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Sectoral Shocks, Reallocation, and Labor Market Policies

Joaquín García-Cabo* Anna Lipińska† Gastón Navarro‡§

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Abstract

Unemployment insurance and wage subsidies are key tools to support labor markets in recessions. We develop a multi-sector search and matching model with on-the-job human capital accumulation to study labor market policy responses to sector-specific shocks. Our calibration accounts for structural differences in labor markets between the United States and the euro area, including a lower job-finding rate in the latter. We use the model to evaluate unemployment insurance and wage subsidy policies in recessions of different duration. We find that, after a temporary sector-specific shock, unemployment insurance improves both productivity and reallocation toward productive sectors at the cost of initially higher unemployment and, thus, human capital destruction. In the United States, unemployment insurance is preferred to wage subsidies when it does not distort job creation for too long. By contrast, wage subsidies reduce unemployment and preserve human capital, at the cost of limiting reallocation. In the euro area, where the job-finding rate is lower, subsidies are preferred.

Keywords: Labor Market Policies, Search and Matching Frictions, Reallocation.

JEL Classification: E24, J64, J68.

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*Federal Reserve Board: joaquin.garcia-caboherrero@frb.gov.

†Federal Reserve Board: anna.lipinska@frb.gov

‡Federal Reserve Board: gaston.m.navarro@frb.gov

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1 Introduction

Recent recessions—including the 2009 Global Financial Crisis (GFC) and the more recent COVID-19 pandemic—had heterogeneous effects across sectors. Interestingly, policy responses to these recessions varied across countries. While the United States largely supported unemployed workers by extending unemployment insurance (UI), several European countries expanded short-time work subsidies (WS) to prevent rapid job destruction in affected sectors (Giupponi, Landais and Lapeyre, 2021).

These different approaches to fight recessions raise natural questions: Which labor market policy, UI or WS, is preferable during recessions, and why did different countries opt for different policies? While both policies provide support to workers during recessions, they also have costs. On the one hand, generous unemployment benefits can deter employment, thus generating human capital losses from permanent separations—which are estimated to be large and persistent, especially during recessions (Davis and von Watcher, 2011). On the other hand, subsidizing declining sectors might prevent an efficient sectoral reallocation of workers, thus weighing on aggregate productivity (Restuccia and Rogerson, 2008). Intuitively, the tradeoff of these costs crucially depends on how quickly workers can reallocate across sectors and how persistent the recession is expected to be.

In this paper, we develop a multi-sector search and matching model to study labor market policy responses to sector-specific shocks. We focus on UI and WS policies, the two labor market policies most commonly used in recent years. The model incorporates key features to address the policy tradeoffs just discussed. We argue that labor market flexibility, as measured by labor market flows, is key to determine which policy is preferred.

Our model extends an off-the-shelf search and matching model in a few dimensions. We assume that workers accumulate job-specific human capital when employed, which is lost upon permanent separation. Firms and workers can endogenously decide to terminate a match, and thus a match duration responds to UI and WS policies. Similarly, workers can only sluggishly reallocate across sectors, making the persistence of the recession key for reallocation gains. Additionally, we assume wage rigidity, which yields inefficient separations and thus possible welfare gains from labor market policies. Finally, we add temporary lay-offs and recall, a ubiquitous feature in the U.S. labor market (Fujita and Moscarini, 2017).

We use key labor market statistics to calibrate two versions of the model: one matched to the U.S. economy and a second one matched to the euro-area economy. We label the U.S. calibration as a *flexible* economy, as it features high job-finding rates, and the euro-area calibration as a *rigid* economy, as job-finding rates are lower. We show that both calibrations deliver a good fit for each respective economy and that they are consistent with the key empirical evidence we present in this paper. In particular, we document that sectoral reallocation, measured following the index proposed by Chodorow-Reich and Wieland (2020), is higher in the United States during recessions compared to the euro area.

We use the model to evaluate UI and WS policies in a short-lived recession induced by a sector-specific shock. In particular, we aim to recreate the initial shock to the services sector during the first half of 2020, when public health restrictions led to a rapid closure of high-contact services.

Our main finding is that, in response to a short-lived sectoral shock, UI policy is preferable in the flexible economy, while WS are preferable in the rigid economy. In the flexible economy, UI policies generate a larger initial economic contraction but also a faster recovery. That is, with higher job-finding rates, UI policies promote necessary reallocation to unaffected sectors, thus achieving a faster recovery. In contrast, with lower job-finding rates in the rigid economy, UI policies do not generate such a fast recovery, making WS more appealing. We compute the welfare gains of each policy, measured as the present discount value of workers' consumption and firms' profits, net of the policy cost. Our welfare analysis shows that UI benefits consumers at the expense of firms, while WS improves welfare of firms, and to some extent, that of consumers. In the United States, UI is preferable as consumer gains more than offset firms' losses. In the euro area, firms losses from UI make this policy welfare deteriorating, making WS preferred. Thus, our results rationalize the difference in policies usually implemented in the United States versus the euro area.

Finally, we show that, while some UI policies may boost reallocation, they may also have the opposite effect if the UI increase is too generous. Generous benefits lead to larger wages and thus to lower profits for firms, which may reduce vacancy postings and job creation. This distortion effect of UI is amplified in the presence of wage rigidity and is particularly strong in persistent recessions, as firms are less willing to pay higher wages for an extended period. We argue that front-loading UI extensions may ameliorate this distortion.

