\right) a_{t-1}^f + \Pi_t, \; a_t^f \geq 0 \tag{13}$$

The corresponding Euler equations is:

$$\mathrm{E}_t \left\{ (1 + r_t) \Delta_{t,t+1} \right\} \leq 1 \tag{14}$$

where $\Delta_{t,t+1} = \beta \left(c_t^f / c_{t+1}^f \right)^\rho$ is the stochastic discount factor of firm owners. Because firm owners invest in vacancies with a higher return than r_t, they would like to borrow in private assets but can not due to the borrowing constraint. Their Euler equation thus holds with strict inequality and, as a result, they hold exactly zero private assets in equilibrium, $a_t^f = 0$, which implies:

$$c_t^f = \Pi_t / (1 - \chi) \tag{15}$$

2.2 Production and wage determination

As in the search and matching literature, each firm is a job. Firms invest in $v_t \geq 0$ vacancies, paying an exogenous unit vacancy cost κ out of which a fraction q_t will be filled to produce goods with a linear technology. The aggregate production function is thus:

$$y_t = \chi n_t z_t \tag{16}$$

where z_t the level of productivity that follows an AR(1) processes subject to iid shocks. Given that the intermediate good is sold on competitive markets at price φ_t, the marginal value of a filled position is:

$$J_t = \varphi_t z_t - w_t + \mathrm{E}_t \left\{ \Delta_{t,t+1} \left((1 - s_t) J_{t+1} + s_t V_{t+1} \right) \right\} \tag{17}$$

where the first argument is the net contribution of the marginal worker, his marginal product less his wage bill, and the second argument is the continuation value. The marginal value of a position remaining vacant is:[5]

$$V_t = -\kappa + q_t J_t + \mathrm{E}_t \left\{ \Delta_{t,t+1} (1 - q_t) V_{t+1} \right\} \tag{18}$$

and we assume that the free entry condition $V_t = 0$ holds, which implies $q_t J_t = \kappa$.[6] The real wage is sticky in the sense that the effective real wage is an average of the past real wage and the (notional) Nash-bargained wage:

$$w_t = \alpha w_{t-1} + (1 - \alpha) w_t^* \tag{19}$$

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[5] Since vacancies can be filled within the period, the current value of a vacancy depends on the current probability of the vacancy to be filled and the current value of a job filled.

[6] A shown in details by Petrosky-Nadeau and Zhang (2021), taking into account the positivity constraint on vacancies, $v_t \geq 0$, implies that the exact free-entry condition writes $\max(v_t, 0)(q_t J_t - \kappa) = 0$.

The notional real wage w_t^* is determined as the solution to a Nash bargaining problem. It maximizes a geometric average of workers and firm job surpluses:

$$w_t^* = \max_{w_t} S_t^{\theta} J_t^{1-\theta}, \; S_t > 0, J_t > 0 \tag{20}$$

where θ is the bargaining power of workers, and S_t expresses the marginal value of being employed:

$$S_t = \max\left(\log\left((1-\tau_t)\, w_t\right) - \log\left(b_t\right) + \beta \mathrm{E}_t \left\{(1-\sigma_{t+1} - f_{t+1})\, S_{t+1}\right\}, 0\right) \tag{21}$$

where, remember, $\sigma_t = s_t\left(1 - f_t\right)$. The solution to this problem implies:

$$w_t^* = \varphi_t z_t + \mathrm{E}_t \left\{\Delta_{t,t+1}\left(1-s_t\right)\kappa / q_{t+1}\right\} - \frac{\left(1-\theta\right) S_t}{\theta\left(1-\tau_t\right)/c_t^e} \tag{22}$$

Retailers buy the intermediate good y_t and then differentiate it into varieties ω to sell them at nominal price $p_t\left(\omega\right)$. Let y_t^d denote the total demand for final goods and $y_t^d(\omega)$ the demand for variety ω. Retailer ω sets its price $p_t\left(\omega\right)$ to maximize the discounted sum of its expected dividends:

$$\mathrm{E}_t \left\{ \sum_{s=t}^{\infty} \Delta_{t,s} \left(\frac{p_s\left(\omega\right)}{p_s} - \varphi_s - \frac{\phi}{2} \left(\frac{p_s\left(\omega\right)}{p_{s-1}\left(\omega\right)} - 1 \right)^2 \right) y_s^d\left(\omega\right) \right\} \tag{23}$$

The demand for each variety depends on aggregate demand, on the relative price of good ω and on the elasticity of substitution between varieties $\eta > 1$, *i.e.* $y_t^d\left(\omega\right) = \left(p_t\left(\omega\right)/p_t\right)^{-\eta} y_t^d$. We denote ϕ as the size of Rotemberg adjustment costs. Optimal pricing conditions are symmetric in equilibrium and imply the following New Keynesian Phillips Curve:

$$\eta - 1 = \eta \varphi_t - \phi\left(\pi_t(1+\pi_t) - \mathrm{E}_t\left\{\Delta_{t,t+1}\pi_{t+1}(1+\pi_{t+1}) y_{t+1}/y_t\right\}\right) \tag{24}$$

where $\pi_t = p_t/p_{t-1} - 1$ is the net inflation rate. Finally, total (intermediate and final) profits distributed to firm owners are:

$$\Pi_t = y_t\left(1 - \phi\pi_t^2/2\right) - \chi n_t w_t - \kappa_t v_t \tag{25}$$

2.3 Government, monetary policy, aggregation and equilibrium

The government provides UI to the unemployed workers with a replacement rate δ_t and finances this stream of expenditure using the labor income tax τ_t:

$$\tau_t n_t = \delta_t u_t \tag{26}$$

In the subsequent analysis, the UI replacement rate δ_t is the key policy instrument. Further, the nominal interest rate on private assets i_t is either set according to the following simplified

Taylor-type rule:

$$\begin{aligned} i_t &= \max\left(i_t^*, 0\right) & (27) \\ \log\left(\frac{1+i_t^*}{1+i}\right) &= \rho_i \log\left(\frac{1+i_{t-1}^*}{1+i}\right) + (1-\rho_i)\, d_\pi \log\left(\frac{1+\pi_{t+1}}{1+\pi}\right) & (28) \end{aligned}$$

or determined optimally by the Ramsey planner. The real rate of return on private assets is determined according to the following Fisher equation:

$$1 + r_t = \mathrm{E}_t \left\{ (1 + i_t) \,/\, (1 + \pi_{t+1}) \right\} \tag{29}$$

Finally, the market clearing condition on the market for final goods and services is:

$$y_t \left(1 - \phi \pi_t^2 / 2\right) = \chi \left(n_t c_t^e + u_t c_t^u\right) + (1 - \chi)\, c_t^f + \kappa v_t \tag{30}$$

A competitive equilibrium in this economy is defined as a situation where, for a given path of the replacement rate of UI benefits and the nominal interest rate $\{\delta_t, i_t\}_{t=0}^{\infty}$: (*i*) for a given path of prices, households's first-order conditions and budget constraints hold, firms and retailers optimize, and the government budget constraint holds, and (*ii*) for a given path of quantities, prices adjust – subject to Rotemberg costs – so that all markets clear and the wage rule holds.

3 Calibration

We calibrate the model so that its initial steady state and dynamics with a Taylor monetary policy rule and a constant replacement rate on UI benefits replicates key steady-state and business cycle features of the average Euro Area economy when driven by productivity and separation shocks.

Calibration for the households. The model is quarterly. The discount factor is $\beta = 0.9875$. Given the precautionary motive implied by the presence of unemployment risk, employed workers would like to self-insure and therefore demand more private assets than in a perfect-insurance economy. Since private assets are in zero net supply, the resulting excess demand of private assets is reflected in a lower equilibrium real interest rate – $r = 0.4\%$ quarterly, around 1.5% – than the interest rate implied by the discount factor alone, that is $r = 0.4\% < 1/\beta - 1 = 1.27\%$. In the initial steady state, we set the value of the replacement rate at $\delta = 0.75$ (close to Esser et al. (2013)) which then implies adjusting the labor income tax to $\tau = 6.17\%$. These numbers imply that the income and consumption drop upon job loss is 20%, which lines up with the results of Saporta-Eksten (2014), the discussion in Den Haan, Rendahl, and Riegler (2017) or more recently Bertheau et al. (2022). As in Challe et al. (2017), who propose a model with a comparable structure of the household sector, we set the share of firm owners to 10%, that is $\chi = 0.9$.

Calibration for firms and monetary policy. We set the steady-state monopolistic competition markup of retailers to 25%, implying $\eta = 5$. This value belongs to the lower bound of recent mark-up estimations for a subset of European countries proposed in a study by the Bundesbank (2017). In addition, the Rotemberg parameter is set to $\phi = 80$. For the parameters of the Taylor-type rule, we follow Christoffel, Kuester, and Linzert (2009), who rely on the estimates of Smets and Wouters (2003), and set the elasticity of the nominal rate to inflation at $d_\pi = 1.5$, and the persistence parameter at $\rho_i = 0.85$.