Related Literature Our analysis is related to several strands of the literature that study the macroeconomic effects of labor market policies.

In terms of modeling strategy, we follow standard search and matching models of the labor market in the spirit of Shimer (2005). In addition, we introduce recall and temporary layoffs as in Fujita and Moscarini (2017), allowing firms the option to recall furloughed workers. We depart from these models by introducing an important inefficiency in terms of wage rigidities, in line with evidence from Gertler, Huckfeldt and Trigari (2020). Finally, we introduce different economic sectors that lead to labor market segmentation. This assumption results in different sectoral job-finding rates that depend on sector-specific productivity and will prove to be key in understanding the effect of labor market policies on labor reallocation in response to sectoral shocks. While several papers in the literature have used multi-sector search models (see, for instance, Chodorow-Reich and Wieland (2020) and Visschers and Carrillo-Tudela (2021)) to study the role of sectoral shocks in driving aggregate fluctuations, the aim of this paper is to study the effectiveness of labor market policies in the presence of sectoral shocks.

Our paper directly speaks to the literature that studies the role of labor market policies over the business cycle (see, for example, Gnocchi, Lagerborg and Pappa (2015) and Mitman and Rabinovich (2015)). For instance, Cacciatore and Fiori (2016) and Cacciatore, Duval, Fiori and Ghironi (2016) study the role of labor market regulations in the short run, such as a reduction in firing costs and unemployment benefits. Our analysis provides a framework to study a variety of policies not only at the aggregate level, but also by sector and to study short- versus long-run effects of these interventions. It is important to mention two recent papers that study the role of market policies, with an application to the recent COVID-19 recession. Gertler, Huckfeldt and Trigari (2021) study the effect of the Paycheck Protection Program in the U.S. labor market during the COVID-19 recession and find that this program facilitated hiring and worker recall. Birinci, Karahan, Mercan and See (2021) study the optimal labor market policy mix in response to the COVID-19 shock, and find that a joint intervention of UI and payroll subsidies is optimal. Yet, neither of these papers takes into account the tradeoff generated by these policies in facilitating labor reallocation across industries at the cost of destroying match-specific productivity, which we model explicitly and show its importance in the aftermath of a sectoral shock.

Empirically, there have been a number of studies that separately analyzed WS and UI policies. Studies on WS predominantly use European data during the 2009 financial crisis. Using Italian data, Giupponi and Landais (2018) find that when the shock is persistent adverse selection of low productivity firms prevents reallocation. In a related manner, using French data Cahuc, Kramarz and Nevoux (2018) show that WS programs were successful at supporting employment in firms that faced strong but temporary negative revenue shocks. Cooper, Meyer and Schott (2017) also find positive effects in supporting employment, but at the cost of allocative efficiency using German data. Finally, Balleer, Gehrke, Lechthaler and Merkl (2016) argue that WS programs are successful in supporting employment provided they are part of the automatic stabilizer toolkit. A more recent paper by Gehrke and Hochmuth (2021) studies the non-linear effects of WS over the business cycle, finding that these policies are not as effective outside of recessions. With regard to UI, a large literature has tried to quantify the effects of UI extensions on unemployment and workers' incentives to take jobs, finding in many case that extending UI can lead to longer unemployment episodes (see for instance Nakajima (2012) and Pei and Xie (2021)). Relative to UI design, Mitman and Rabinovich (2015) study the optimal level and duration of UI during recession of different persistence. In a COVID-19 application, Mitman and Rabinovich (2021) assess the U.S. policy, finding that a large, transitory, and front-loaded policy, similar to the one implemented in early 2020, is optimal. Finally, Ganong, Greig, Liebeskind, Noel, Sullivan and Vavra (2021) study the 2020 expansion of UI, finding that larger benefits did not lead to a strong decrease in employment.

In this paper, we take stock of both the empirical and theoretical literature to provide a structural analysis of labor market policies focusing on the selection and reallocation effects and also importance of the persistence of recessions in evaluating the policy response.

Section 2 documents empirical evidence on sectoral reallocation across countries, section 3 presents the structural model, and section 4 provides the calibration for the flexible and rigid economies. Section 5 describes the simulation of a short-lived recession for the flexible and rigid economies, as well as the model predictions on reallocation and welfare under WS and UI for these economies. Section 6 discusses the role of recession persistence and policy design in our findings. Section 7 concludes.

2 Sectoral Reallocation: Cross-Country Evidence

In this section, we document empirically how labor reallocation behaves over the business cycle and how it relates to unemployment and productivity changes. We present our results for both the euro area and the United States.

We analyze labor reallocation, relying on the reallocation index proposed by Chodorow-Reich and Wieland (2020) (hereafter, CRW index) based on employment growth dispersion across industries. In particular, reallocation across a number I of industries between t and $t+j$ is given by

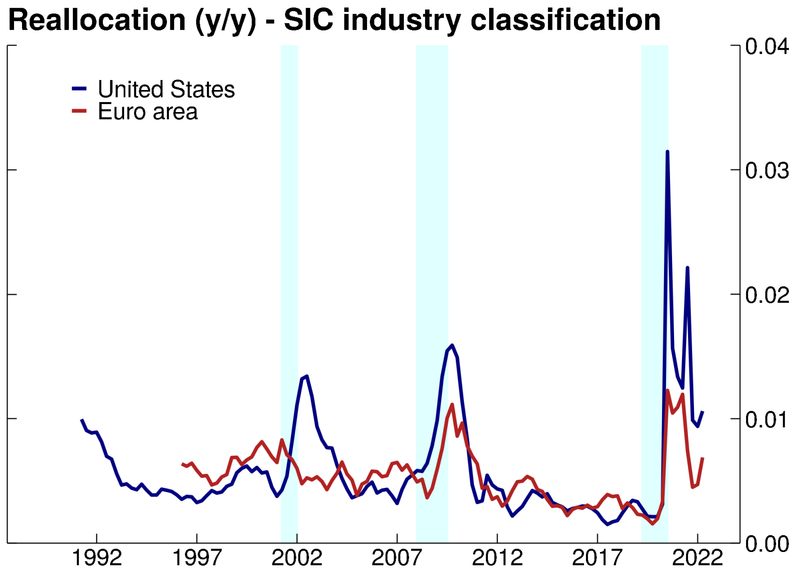
$$R_{t,t+j} = \frac{1}{2}\sum_{i}^{I} s_{i,t}\left|\frac{1+g_{i,t,t+j}}{1+g_{t,t+j}} - 1\right|. \tag{1}$$

In equation (1), g and g_i represent the aggregate and sectoral growth rates of employment e and e_i, respectively, and $s_i = \frac{e_i}{e}$ is the share of employment in sector i relative to the aggregate.[1] The index can take values between 0 and 1. $R_{t,t+j} = 0$ implies that the employment growth rate in every industry between t and $t+j$ is identical. The index takes the value $R_{t,t+j} = 1$ when all employment in existing industries at t disappears by $t+j$ and new industries with zero employment at t account for all the employment in $t+j$. We compute the index using aggregate data from 10 industries, following theStandard Industrial Classification (SIC) and homogenizing across the United States and the euro area. Data from the United States come from the Bureau of Labor Statistics and for the euro area from Eurostat. We compute year-over-year employment growth rates.[2]

[1] As argued in Visschers and Carrillo-Tudela (2021), the pre-multiplication of the index by 0.5 aims to avoid double counting from net inflows into some industries that are net outflows from other industries.

[2] We exclude employment in agriculture for these calculations. We have performed robustness in calculating this index. In particular, we have used NAICS industry classifications leading to a total of 19 industries, instead of 10. The reallocation index implied by a higher disaggregation is slightly larger, as expected, but comes at the cost of a shorter time span. We have also calculated the index with quarterly growth rates instead of year, leading to very

Figure 1: Reallocation Index: Euro Area and United States



Note: The shading indicates recessions as determined by the NBER.
Source: NBER, Statistical Office of European Communities, and Bureau of Labor Statistics, via Haver Analytics.

Figure 1 presents the comparison between reallocation indexes in the United States and the euro area. While both economies present low industry reallocation during expansions, reallocation increases during a recession. The reallocation increase is larger in the United States, relative to the euro area, and particularly sharp in the COVID-19 recession, when unemployment reached historically high peaks in the United States. Thus, the reallocation data suggest that the U.S labor market appears to be more dynamic than its euro-area counterpart.

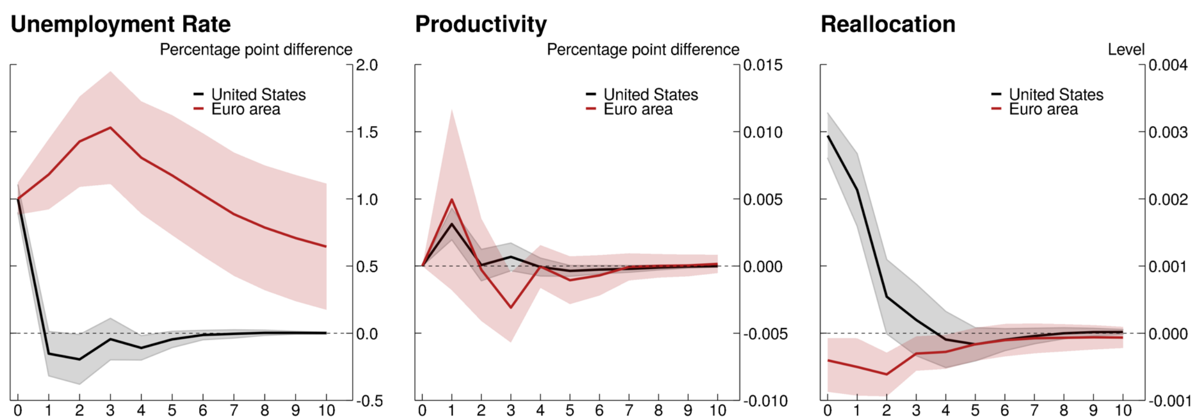
We confirm these findings when estimating a structural vector autoregression (SVAR) model, which provides a more systematic analysis of the relation between reallocation, productivity, and unemployment.[3] In particular, we use these three variables in the SVAR, which we estimate separately for the United States and the euro area. We identify shocks following a Cholesky decomposition, with variables ordered as productivity, unemployment, and reallocation. The data

similar, although slightly noisier results. These findings can be found in the appendix.