Calibration for the labor market. On the labor market, we also seek to replicate key Euro Area numbers. The elasticity of matches with respect to unemployment is set to $\gamma = 0.7$, which is the upper bound of the range of estimates proposed by Pissarides and Petrongolo (2001). Based on the labor-market transition probabilities estimated by Elsby, Hobijn, and Şahin (2013), we impose a net separation rate of $\sigma = s(1 - f) = 0.015$ and adjust the job-finding rate to deliver a 7.6% unemployment rate as reported by the AWM database in December 2019, implying $f = 0.1823$. We impose a steady-state worker-finding probability of $q = 0.8$ to match the observed job-vacancy rate $v/(v + n)$ in European data of 2.2% in 2019Q4. This probability is close to the number suggested by Christoffel, Kuester, and Linzert (2009) and references therein. This transition probability, together with the targeted unemployment rate, implies adjusting the matching efficiency parameter to $\psi = 0.2841$. Finally, the steady-state vacancy posting cost parameter κ remains to be pinned down. Along with the rest of the calibration – the worker-finding probability q in particular – it determines the bargaining power of workers θ. We set $\kappa = 0.488w$ – vacancy costs represent slightly less than half the quarterly wage, well in line with Hagedorn and Manovskii (2008). It implies a bargaining power $\theta = 0.6391$, just below the elasticity of matches to unemployment $\gamma = 0.7$.

Shocks and business cycle moments. The remaining parameters are estimated using the Simulated Method of Moments: we set the degree of wage stickiness α, the risk-aversion parameter of firm owners ρ_f, the AR(1) parameters of the shock processes $\{\rho_z, \rho_s\}$ and the standard deviation of innovations $\{\sigma_z, \sigma_s\}$ so as to the volatility, persistence and correlation with output of key variables:[7] output y_t, the real wage w_t, the rate of unemployment u_t and vacancies v_t. The business cycle moments are computed on times series of the Euro Area as a whole, taken from the AWM and OECD databases.[8] The model is solved up to a second-order approximation using perturbation methods around the initial steady state with a constant replacement rate of UI benefits $\delta_t = \delta$, and fed with random productivity and separation shocks. Both shocks are usually seen as important drivers of the business cycle: productivity shocks are the traditional driver in the literature while separation shocks have recently been considered important contributors to the two most recent crises, namely the Great Recession (see Ravn and Sterk (2017) or Auray, Eyquem, and Gomme (2019)) and the recession due to the Covid-19 Coronavirus (see Auray and Eyquem (2020)). We obtain the following parameter values $\alpha = 0.9846$, $\rho = 2.3443$, $\rho_z = 0.8244$,

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[7] The SMM involves minimizing the squared distance of the vector of theoretical moments with observed moments using an optimal weighting matrix based on the variance-covariance matrix of moments in the data, corrected for autocorrelation and heteroscedasticity using the Newey-West method.

[8] See Table 1 for a description of the data.

Table 1: Business cycle moments.

	Data			Model		
$\downarrow x$	$\frac{\sigma(x)}{\sigma(y)}$	$\rho(x)$	$\rho(x,y)$	$\frac{\sigma(x)}{\sigma(y)}$	$\rho(x)$	$\rho(x,y)$
Output (y)	1.24	0.88	1.00	1.26	0.71	1.00
Real wage (w)	0.25	0.74	0.11	0.22	0.93	0.48
Unemp. rate (u)	4.76	0.92	−0.89	5.22	0.87	−0.61
Vacancies (v)	11.41	0.83	0.77	12.68	0.52	0.56

Note: Real GDP, the real wage and the unemployment rate are taken from the AWM database. Vacancies are aggregated using country-level data from the OECD Main Economic Indicators database. All variables range from 1999Q1 to 2017Q4. They are logged and HP-filtered using a smoothing parameter of 1600. Model-based moments are computed from stochastic simulations of the model for 2000 quarters at the second order, the simulated time series being then treated as the data.

$\sigma_z = 0.008$, $\rho_s = 0.6010$ and $\sigma_s = 0.164$. The corresponding model-based business cycle moments are reported in Table 1 and compared to the data.

4 Ramsey transition

4.1 Instruments

Our ultimate goal is to analyze the optimal UI scheme in the above tractable economy with incomplete markets and sticky prices and wages. We consider two policy instruments: the level of UI benefits in the form of the replacement rate δ_t, *i.e.* the amount of UI benefits relative to the pretax real wage received when working, and the nominal interest rate. We solve the dual form of the Ramsey problem. Under Ramsey policies, a benevolent planner credibly commits for an infinity of periods to a sequence of policy instruments $\{\delta_t, i_t\}_{t=0}^{\infty}$ that maximizes the following aggregate welfare measure:

$$\mathrm{E}_0 \sum_{s=0}^{\infty} \beta^s \mathcal{U}\left(c_s^e, c_s^u, c_s^f\right) \tag{31}$$

where

$$\mathcal{U}\left(c_t^e, c_t^u, c_t^f\right) = \chi\left(n_t \log c_t^e + u_t \log c_t^u\right) + (1-\chi)\left(\left(c_t^f\right)^{1-\rho} - 1\right) / (1-\rho_f) \tag{32}$$

subject to the equations defining a competitive equilibrium and given that the economy is in its initial steady state in period 0.

4.2 Optimal transition

Let us first investigate the Ramsey-optimal transition path from the initial steady state to the Ramsey steady state. Table 2 reports the initial steady state as well as the Ramsey steady state.

The Ramsey steady state features a lower level of the replacement rate of 59.3% against 75%

Table 2: Initial and Ramsey steady states

Variables ↓	Initial	Ramsey
Output (y)	0.8316	0.8483
Aggregate consumption (c)	0.8235	0.8338
Consumption of unemployed (c^u)	0.5890	0.4592
Consumption of employed (c^e)	0.7369	0.7465
Consumption of firm owners (c^f)	1.7039	1.7689
Real wage (w)	0.7853	0.7745
Unemployment rate (u)	0.0760	0.0575
Job-finding probability (f)	0.1823	0.2312
Labor tax rate (τ)	0.0617	0.0362
Replacement rate (δ)	0.7500	0.5930

in the initial steady state. In the long run, the vacancy creation motive clearly dominates: the lower UI benefits reduce the outside option of workers and the real wage drops. Matches become more profitable which pushes firms to post (roughly twice) more vacancies, which then lowers the unemployment rate to 5.75% (against 7.6% in the initial steady state). The joint fall in unemployment and UI benefits allows the government to lower the tax rate from 6.17% to 3.62%, and contributes to raise the individual consumption of employed workers in spite of a slightly declining real wage. The aggregate consumption gains stem from the fall in the labor income tax that raise the consumption of employed workers, from the rise in firms' profits that benefit to firm owners' consumption, and from a composition effect by which the lower rate leads more workers to be employed and enjoy the higher associated consumption level. In the mean time, the fall in UI benefits widens the income drop upon job loss which raises desired precautionary savings which, given the zero net supply in assets, translates into a lower real interest rate.

How does the Ramsey planner implement the optimal transition? Figure 1 reports the Ramsey-optimal transition path in the baseline case.[9] It also reports the optimal transition paths under flexible prices (setting $\phi = 0$) and under flexible wages ($\alpha = 0$) to highlight the role of price and wage rigidities along the transition.[10]

In all three cases, Figure 1 shows an interesting contrast between the optimal dynamics of the replacement rate δ_t in the short run and in the long run. On impact, the planner raises the replacement rate to sustain aggregate demand directly through the consumption of unemployed workers and indirectly through rising wages. The chief reason is that, given that workers are hand-to-mouth, an upfront and brutal drop in the replacement rate would depress the economy and result in large consumption losses for all types of households: unemployed workers through