[3]We also computed the cyclical correlations between unemployment and reallocation for both economies, using a Hodrick-Prescott filter with smoothing parameter 1600. Unemployment and reallocation are highly correlated contemporaneously in the United States (0.79). In the euro area, the correlation is also positive, but weaker (0.40). We also inspected the correlation between cyclical productivity and reallocation, finding that it is contemporaneously weakly positive in the United States (0.12) and negative in the euro area (-0.60). Finally, increases in reallocation today are positively correlated with future productivity in both economies.

are quarterly and are between 1990:Q3 and 2022:Q2 for the United States, and between 1995:Q3 and 2022:Q2 for the euro area.[4] We are interested in the average behavior of the reallocation, productivity, and unemployment variables during recessions. As such, we analyze an exogenous 1 percentage point increase in unemployment, which we refer to as an "unemployment shock."[5] The results are presented in figure 2. In the United States, the unemployment shock leads to a

Figure 2: Impulse Responses to 1 pp Unemployment Shock in the Euro Area and the United States



Note: Shading represents the 90% confidence interval. Productivity is defined as output per employee and reallocation is constructed following Chodorow-Reich and Wieland's (2020) methodology.

contemporaneous sharp increase in U.S. unemployment, which quickly reverts back to zero. At the same time, U.S. productivity and reallocation increase after the unemployment shock. In the euro area, interestingly, the unemployment shocks lead to a more persistent increase in unemployment. Productivity does not strongly react—the 90 percent confidence interval around the impulse response of productivity always contains zero—while reallocation mildly decreases for a couple of periods.

UI policies typically implemented in the U.S. tend to boost unemployment and reallocation more than the WS policies typically implemented in the euro area. In order to understand the exact role of both institutions and policies we develop a structural model in the next section. Our goal is to assess the effectiveness of the WS and UI policies in response to sector-specific shocks, and quantify the winners and losers from the two policy choices in labor markets with different

[4]See the appendix for more details on data sources and computations.

[5]This unemployment shock may represent any combination of shocks that increase unemployment while not affecting productivity contemporaneously.

institutions.

3 Model

In this section, we present a multi-sector search and matching model of the labor market. We assume workers accumulate job-specific human capital while employed, and they can decide whether to leave or stay with the match at any time. Firms can also decide whether to temporarily or permanently separate from workers. Job-specific human capital is preserved when firms recall workers on temporary layoff but is lost when the separation is permanent. Workers can move across sectors, but reallocation is sluggish due to matching frictions and because searching in a different sector only occurs with a certain probability. Finally, matches are subject to wage rigidity, and thus productivity changes do not immediately pass through to wages. We provide a more detailed description in the next subsection.

3.1 Environment

Time is discrete, infinite, and indexed by $t = 1, 2, \ldots$. The economy is populated by a continuum of workers and firms. Firms post vacancies in order to find workers. The cost of a vacancy is κ and the probability of contacting a worker is q_t. Firms belong to a sector indexed by s, and we assume there are two sectors in the economy: $s = 1, 2$. Upon forming a match, the firm and the worker draw a match-specific productivity z_0 distributed according to $G(z_0)$. We consider deterministic transition dynamics where agents have perfect foresight, and we use time t to denote the aggregate state of the economy.

A match can be either active or idle. We refer to a worker in an idle match as in temporary unemployment or furlough. The match-specific productivity evolves stochastically following a Markov chain: $z' \sim P^a(z'|z)$ for active matches and $z' \sim P^i(z'|z)$ for idle matches. Under both processes $P^a(z'|z)$ and $P^i(z'|z)$, a productivity of $z = 0$ is an absorbing state—akin to an exogenous separation. When the match dissolves permanently, either exogenously or endogenously, z is lost. The output of an active firm produces an match at is given as: $y_t(s, z) = x_t(s)z$, where $x_t(s)$ is the sector-specific productivity.

Active matches re-set wages subject to a Calvo-style friction. New matches have flexible wages given initial productivity z_0 and sectoral productivity $x(s)$. After observing the realized match and sectoral productivity, z and x, a match re-sets wages with probability λ. After the wage-setting stage, the worker decides whether to stay in the match or quit. If the worker decides to stay, the firm has the next move and has three options: to remain active, to remain idle, or to terminate the match. If the match remains active, output is produced, the worker gets wage w, and the operating cost c_o must be paid. If the match is idle, the worker goes into temporary unemployment, no wages are paid, and the firm faces a cost c_i of keeping the idle match. At any point, a furloughed worker can be either recalled or terminated at no cost to the firm. If the match is terminated, the firm ceases to exist.

Unemployed workers can be either in furlough or unmatched. They are attached to the last sector where they worked, s, and search for a job in sector $\tilde{s}$ with probability $\pi_u(s, \tilde{s}) \leq \pi_u(s, s)$—which may differ across furloughed and unmatched workers, $u = U, F$. The probability that a worker contacts a firm is sector-specific and given by $f_t(s)$. There is no cost of searching while unemployed, and job offers can be rejected. Unemployed workers receive benefits b_t that do not expire.

The timing of events is as follows: (1) productivity shocks are realized, (2) unemployed and furloughed workers search for jobs and matching occurs, (3) wage renegotiation occurs with probability λ, (4) employed and furloughed workers decide whether to stay in the match or quit, (5) remaining matches decide whether to be active, idle, or exit, and (6) production and consumption takes place. All of the following value functions below are written at point (6).