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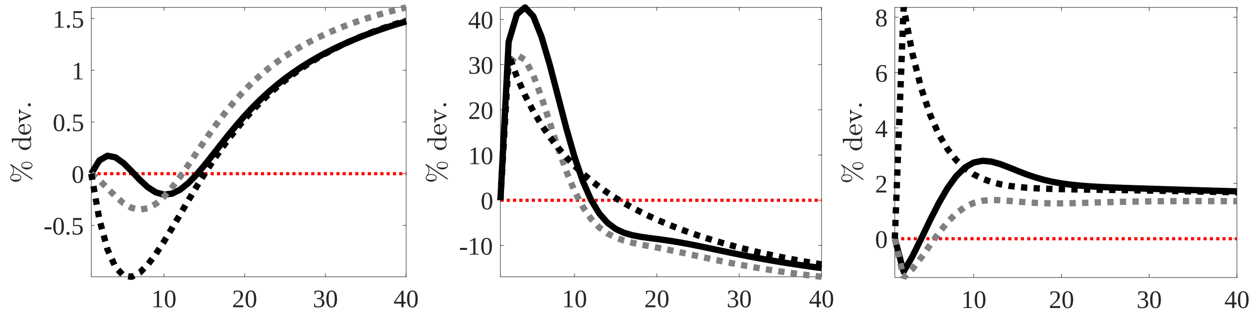
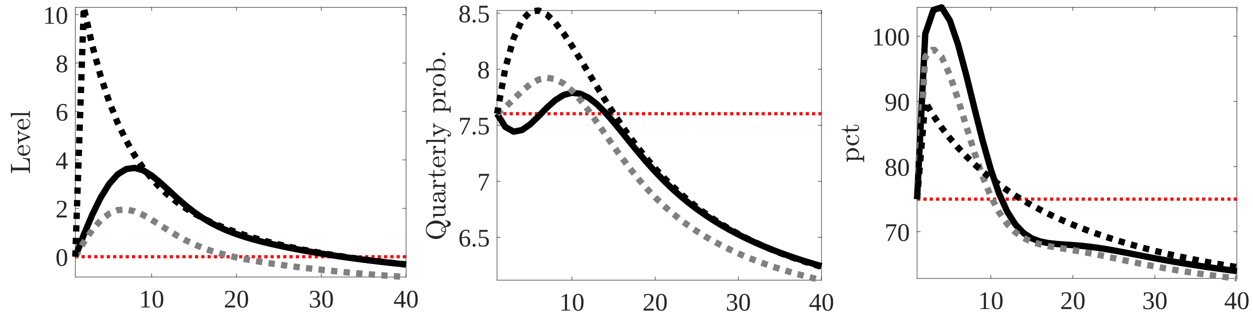
[9] The model is solved under perfect foresight using the initial steady state as initial conditions – assuming Ramsey multipliers are initially equal to zero – and then uses the Ramsey first-order conditions along with the equations characterizing the equilibrium to converge to the final Ramsey steady state. The algorithm used is a two-point boundary problem using a trust region method and implemented through the Dynare set-up for deterministic simulations (see Adjemian et al. (2011)).

[10] Neither price or real wage rigidities affect the final steady state implied by the reform.

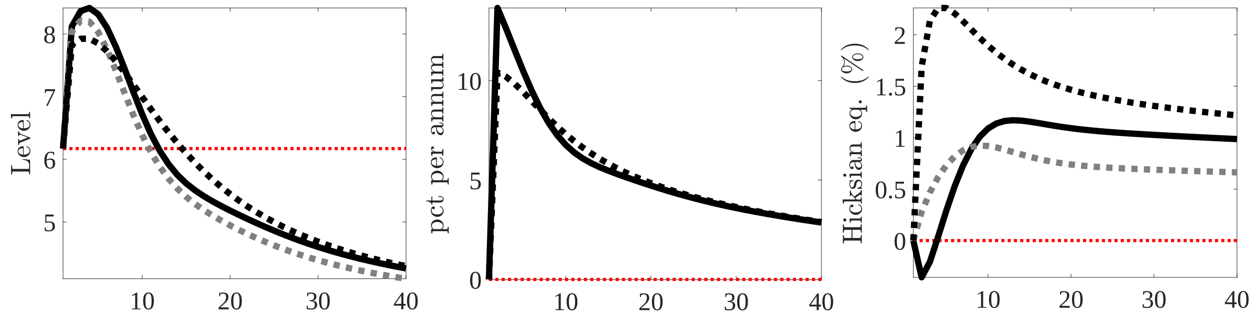
Figure 1: Optimal transition paths.



(a) Output (b) Cons. of unemployed (c) Cons. of employed



(d) Real wage (e) Unemployment (f) Repl. rate δ_t



(g) Labor tax τ_t (h) Inflation rate (i) Welfare gains

Solid black: Baseline. Dotted grey: Flexible prices. Dotted black: Flexible wages. Red: Initial conditions lower UI benefits, employed workers through lowers wages and firm owners through lower profits. Hence, the planner chooses to raise the level of UI benefits on impact against the commitment to lower it in the future. Aggregate demand is sustained in the short run and the hiring activities of forward-looking firms are not depressed too much.

The size of these short-run movements and their implications depend on whether prices and wages are flexible or sticky. Under flexible real wages, the replacement rate jumps from 75% to 90% and the impact on the effective real wage is massive, as the latter increases by 10%. As a result, the consumption of both employed and unemployed workers rises significantly. However, the real wage hike also hurts the profitability of vacancy posting which leads firms to reduce their hiring activities and the unemployment rate rises by almost 1pp, peaking roughly 5 quarters after the reform is implemented. Under sticky real wages, the effects of the initial hike in UI benefits on the effective real wage are both smaller and more gradual, as shown in panel (d) of Figure 1. As such, the planner can exploit this stickiness to raise the level of UI benefits more in the short run. Under sticky real wages but flexible prices, the replacement rate jumps from 75% to almost 100% on impact before decreasing sharply and falling below its initial level after 10 quarters. Under sticky real wage and prices, the replacement rate rises even more, reaching 100% on impact and keeping rising for 5 quarters. Since the effective real wage increases less in both cases, the consumption of employed workers falls on impact because the effects of the tax hike dominate the effects of the rising wage. In this situation, the planner sustains aggregate demand by raising more the consumption of unemployed workers by increasing more the level of UI benefits. Under sticky prices, the planner can further exploit this short-run demand effect, since real wages increase more than under flexible prices: the planner offers employed and unemployed workers a larger consumption boost which is large enough to produce a stable – instead of rising – unemployment rate in the short run.

After impact of after a few quarters, the replacement rate falls monotonically. The fall is very strong after the peak until the replacement rate falls below its initial value, and then much milder until convergence to the final steady-state value. As the replacement rate falls, firms post more vacancies and the unemployment rate drops steadily. The consumption of unemployed workers per-capita falls along with UI benefits but this negative effect is compensated at the aggregate level since more of them become employed as the unemployment rate shrinks. The consumption of employed workers per-capita rises along the fall of the labor income tax rate. In addition, since real wages display decreasing dynamics, vacancies become more profitable and firm owners experience consumption gains.

These results suggest that a Ramsey UI reform features intertemporal trade-offs: more insurance in the short-run against the promise of less insurance and less taxes but more employment in the future. Let us now look at the welfare effects of the reform. We adopt a utilitarian approach

Table 3: Lifetime welfare gains from the Ramsey UI reform, in percents.

	St. state	Transition		
		Base.	$\phi = 0$	$\alpha = 0$
Aggregate (ζ_∞)	0.38	0.71	0.52	0.81
Employed (ζ^e_∞)	1.30	1.55	1.17	1.84
Unemployed (ζ^u_∞)	−22.0	−12.6	−14.5	−12.6
Firm owners (ζ^f_∞)	3.81	−3.62	1.14	−6.05
No composition effect (ζ'_∞)	−0.47	0.19	−0.05	0.29

to the welfare criterion, and consider the Hicksian consumption equivalent ζ_T that solves:

$$\sum_{s=0}^{T} \beta^s \left(\mathcal{U} \left(c^e_s, c^u_s, c^f_s \right) - \mathcal{U} \left(c^e_0 \left(1 + \zeta_T\right), c^u_0 \left(1 + \zeta_T\right), c^f_0 \left(1 + \zeta_T\right) \right) \right) = 0 \tag{33}$$

where c^e_0, c^u_0, c^f_0 denote the individual consumption levels in the initial steady state. Since reforms of the UI scheme clearly induce redistributive effects, we also compute the individual lifetime welfare gains (or losses if $\zeta < 0$) of each of the three types of agents, respectively denoted ζ^e_T, ζ^u_T and ζ^f_T. Finally, since these gains/losses do not account for the situation of workers that just lost their jobs and of newly employed workers, we also compute the welfare losses ζ'_T using constant proportions of employed and unemployed households instead of time-varying ones in Equation (32). The difference between ζ_T and ζ'_T is therefore entirely driven by changes in the composition of the labor force, and measures the gains/losses from recently unemployed/employed workers. As an alternative to the above welfare computation, we also compute the steady-state to steady-state welfare gains. The latter disregard the welfare gains/losses from the transition and thus provide information about the pure welfare gains from the transition.

The left panel of Table 3 reports the welfare gains computed as the consumption equivalent from one steady-state to another, *i.e.* without accounting for the welfare losses/gains arising from transition path. It shows that the reform produces a steady-state aggregate welfare gain around 0.38% of consumption equivalent and, as expected, reveals large steady-state distributional effects of the reform: employed workers experience a 1.3% consumption equivalent welfare gain, unemployed workers a 22% welfare loss and firm owners a 3.81% welfare gain. Last but not least, the last line of Table 3 shows the welfare effect for a constant composition of the household sector, *i.e.* if the reform had no effects on the steady-state level of unemployment, and reveals that in this case the reform would yield a 0.47% consumption equivalent welfare loss. In other words, most of the steady-state welfare gains from the reform come from the composition effect, the fact that more workers become employed and experience larger individual levels of consumption when employed.

The second column of Table 3 shows that taking into account the transition matters substantially both for aggregate welfare and for the distribution of the welfare gains and losses. In the baseline case, the aggregate welfare gains exceed those of the steady-state to steady-state comparison (0.71% against 0.38%). Those are driven by the positive short-run paths of the consumption of employed and unemployed workers, who experience larger gains or lower losses than in the steady state comparison (1.55% against 1.30% for employed and -12.6% against -22% for unemployed workers). Since the short-run transition path is less favorable to firms and the firm owners, their individual welfare gains are much smaller and even negative for the baseline case (-3.62% against 3.81%). Finally, taking into account the transition delivers welfare gains even when the composition effect is neutralized (0.19% against -0.47%).

The transition path under flexible prices yields lower aggregate welfare gains. While surprising at first glance, this result can be understood as a second-best result. Our model combines multiple interacting distortions: incomplete markets, sticky prices, distortionary taxation, and monopolistic competition. In such an environment, it is not surprising that removing one distortion (sticky prices or sticky wages) might actually hurt households' welfare, since it may exacerbate the effects of other distortions, such as financial market incompleteness. In the present case, sticky prices allow the planner to implement the reform by increasing risk-sharing among households in the short-run and by fostering a more positive path of the real wage without hurting vacancy creations, providing aggregate consumption gains along the transition. Further, risk-sharing among workers is improved in the early stages of the reform by raising the consumption level of unemployed workers, who enjoy a lower initial level of consumption, until the point where unemployment falls enough for the favored channel of risk-sharing to be the composition of the pool of workers (less unemployed and more employed). Of course, those workers who remain unemployed after the reform (about 5.7% of workers), still experience large welfare losses from the reform, given the very low post-reform replacement rate.

Finally, under flexible wages – but sticky prices – the sensitivity of the real wage to changes in the replacement rate is so large that the initial rise produces much larger short-run consumption and welfare gains for employed workers, and to a lesser extent for unemployed workers. These imply much lower gains for firms and firm owners, but the overall effect on aggregate welfare is positive.

5 Ramsey policies in response to large shocks

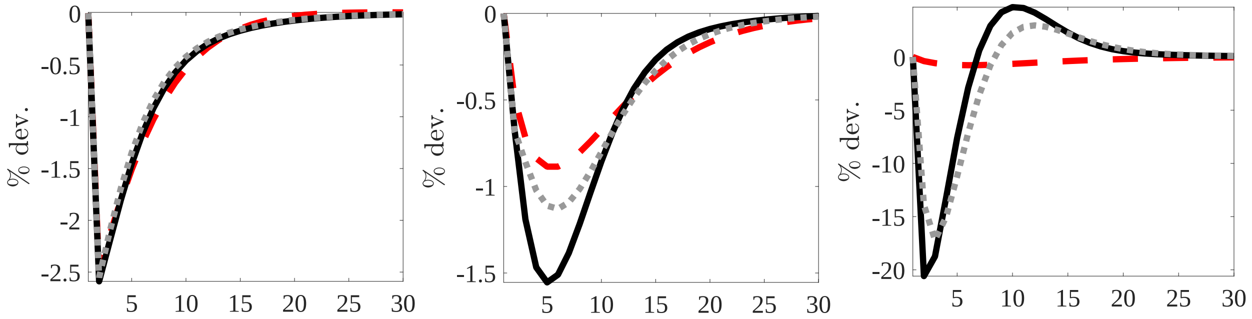
We now investigate the Ramsey-optimal responses of our economy around the Ramsey steady state in the event of large recessionary shocks. We consider two "MIT" shocks: a negative productivity shock and a positive shock to the gross rate of separation. In both cases, we use the estimated values of the persistence parameters, and adjust the size of the shock to generate a 2.5% recession at the trough under a passive UI policy ($\delta_t = \delta$) and a Taylor rule around the Ramsey steady state. In addition to this case, we also report the Impulse Response Functions (IRFs) under the baseline Ramsey equilibrium where both UI benefits and the nominal interest rate are chosen optimally, and the IRFs of an optimal UI policy with a Taylor monetary policy rule. The resulting IRFs are reported in Figure 2 and Figure 4.

5.1 Negative productivity shock

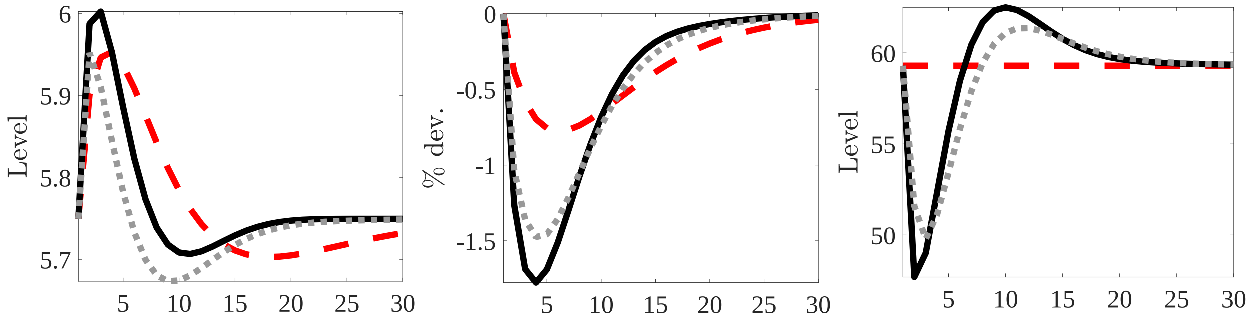
When the replacement rate δ_t remains constant, Figure 2 shows that a negative productivity shock hurts vacancy creations and therefore raises unemployment, lowers output, the real wage and hence the consumption of workers, employed or not. The shock is also inflationary: productivity falls more than the real wage so the production cost rises, which induces a rise in inflation.

Figure 2: Optimal responses to a large negative productivity shock.

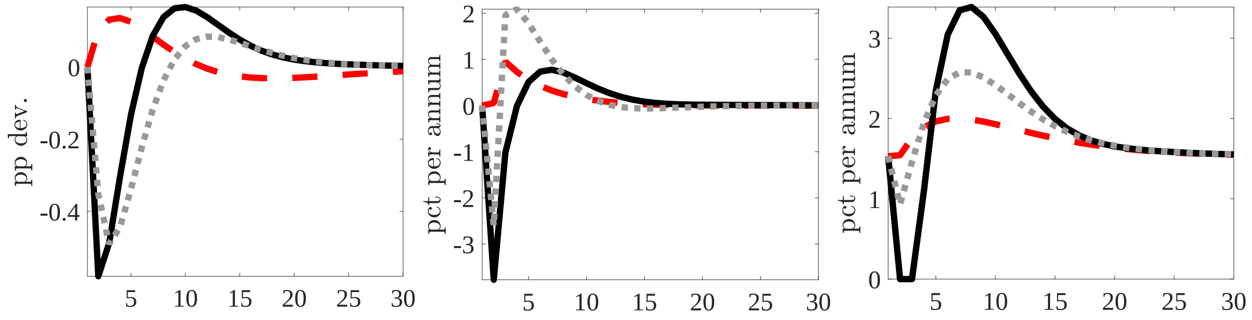
(a) Output (b) Cons. of employed (c) Cons. of unemployed



(d) Unemployment (e) Real wage (f) Repl. rate δ_t



(g) Labor tax τ_t (h) Inflation rate (i) Nom. int. rate



Solid black: Baseline. Dotted grey: Optimal UI policy with a Taylor rule. Dashed red: Constant UI ($\delta_t = \delta$) with a Taylor rule.

In a similar environment, Challe (2019) showed that, after a negative productivity shock, the rise in unemployment risk and the demand for precautionary savings could rise enough for aggregate demand to drop more than supply, leading the inflation rate to *fall*. A similar mechanism is at work in our model but its strength given our calibration is simply not enough to overturn the inflationary forces at play.[11] Whether monetary policy is conducted through a Taylor rule or optimally, the optimal UI benefit policy consists in lowering the replacement rate δ_t by roughly 10 percentage points on impact, and then raise it above its steady-state value by about 2 percentage points before letting it slowly converge to its steady-state value very slowly from above. This path helps attenuate the negative effects of the shock on vacancy creations. Unemployment is slightly stabilized compared to the case of a passive UI policy or at least less persistent. The large fall in the replacement rate lowers the outside option of workers and the real wage falls much more under the optimal policy but then recovers much faster. Individual consumption levels for employed and unemployed respectively follow the path of the real wage and the path of the replacement rate, and fall much more initially under the optimal policy before recovering much faster as well.

As a result of this UI policy, the real wage falls more and aggregate demand is more depressed than supply, which overturns the effects of the productivity shock on inflation, making it deflationary. Under the optimal UI policy, the fall in inflation is met with a moderate reduction in the nominal interest rate with a Taylor rule, and with a much larger reduction under an optimal monetary policy. The reduction is so large that the nominal interest rate hits the zero lower bound. Is it to say that the zero lower bound constraint prevents the central from implementing an optimal monetary policy, which would consist in achieving perfect price stability? Actually no, as depicted in Figure 6 in the Appendix, which compares the optimal Ramsey UI and monetary policy and the optimal UI policy under full price stability after a similar productivity shock ignoring the zero lower bound constraint. It shows that, even though both responses are qualitatively very similar, the central bank still finds it optimal not to fully stabilize inflation because it would hurt the consumption of firm owners too much.