3.2 Search and Matching Technologies

Firms direct vacancies toward each sector s—that is, markets are segmented. Let be v number of vacancies posted in sector s, and n the number of workers searching for a job in that sector—including unmatched and furloughed workers. The total number of matches is then given by the constant-return-to-scale matching function with matching efficiency ϕ (as in den Haan, Ramey and

Watson (2000)):

$$m = \frac{\phi n v}{[n^\eta + v^\eta]^{\frac{1}{\eta}}}. \tag{2}$$

The worker's job-contact probability f and the firm's worker-contact rate q are given by

$$f(s) = \frac{m}{n} \qquad q(s) = \frac{m}{v}. \tag{3}$$

Market tightness $\theta(s)$ is defined as the ratio of vacancies to searchers: $\theta(s) = v/n$.

3.3 Firms

Let $J_t(z, w, s)$ be the maximal attainable value for a firm in an active match with productivity z, wages w, and sector s, at time t. Analogously define $V_t(z, w, s)$ as the value for a firm in an idle match. The value for an active firm is

$$J_t(z, w, s) = \Pi + \beta \mathbb{E}_t \left[\left(1 - \eta^a_{t+1}(z', w', s)\right) \max \left\{ J_{t+1}(z', w', s), V_{t+1}(z', w', s), 0 \right\} |z \right] \tag{4}$$

$$\Pi = y_t(z, s) - (1 - \sigma_t) w - c_o$$

$$w' = \begin{cases} w & \text{w.p. } \lambda \\ w^*_{t+1}(z', s) & \text{w.p. } 1 - \lambda \end{cases} \tag{5}$$

where $\eta^a_t(\cdot)$ is the quitting decision of a worker in an active match. The firm's profits, Π, are given by output net of wages and operating costs, including the subsidy to the wage bill σ_t. The continuation value in (4) shows an active firm's three options each period: continue the match, set the match to be idle, or terminate the match. The next-period wage w' adjusts with probability $1 - \lambda$, in which case it is set with a rule $w^*_t(\cdot)$, which we discuss in more detail later.

The value for firm in an idle match is

$$V_t(z, w, s) = -c_i + \beta \mathbb{E}_t \left[\left(1 - f^i_{t+1}(z', w, s)\right) \left(1 - \eta^i_{t+1}(z', w', s)\right) \max \left\{ J_{t+1}(z', w', s), V_{t+1}(z', w', s), 0 \right\} |z \right] \tag{6}$$

where $\eta_t^i(\cdot)$ is the quitting decision of a worker in an idle match, and $f_t^i(\cdot)$ is the probability that an idle/furloughed worker will find and accept another job—we will return to this topic later. Note that the continuation value for an idle firm in equation (6) is the same as for an active firm, although the stochastic process for z may be different.

Let $e_t^a(z, w, s)$ be the decision of a firm to exit an active match, and $d_t(z, w, s)$ the decision to set a match to be idle. Similarly, let $e_t^i(z, w, s)$ be the decision to exit an idle match and $r_t(z, w, s)$ the decision to recall an idle worker. These decisions are given as

$$e_t^a(z, w, s) = \begin{cases} 0 & \text{if } \max\{J_t(z, w, s), V_t(z, w, s)\} \geq 0 \\ 1 & \text{otherwise} \end{cases} \tag{7}$$

$$d_t(z, w, s) = \begin{cases} 0 & \text{if } J_t(z, w, s) \geq V_t(z, w, s) \\ 1 & \text{otherwise} \end{cases} \tag{8}$$

$$e_t^i(z, w, s) = e_t^a(z, w, s) \tag{9}$$

$$r_t(z, w, s) = 1 - d_t(z, w, s). \tag{10}$$

That is, a firm terminates the match if the values of being active or idle are both below zero, and the firm make a match idle when the value is larger that being active.

3.4 Workers

Let $W_t(z, w, s)$ be the maximal attainable value for a worker in an active match with productivity z, wage w, and sector s, at time t. Analogously define $F_t(z, w, s)$ as the value of a worker in an idle match. Let $U_t(s)$ be the value of being unemployed when attached to sector s. The value of being in an active match is given as

$$W_t(z, w, s) = w + \beta \mathbb{E}_t \left[\max \left\{ \hat{W}_{t+1}(z', w', s), U_{t+1}(s) \right\} |z \right] \tag{11}$$

where next-period wages, w', are given as in equation (5). The continuation value in equation (11) is the maximum between quitting (being unemployed) or staying in the match. The value of staying in the match, $\hat{W}_t(z,w,s)$, is given as

$$\hat{W}_t(z,w,s) = (1-e^a_t(z,w,s))\left\{(1-d_t(z,w,s))W_t(z,w,s) + d_t(z,w,s)F_t(z,w,s)\right\} \qquad (12)$$
$$+ e^a_t(z,w,s)U_t(z,w,s).$$

Thus, the value of staying in a match accounts for the exit and idle decisions, $e^a_t(\cdot)$ and $d_t(\cdot)$, which the firm will make later in the period.