After a productivity shock, our model points to an optimally pro-cyclical unemployment insurance. The planner uses the replacement rate to engineer a larger fall in the real wage to achieve a quicker stabilization of the unemployment rate. Doing so raises the income loss upon job loss and raises precautionary savings, and makes the productivity shock look like a negative demand shock: inflation falls and the optimal policy consists in lowering the nominal interest, although not to the point where inflation is fully stabilized.

How robust to alternative assumption are our results? Figure 3 compares the optimal UI and monetary policy in the baseline case with sticky prices and sticky wages with alternative cases: flexible prices, flexible wages or both.

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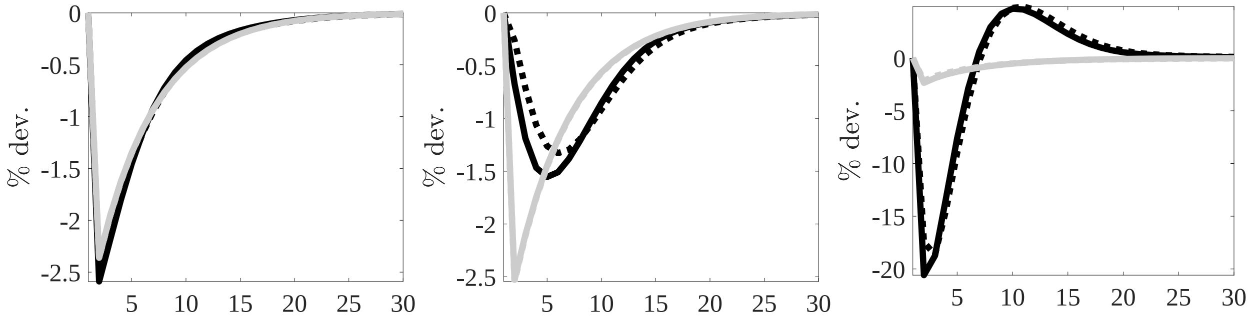
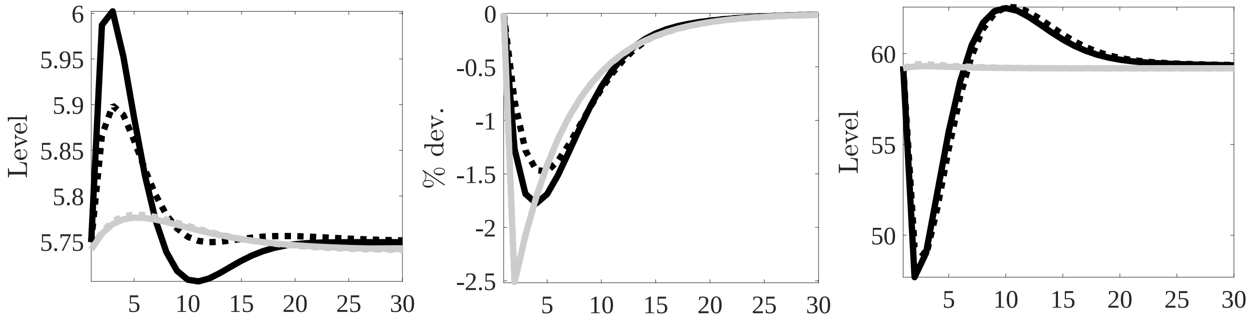
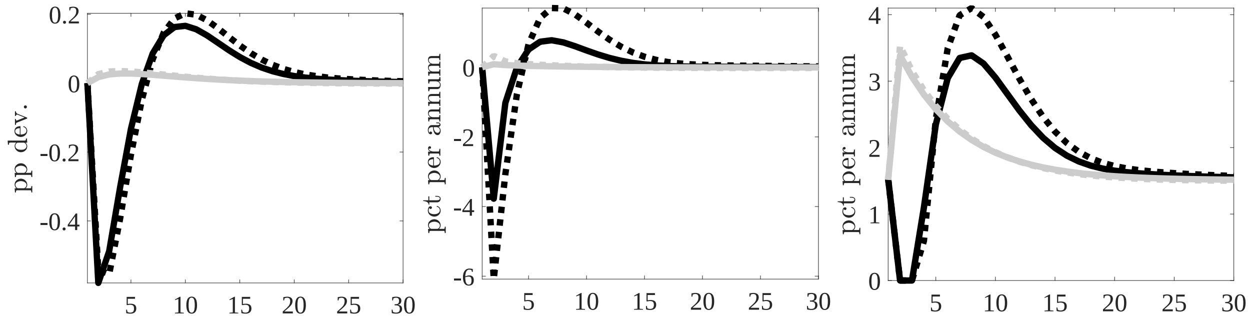
[11] In particular, all the parameters affecting the size and persistence of unemployment fluctuations are critical in determining the respective size of supply and demand effects at work after a productivity shock.

Figure 3: Optimal responses to a large negative productivity shock – alternative assumptions.


(a) Output (b) Cons. of employed (c) Cons. of unemployed


(d) Unemployment (e) Real wage (f) Repl. rate δ_t


(g) Labor tax τ_t (h) Inflation rate (i) Nom. int. rate

Solid: Sticky prices, dotted: flexible prices, black: sticky wages, light grey: flexible wages.

Figure 3 shows quite clearly that optimal responses are qualitatively similar whether prices are sticky or flexible, and that the key assumption is real wage stickiness. Indeed, the optimal response of the replacement rate δ_t under flexible wages is almost muted. In practice it increases slightly, but these movements remain negligible in comparison of the large response observed under sticky wages. The reason is that under flexible wages, fluctuations in unemployment are already stabilized almost by construction, and the planner favors the insurance motive over the vacancy creation motive.

5.2 Positive separation shock

Figure 4 shows very different results when a large recession is triggered by a shock on the separation rate.

First, in this case, the unemployment rate rises by several percentage points, much more than after a negative productivity shock. A separation shock that lowers output by 2.5% under passive policies leads unemployment to rise from 5.75% to more than 8%, since all the adjustment in output occurs through employment. The additional reason for the persistence of this rise can be traced to Equation (4), which shows that the AR(1) coefficient implied by the laws of motion of employment, $(1 - \sigma_t)$ is very large for empirically realistic calibrations. Hence, a separation shock has very large and persistent effects on unemployment irrespective to the dynamics of the job-finding probability, whose ability to affect employment is limited, as shown by Equation (4). In addition, under a passive policy (dashed red line on Figure 4), the rise in unemployment risk triggers a rise in precautionary savings that leads aggregate demand to fall more than supply. The shock is thus massively deflationary.

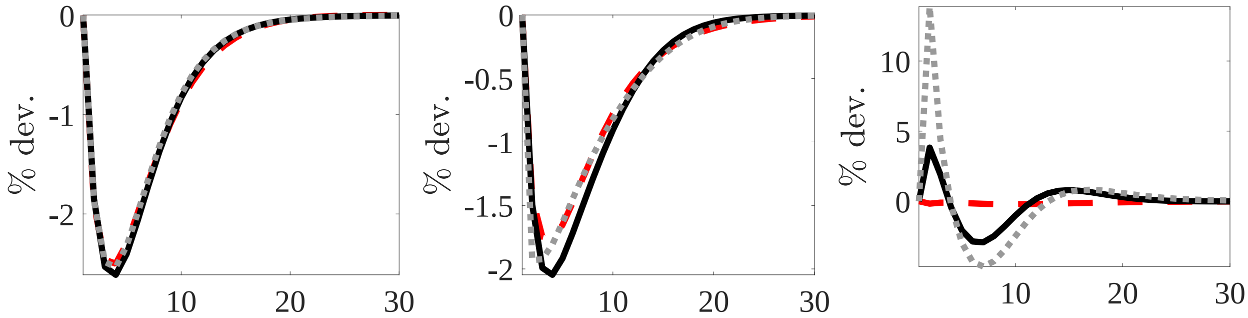
Conditional on this shock, the ability of the planner to alter unemployment through vacancy creations is thus very limited. Since the vacancy creation motive is almost shut down in this case, only the insurance motive remains, and the planner optimally chooses to increase the level of UI benefits on impact by 2pp in the baseline case and by 8pp with a Taylor rule. On top of the insurance motive, the planner also cares about stabilizing inflation by sustaining aggregate demand in the first quarters. With an optimal response of UI benefits and monetary policy, this is achieved by raising moderately the replacement rate and by lowering significantly the nominal interest rate. When monetary policy is not optimized but set according to a Taylor rule, the stabilization of inflation is achieved by raising much more the replacement rate. After 5-6 quarters, these movements reversed: the replacement rate is lowered and the nominal rate raised.

Overall, the optimal policy responses are very different under a separation shock because the planner's ability to affect the rate of unemployment is very limited. Since the vacancy creation motive is basically muted, the planner is left with the insurance motive and with the aggregate demand stabilization motive which are both connected and call for similar policy actions.

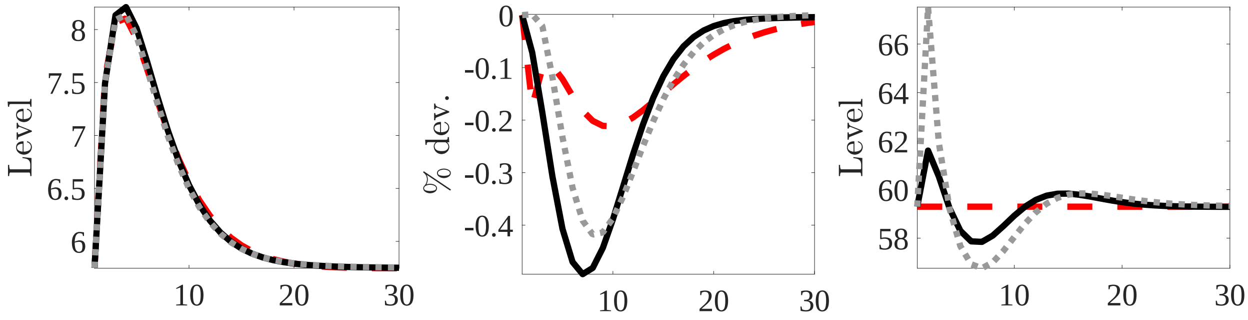
In the case of separation shocks one may also wonder about the relative importance of price and wage stickiness. Figure 5 reports the optimal responses under flexible prices, flexible wages

Figure 4: Optimal responses to a large positive separation shock.

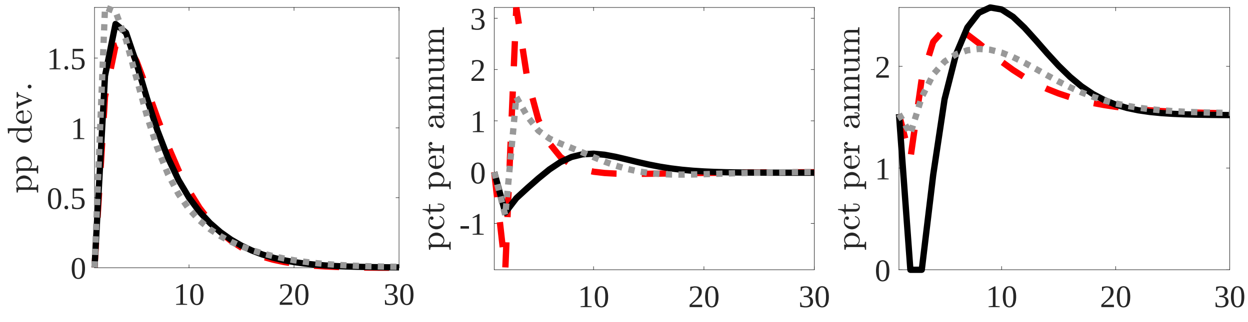
(a) Output (b) Cons. of employed (c) Cons. of unemployed



(d) Unemployment (e) Real wage (f) Repl. rate δ_t



(g) Labor tax τ_t (h) Inflation rate (i) Nom. int. rate

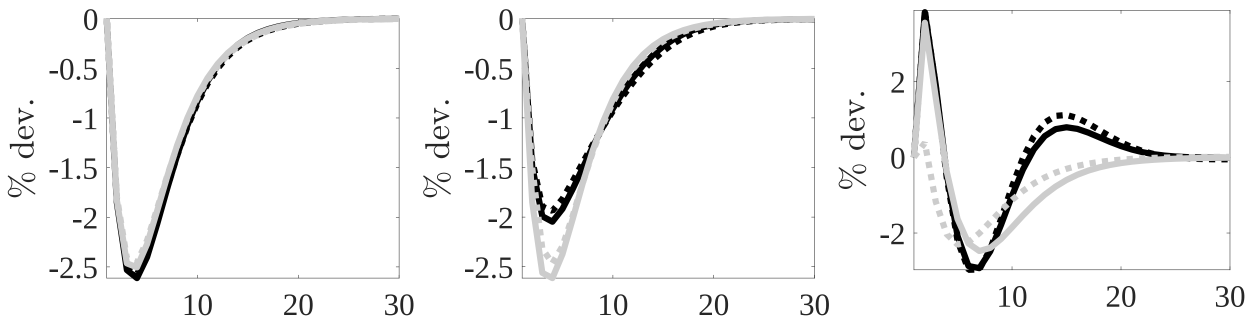


Solid black: Baseline. Dotted grey: Optimal UI policy with a Taylor rule. Dashed red: Constant UI ($\delta_t = \delta$) with a Taylor rule.

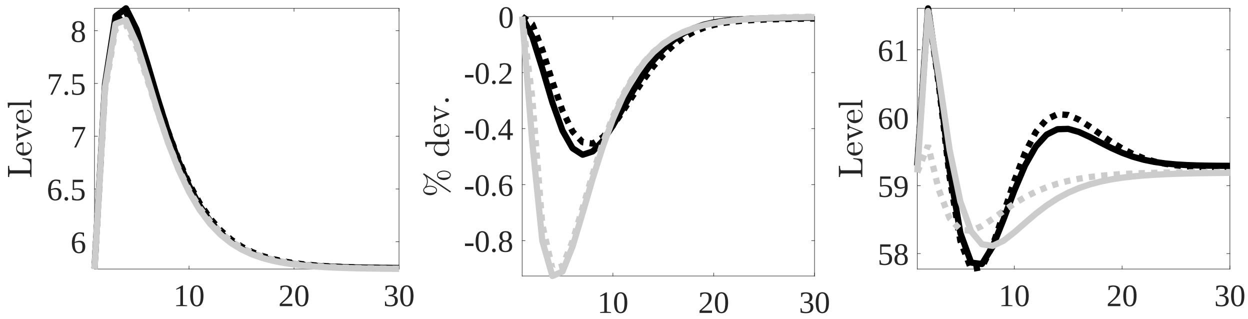
or both and compares them to the baseline case with sticky prices and wages.

Figure 5: Optimal responses to a large positive separation shock – alternative assumptions.

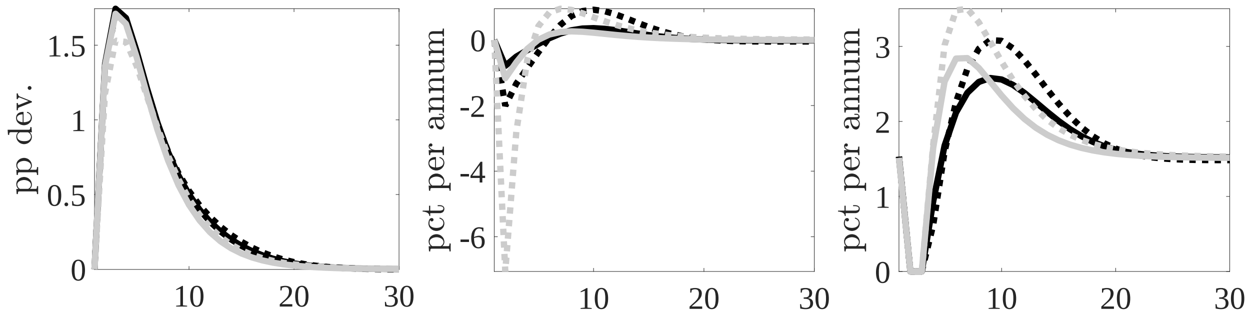
(a) Output (b) Cons. of employed (c) Cons. of unemployed



(d) Unemployment (e) Real wage (f) Repl. rate δ_t



(g) Labor tax τ_t (h) Inflation rate (i) Nom. int. rate



Solid: Sticky prices, dotted: flexible prices, black: sticky wages, light grey: flexible wages.

Figure 5 shows that optimal responses are qualitatively similar to the baseline case if either wages or prices are sticky. Only when prices and wages are flexible is the response of UI benefits really different: in this case, the planner lowers UI benefits by 1.5pp and slowly adjusts from below their steady-state level.

Overall, separation shocks imply counter-cyclical responses of the replacement rate δ_t. The chief reason is the limited ability of the planner to curb unemployment and to affect vacancy creations conditional on this shock, which shifts the planner's trade-off in favor of the insurance and aggregate demand stabilization motives. The effects of price and wage flexibility on the qualitative design and welfare effects of optimal UI policies conditional on separation shocks are thus not as critical as they are conditional on productivity shocks, unless prices and wages are flexible altogether.

6 Business cycle implications and welfare

In this last section we run dynamic simulations and feed the model with random productivity and separation shocks to investigate the business cycle and welfare implications of our model under various assumptions. We run fully non-linear stochastic simulations using the stochastic extended path algorithm (See Fair and Taylor (1983) or more recently Auray, Eyquem, and Gomme (2019)). Its main advantage is the preservation of the model's non-linearities, including potential episodes of a binding zero lower bound. We draw 500 periods of productivity and separation shocks and use the same draw for all simulations. Table 4 reports the resulting standard deviations and some correlations of interest. In addition, a second panel reports the welfare gains from optimal UI and/or monetary policies with respect to the pre-reform equilibrium. These gains combine steady-state gains – resulting from an optimal steady-state replacement rate – as well as business cycle welfare gains resulting from the impact of parameter values or policies on the welfare losses from fluctuations. Hence, the last panel reports the welfare gains net from the steady-state gains, capturing the business cycle welfare gains.