While idle, a furloughed worker receives unemployment benefit b and searches for jobs at intensity $\zeta < 1$. The probability of finding a job in sector $\tilde{s}$ is the compound of the job-finding probability $f_t(\tilde{s})$ times the probability of switching sectors $\pi_F(s,\tilde{s})$. Upon receiving and accepting an offer, the worker starts with initial productivity z_0 and wages w_0. When recalled, the worker returns to the same wage w they had before. Thus, the value $F_t(z,w,s)$ of being in an idle match is given as

$$F_t(z,w,s) = b_t + \beta\mathbb{E}_t\Bigg[\sum_{\tilde{s}}\pi_F(s,\tilde{s})\Bigg((1-\zeta f_{t+1}(\tilde{s}))\max\left\{U_{t+1}(s),\hat{F}_{t+1}(z',w,s)\right\} \qquad (13)$$
$$+ \zeta f_{t+1}(\tilde{s})\int\max\left\{W_{t+1}(z_0,w^*_{0t},\tilde{s}),\max\{\hat{F}_{t+1}(z',w,s),U_{t+1}(s)\}\right\}dG(z_0,s)\Bigg)|z\Bigg]$$

where $w^*_{0t} = w^*_t(z_0,s)$ is the initial wage of a newly formed match, and $\hat{F}_t(z,w,s)$ is the value of staying in the idle match as

$$\hat{F}_t(z,w,s) = (1-e^i_t(z,w,s))\left[r_t(z,w,s)W_t(z,w,s) + (1-r_t(z,w,s))F_t(z,w,s)\right] \qquad (14)$$
$$+ e^i_t(z,w,s)U_t(s)$$

which incorporates the exit and recall decisions, $e^i_t(\cdot)$ and $r_t(\cdot)$, which the firm will make later in the period.

We can now compute $f^i_t(\cdot)$, the probability that a furloughed worker will find and accept a job offer, which we use in equation (6) to define the value of a firm in an idle match. In particular, the probability $f_t^i(\cdot)$ is given as

$$f_t^i(z,w,s) = \sum_{\tilde{s}} \pi_F(s,\tilde{s})\zeta f_t(\tilde{s}) \int \mathbb{I}\left\{W_t(z_0, w_{0t}^*, \tilde{s}) > \max\{\hat{F}_t(z', w, s), U_t(s)\}\right\} dG(z_0, s) \tag{15}$$

where $\mathbb{I}\{\}$ is an indicator function. Thus, the probability $f_t^i(\cdot)$ compounds the probability that a worker searches in sector $\tilde{s}$ and receives an offer better than staying furloughed.

Finally, the value of being unemployed for a worker attached to sector s is given as

$$\begin{aligned} U_t(s) = b_t + \beta \sum_{\tilde{s}} \pi_U(s,\tilde{s}) \Bigg(& f_{t+1}(\tilde{s}) \int \max\left\{W_{t+1}(z_0, w_{0t}^*, \tilde{s}), U_{t+1}(s)\right\} dG(z_0, s) \\ & + (1 - f_{t+1}(s'))U_{t+1}(s) \Bigg). \end{aligned} \tag{16}$$

The quit decisions for workers in an active and idle match, $\eta_t^a(\cdot)$ and $\eta_t^i(\cdot)$, are given as

$$\eta_t^a(z,w,s) = \begin{cases} 0 & \text{if } W_t(z,w,s) \geq U_t(s) \\ 1 & \text{otherwise} \end{cases} \tag{17}$$

$$\eta_t^i(z,w,s) = \begin{cases} 0 & \text{if } F_t(z,w,s) \geq U_t(s) \\ 1 & \text{otherwise.} \end{cases} \tag{18}$$

3.5 Wage Setting

Wages are set following a simple rule that splits the (discounted) per-period flows of profits and unemployment benefits. In particular, the re-set wage $w_t^*(z,s)$ function is given as

$$w_t^*(z,s) = \omega \bar{\Pi}_t(z,s) + (1-\omega)\bar{b}_t \tag{19}$$

where $\bar{\Pi}_t(z,s)$ and $\bar{b}_t$ are given as

$$\begin{aligned} \bar{\Pi}_t(z,s) &= \sum_{j=0}^{n} \mathbb{E}_t\left[\Omega_{t+j}(y_{t+j}(z_{t+j}, s) - c_o)|z\right] \\ \bar{b}_t &= \sum_{j=0}^{n} \Omega_{t+j} b_{t+j} \end{aligned}$$

where weights $\Omega_{t+j} \geq 0 \ \forall j$ and $\sum_{j=0}^{n} \Omega_{t+j} = 1$.

This wage rule is similar to a static Nash bargain that splits current profits, with ω akin to the worker's bargaining power. However, because wages are re-set infrequently, the values $\bar{\Pi}_t$ and $\bar{b}_t$ also incorporate expected future paths for productivity and benefits. As in Cooper *et al.* (2017),we assume the subsidy does not enter the division of surplus between the firm and worker. However, current or expected increases in benefits do pass through to wages.

Our wage specification is an alternative to setting wages via Nash bargaining over the firm's and worker's value functions. In the presence of wage rigidity, Nash bargaining over values would be computationally intensive, especially with heterogeneous productivity across workers and multiple sectors. Our simple rule is meant to ease the computational burden in an economically intuitive manner.

3.6 Free Entry

Let $\mu_t^W(z, w, s)$ be the measure of workers in an active match with productivity z and wages w in sector s at time t. Analogously define $\mu_t^F(z, w, s)$ as the measure of workers in an idle match, and let $\mu_t^U(s)$ be the measure of unmatched workers.