The first column reports the results for the pre-reform equilibrium with "passive" policies where monetary policy follows a Taylor rule and the replacement rate δ_t is not optimized, constant and equal to its initially calibrated value $\delta = 0.75$. Basically the cyclical patterns in this case are identical to those contrasted in Table 1, but Table 4 reports more variables and includes, among other additional statistics, the standard deviation of aggregate consumption and a decomposition among household types. In this case, the standard deviation of the replacement rate is simply zero.

The second column reports the case of "passive" policies: a constant replacement rate and a Taylor rule when shocks hit the economy around the Ramsey steady-state. This case differs from the previous only in the steady-state around which the shocks hit. Changes in standard deviations can mostly be traced to the different levels around which they are computed: the standard deviation of output drops because the steady-state level of output is larger, the standard deviation of unemployment is larger because the steady-state level of unemployment is lower, etc... Quantitatively speaking, Table 4 shows that the case of a constant (but optimal) level of UI benefits already produces net welfare gains, *i.e.* welfare gains beyond the steady-state welfare gains. Those amount to 0.05% of steady-state consumption and are mostly driven by the fall in the volatility of the consumption of employed workers and firm owners.

The third column of Table 4 adds a layer of optimal policy by considering an optimally time-varying UI policy with a Taylor monetary policy rule. As already explained in the previous section, the optimal UI policy is used by the planner as a substitute for wage flexibility after

Table 4: Business cycle implications and welfare gains from optimal policies.

Steady-state repl. rate →	$\delta = 0.75$	Optimal $\delta = 0.593$				
Monetary policy →	Taylor rule	Taylor rule		Optimal		
UI policy →	$\delta_t = \delta$	$\delta_t = \delta$	Optimal	Optimal		
Calibration →	Baseline	Baseline		Base.	$\phi = 0$	$\alpha = 0$
↓ Business cycle moments						
Std output (y_t)	1.24	1.11	1.08	1.12	1.09	1.03
Std agg. cons. (c_t)	1.23	1.12	1.13	1.12	1.12	1.12
Std cons. employed (c_t^e)	0.70	0.66	0.71	0.84	0.79	1.10
Std cons. unemployed (c_t^u)	0.37	0.49	5.92	6.14	6.43	1.20
Std cons. firm owners (c_t^f)	3.41	2.80	2.17	1.66	2.13	0.79
Std unemployment rate (u_t)	8.40	8.95	8.82	9.09	8.91	8.52
Std real wage (w_t)	0.37	0.49	0.68	0.76	0.70	0.96
Std replacement rate (δ_t)	–	–	5.47	5.73	6.09	0.68
Std labor income tax (τ_t)	9.09	9.49	10.15	10.11	10.40	9.13
Std annual inflation $(1+\pi_t)^4$	0.42	0.47	0.88	0.83	–	0.16
Std annual interest rare $(1+i_t)^4$	0.38	0.33	0.54	1.34	–	0.87
Corr (δ_t, y_t)	–	–	0.67	0.66	0.64	−0.03
Corr (δ_t, u_t)	–	–	−0.14	−0.21	−0.16	0.11
Corr (i_t, π_t)	0.68	0.59	0.57	0.93	0.94	0.78
↓ Welfare gains wrt pre-reform						
Aggregate (ζ'_∞)	–	0.43	0.46	0.51	0.49	0.58
Employed $(\zeta^{e'}_\infty)$	–	1.38	1.35	1.44	1.40	1.59
Unemployed $(\zeta^{u'}_\infty)$	–	−21.99	−20.90	−21.27	−21.32	−22.03
Firm owners $(\zeta^{f'}_\infty)$	–	3.65	3.55	3.37	3.62	3.21
↓ Welfare gains, removing SS gains						
Aggregate	–	0.05	0.08	0.13	0.11	0.20
Employed	–	0.08	0.05	0.14	0.10	0.29
Unemployed	–	0.01	1.10	0.73	0.68	−0.03
Firm owners	–	−0.16	−0.26	−0.44	−0.19	−0.60

productivity shocks and to insure unemployed workers after separations shocks. The mildly negative correlation of δ_t with the unemployment rate suggests that the effects of productivity shocks are slightly dominant in our simulations. As a result of this policy set-up, each component of aggregate consumption is more volatile than with a constant UI policy in this case but aggregate output is less volatile which means that vacancies become less volatile. In addition, the unemployment rate is less volatile as well, which suggests that most welfare gains stem from the composition effect rather than from the individual effects. The aggregate net business cycle welfare gains from an optimal UI policy with a Taylor rule are modest, around 0.08% in comparison to the initial (pre-reform) steady-state. That's an additional 0.03% compared to running "passive" policies around the optimal steady-state. Importantly, the individual business cycle gains from an optimal UI policy are very large for unemployed workers: even though they experience the largest steady-state welfare losses, the business cycle component of welfare gains/losses is positive and the largest among households. The opposite holds for firm owners: while they experience the largest steady-state gains, they experience net business cycle welfare losses from optimal policies.

The fourth column of 4 considers the additional effects of an optimized monetary policy. A jointly optimized UI and monetary policy results in further additional volatility of the real wage. Further, as already mentioned in the previous section, the optimal monetary policy features much more activism – although full price stability is not the optimal policy, even when the ZLB constraint does not bind, see Appendix A. Indeed, the relative volatility of the nominal interest rate is much larger than the volatility of inflation when monetary policy is optimized while the opposite holds true under a Taylor rule. In addition, inflation and the nominal rate become more closely and positively correlated under an optimal monetary policy. A jointly optimal policy delivers 0.13% consumption-equivalent net welfare gains compared to the initial equilibrium, which represents roughly 1/3 of the steady-state welfare gains. Compared to "passive" policies conducted around an optimal steady state, the welfare gains of fully optimal UI and monetary policies drop to a modest 0.08%. The distribution of these gains among households is very similar to the distribution that prevails in the case of a Taylor rule with an optimal UI policy.

The last two columns contrast the business cycle implications of price and wage flexibility under fully optimal policies. Most aspects have already been discussed in the previous section and are no surprise at this stage. Results under flexible prices are very close (but not identical) to the fully optimal policy. The welfare "losses" from price flexibility entirely stem from the fact that the optimal monetary policy does not consists in fully stabilizing prices and are negligible, around 0.02% of consumption equivalent. Results under flexible wages show that, in this case, the optimal volatility of the replacement rate, *i.e.* the activism of UI policy, falls dramatically. This result is consistent with the idea that UI policy is basically used to circumvent wage stickiness after productivity shocks, implying a large volatility of δ_t. Under flexible wages, this motive vanishes and the volatility of δ_t is an order of magnitude lower, suggesting little room for active UI policies in this case.

7 Conclusion

We propose a THANK model with endogenous unemployment risk to analyze the macroeconomic and distributional effects of Ramsey-optimal UI policies. After calibrating the model to represent the average economy of the Euro Area and match its key ratios and labor-market business cycle properties, we characterized the optimal reform of the UI system. The planner chooses the replacement rate optimally over the transition. In the long run, the vacancy creation motive dominates, as the replacement rate falls, lowering the unemployment rate. Employed workers gain through lower labor taxes, unemployed lose through the lower replacement rate and firm owners gain through lower wages. In the short run however, the insurance motive dominates until unemployment falls enough to generate larger welfare gains from a lower unemployment rate. Price and wage rigidities matter for the short-run and transitional welfare effects of the reform.

Over the business cycle around the Ramsey-optimal steady state, we find that the optimal changes in the replacement rate depend (*i*) on the nature of the shock and (*ii*) on the presence of price and wage rigidities. After productivity shocks, the vacancy creation motive dominates and calls for a pro-cyclical UI policy aimed at sustaining job creations by lowering the real wage. We trace the origins of this result to the presence of sticky real wages: when real wages are flexible, the replacement rate is optimally chosen to remain close to its steady-state value. After separation shocks, the planner has almost no traction over vacancy creations. Only the insurance and aggregate demand stabilization motives remain, and both point to a counter-cyclical UI policy. These results call for a careful analysis of the drivers of recessions and of the presence of rigidities on the labor market before deciding of changes in UI policies. These can indeed have large redistributive and hence aggregate welfare effects.

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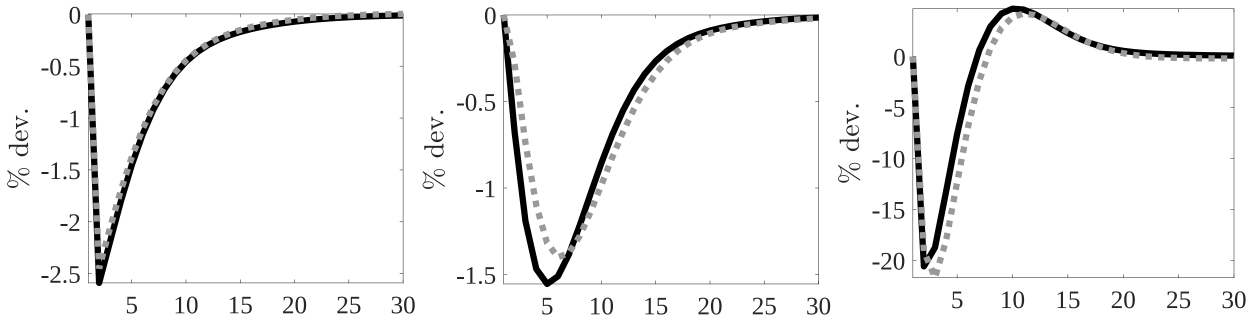
A Price stability vs. optimal monetary policy

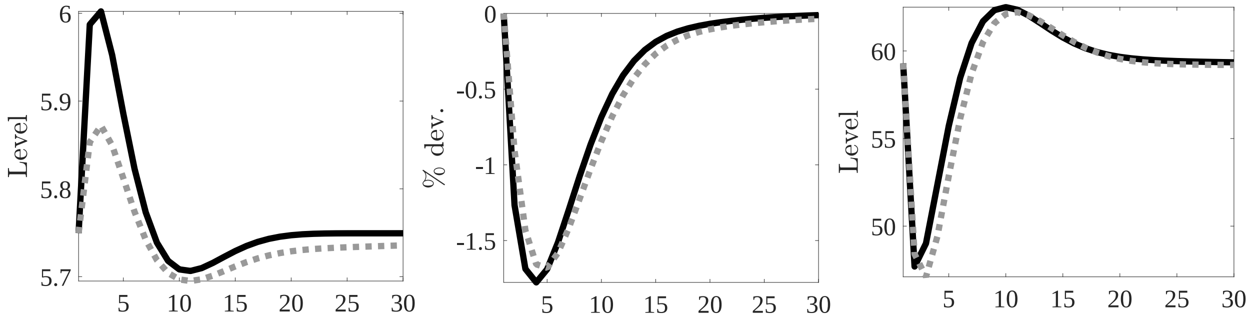
This Appendix reports the IRFs to productivity and separation shocks after large shocks under a Ramsey optimal UI and monetary policy, and compares them to a Ramsey optimal UI policy under price stability $\pi_t = 0$. In both cases the zero lower bound on the nominal interest rate is not considered. In the case of price stability, this is to allow the central bank to effectively achieve price stability. In the case of a Ramsey optimal policy, this allows us not to attribute the results to the presence of the zero lower bound. The results are reported in Figure 6 and 7 below.

Figure 6: Responses to a large negative productivity shock.

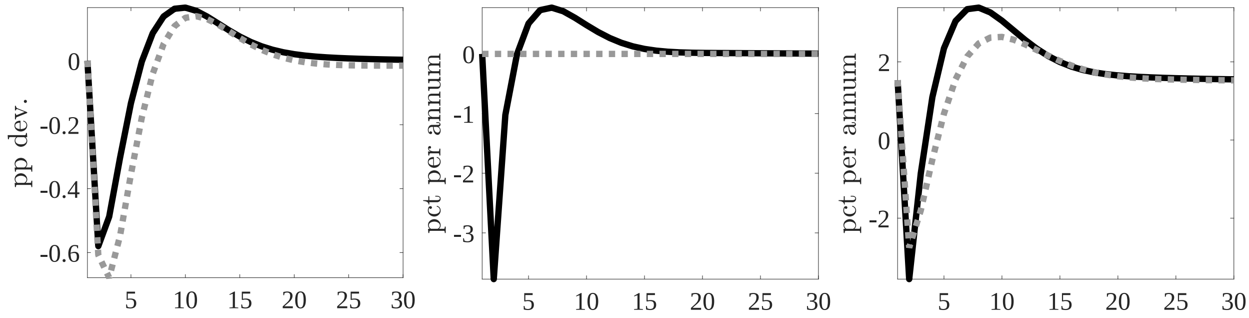
(a) Output (b) Cons. of employed (c) Cons. of unemployed



(d) Unemployment (e) Real wage (f) Repl. rate δ_t

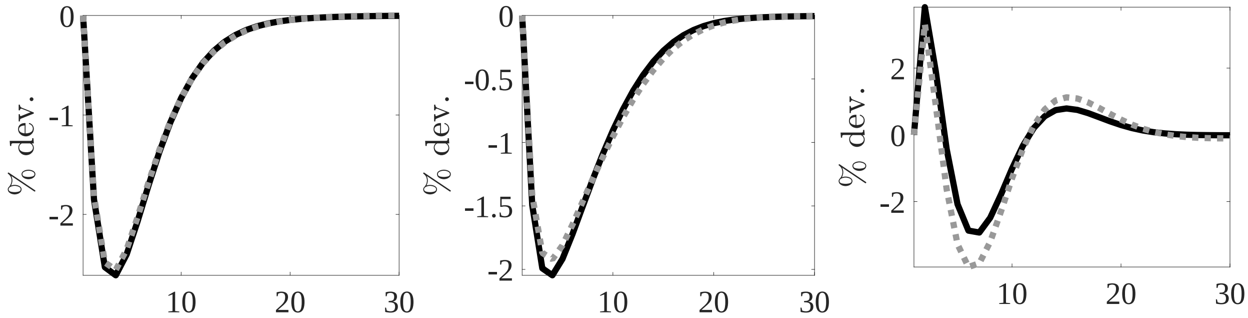


(g) Labor tax τ_t (h) Inflation rate (i) Nom. int. rate



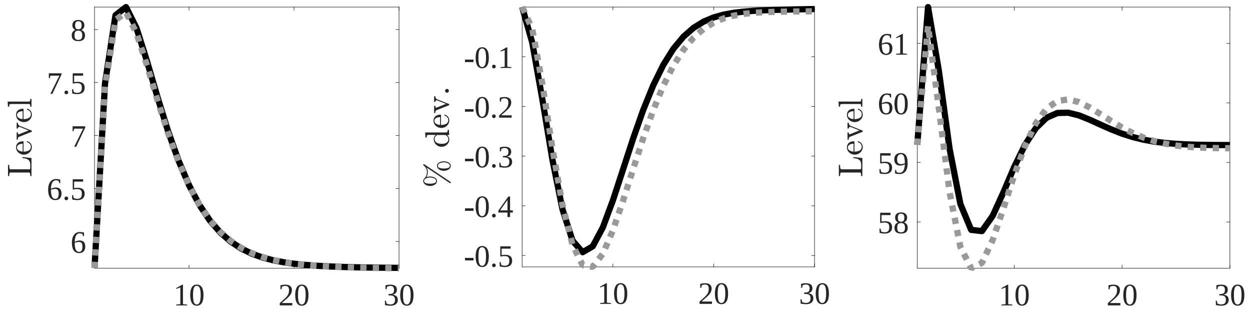
Solid black: Ramsey optimal UI and monetary policy. Dotted grey: Optimal UI policy with price stability.

Figure 7: Responses to a large positive separation shock.


(a) Output

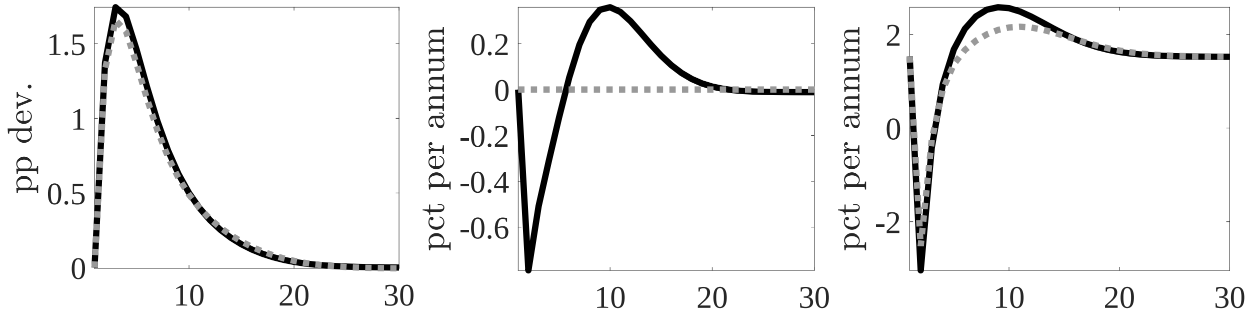
(b) Cons. of employed

(c) Cons. of unemployed


(d) Unemployment

(e) Real wage

(f) Repl. rate δ_t


(g) Labor tax τ_t

(h) Inflation rate

(i) Nom. int. rate

Solid black: Ramsey optimal UI and monetary policy. Dotted grey: Optimal UI policy with price stability.

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