Let $n_t(s)$ be the number of workers searching for a job in sector s. Let $\mathcal{M}_t^F(s)$ and $\mathcal{M}_t^U(s)$ be the number of furloughed and unmatched workers who would accept a job offer if they were to receive one. Then

$$n_t(s) = \sum_{\tilde{s}} \left\{ \pi_U(\tilde{s}, s)\mu_t^U(\tilde{s}) + \pi_F(\tilde{s}, s)\zeta \int d\mu_t^F(z, w, \tilde{s}) \right\}$$

$$\mathcal{M}_t^F(z_0, s) = \sum_{\tilde{s}} \pi_F(\tilde{s}, s)\zeta \int \mathbb{I}\left(W_t(z_0, w_{0t}^*, s) \geq \hat{F}_t(z, w, \tilde{s}) \right) d\mu_t^F(z, w, \tilde{s})$$

$$\mathcal{M}_t^U(z_0, s) = \sum_{\tilde{s}} \pi_U(\tilde{s}, s)\mathbb{I}\left(W_{t+1}(z_0, w_{0t}^*, s') \geq U_t(\tilde{s}) \right) \mu_t^U(\tilde{s})$$

where we set w_{0t}^* as a function of z_0.

The free entry condition for job creation is given as

$$\kappa = q_t(s)\left[\int_{z_0} \max\left\{J_t(z_0, w_{0t}^*, s), 0\right\} p_t(z_0, s) dG(z_0, s)\right] \tag{20}$$

where $p_t(z_0, s) = \frac{\mathcal{M}_t^F(z_0,s)+\mathcal{M}_t^U(z_0,s)}{n_t(s)}$ is the probability that the worker accepts an offer. Equation (20) equates the cost of creating a vacancy to the expected profit of finding a worker. Note that, upon the realization of the initial productivity z_0, the firm can decide not to create the position.

3.7 Equilibrium

We define a recursive equilibrium in this model as (i) a set of value functions: J, V, W, F, and U; (ii) separation, idle, and recall decisions for the firm: e^a, d, e^i, and r; (iii) a quitting decision for the workers: η^a, and η^i; and (iv) a distribution of workers across states and sectors μ^W, μ^F, and μ^U such that the firm's and worker's decisions are optimal and the free entry condition is satisfied.

4 Quantitative Analysis: Flexible versus Rigid Labor Markets

For the quantitative analysis, we extend the model from the previous section by including a set of Gumbel shocks for firm and worker decisions. These decisions resemble those in discrete choice models, and the shocks help smooth the computational burden. We describe the full model with Gumbel shocks in the appendix and proceed to the calibration next.

4.1 Calibration and Model Assessment

In this section, we assess the ability of the model to replicate common labor market features and to account for structural differences in labor markets across countries. For this reason, we provide two calibrations for the economy in steady state: one that aims at replicating the U.S. (*flexible*) labor market's more prominent features and a second one for the euro-area's (*rigid*) labor market. Next, we describe the common parameters and the labor market specific calibration for these two economies.

4.1.1 Common Parameters across Labor Markets

The calibration is monthly. Common parameter choices across labor markets are summarized in Table 1 and described next. Firm's and workers discount the future at a monthly rate of $\beta = 0.99^{1/3}$, consistent with a 4 percent annual interest rate. We assume there are two sectors that are symmetric in steady state. There exists an exogenous separation probability for active matches of 1.4 percent at a monthly frequency in each sector. Moreover, furloughed and unemployed workers continue searching in the same sector with a monthly probability of $\pi_F(s, s) = 0.75$ and $\pi_U(s, s) = 0.50$, respectively in line with empirical findings (see, for instance, Visschers and Carrillo-Tudela (2021), supplemental appendix B). We set furloughed workers' search efficiency to $\psi = 0.75$ relative to unemployment to account for the lower effort exerted by those furloughed relative to permanently unemployed in looking for new jobs. For wages, we set $n = 8$ and the forward-looking weights in the wage function $\Omega_{t+j} \quad \forall j \in (0, n)$ to be 1/9. We set the firm's bargaining power $\omega = 0.55$, which generates an elasticity of wages relative to a change in unemployment benefit b as reported in Mitman and Rabinovich (2015). We set the matching function elasticity η to be 1.50, in line with Schaal (2017) and Blanco and Navarro (2017)

We assume match productivity z follows an AR(1) process with long-run productivity $\bar{z}$, persistence ρ^z, and variance σ^z, as

$$\ln z_t = (1 - \rho^z)\bar{z} + \rho^z \ln z_{t-1} + \sigma^z \epsilon_t. \tag{21}$$

We follow Kehoe, Midrigan and Pastorino (2019) and set $\bar{z} = 2.7$, $\rho^z = 0.995$, and $\sigma^z = 0.065$. We discretize the process for z into a Markov process with 90 points using Tauchen's method. We calibrate the initial productivity value z_0 as $0.65\bar{z}$.

4.1.2 Calibration: Parameterizing Two Distinct Labor Markets

We turn next to describing the choice of parameters that will characterize two economies with labor market structural differences: the United States (which we refer to as a flexible economy) and the euro area (rigid economy). For each economy, there are two sets of parameters, some externally

Table 1: Calibration: Common External Parameters

Parameter	Description	Value
β	Discount factor	$0.99^{1/3}$
δ	Monthly exogenous separation rate: Active	0.014
η	Matching function elasticity	1.50
ω	Firm's bargaining power	0.55
π_F	Rate of sectoral persistence: Furloughed	75%
π_U	Rate of sectoral persistence: Unemployed	50%
ψ	Search efficiency idle	0.75
$\bar{\mu}$	Long-run match productivity	2.7
ρ_z	Persistence match productivity	0.995
σ_z	Std. dev match productivity	0.065

set, shown in Table 2, and the remaining internally calibrated by solving the model to target some distinct moments of each labor market, shown in Table 5. We set five external parameters to characterize each economy: the monthly workers' job contact rate (f) and firms' contact rate (q) in each sector, the probability of re-bargaining wages every period (λ), and the baseline labor market policies for UI (b) and WS (σ) in steady state.[6]

Table 2: Calibration: External Parameters - Flexible and Rigid Economies

Parameter	Description	Flex value	Rigid value
f	Worker's job contact rate	45%	20%
q	Firm's contact rate	70%	50%
λ	Probability of wage adjustment	1/9	1/13
b	Unemployment insurance	0.40	0.65
σ	Wage subsidy to firms	0%	0%

The seven remaining parameters are set to match eight data moments. These parameters are all jointly estimated. In particular, we estimate the monthly separation rate from furlough into unemployment, δ_F, as well as the Gumbel shocks received by firms when making their active/idle/separation decisions $\rho_{J,V}$ and $\rho_{M,0}$; active and furloughed workers' quitting decisions

[6]Given the values for f and q, we obtain a value for matching efficiency ψ and vacancy cost κ in each labor market. We estimate ψ to be 0.92 and 0.58, and κ to be 5.31 and 4.75 in the flexible and rigid markets, respectively.

$\rho_{W,U}$ and $\rho_{F,U}$; and furloughed and unemployed workers decisions to accept new jobs ρ_{H,W_0} and ρ_{U,W_0}, respectively. In terms of data moments, we present the full set of moments and associated values in Table 3 and briefly describe them next. We target the average unemployment rate for each economy (5.8 percent for the United States and 9.5 percent for the euro area) as well as the stock of workers in permanent unemployment and those in temporary layoffs.[7] We also target transitions in and out of furlough, and, particularly for the United States we target the reported transitions in Gertler *et al.* (2021). For the last two moments we target the monthly transition rates from unemployment to employment, a standard value in the literature for the United States (Shimer (2012) and Gertler *et al.* (2021)), and we take the mid-range of the estimates presented by Balleer *et al.* (2016) and Hobijn and Şahin (2009) for the euro area. Finally, we target a pure recall rate from furlough of 76 percent in both economies, which is in the mid-range of the non-imputed and imputed values reported by Fujita and Moscarini (2017) for temporary layoff workers (we use recall rates excluding permanent separators, as, in our model, these workers do not have a recall option). The estimated parameters are presented in Table 5 in the appendix.

4.1.3 Model Assessment: Flexible Labor Market

We next assess the predictions of the calibrated flexible labor market model in steady state. The results are presented in Table 3. The calibrated model provides a good fit for the U.S. labor market. In terms of targeted moments, the model replicates the total unemployment rate and decomposition between permanently unemployed and furloughed workers. We find a monthly transition probability from furlough to employment of 60.1 percent, slightly higher than in the data, but we do a good job in matching that, among furloughed workers returning to active employment, 78.5 percent of those transitions are driven by recalls. This result implies that, given the job-contact rate and search effectiveness, actual job-to-job transitions account for only 21.5 percent of furlough transitions to employment. We find a transition probability from unemployment to employment of 45 percent; hence, there are virtually no rejections of employment offers from unemployed workers in steady

[7] These moments are calculated from the Current Population Survey (CPS) averages between 1990 and 2019 for the United States and from Eurostat averages during the 1998-2019 period for the euro area, and pulled via Haver Analytics.

state, as all workers start with the same initial productivity z_0 and wage w_0. The model also successfully matches the data in moments that were not originally targeted. In particular, the rate of monthly total transitions in each sector from employment to unemployment is 2.3 percent, in line with Kehoe *et al.* (2019) using CPS data. Given our calibrated exogenous separation rate, the monthly rate for endogenous separations is 0.9 percent. We obtain a replacement rate of UI relative to newly employed workers of about 35 percent (Shimer, 2005), as is regularly assumed for the United States, and the profit share for the newly hired, w_0/π, accounts for about 51 percent of the profit of the firm.

Table 3: Model Assessment: Flexible and Rigid Economies Targeted Moments

Moment	Description	Flex data	Flex model	Rigid data	Rigid model
$U+I$	Total unemployment rate	5.84%	5.82%	9.52%	9.52%
U	Permanent unemployment rate	5.09%	5.11%	9.47%	9.48%
I	Temporary unemployment rate	0.75%	0.71%	0.05%	0.04%
$U-E$	Job acceptance rate	30.00%	45.00%	20.00%	20.00%
$F-E$	Furlough-to-employment rate	48.10%	60.10%	10.00%	15.13%
$F-U$	Furlough-to-unemployment rate	20.70%	22.78%	80.00%	74.70%
$F-F$	Furlough-to-furlough rate	31.20%	17.12%	10.00%	10.17%
Recall	Recall rate from furlough	75.70%	78.48%	75.70%	57.10%

4.1.4 Calibration: Rigid Labor Market

We next describe the calibration and model assessment of a more rigid labor market in terms of policies and employment protection relative to the United States. We target the euro-area economy for this exercise. As in the previous economy, we have two sets of parameters: one is set externally to common values in the literature and data, and we estimate the other set internally to match some data moments. The five externally set parameters are displayed in the right column of Table 2. The monthly job contact rates for workers and firms are set to 20% and 50% respectively, implying longer unemployment episodes in European economies relative to the United States, and in line with empirical findings by Hobijn and Şahin (2009). We assume the wage duration is also longer–meaning higher rigidity–and set $\lambda = 1/13$. This assumption is in line with the evidence presented by Lamo and Smets (2010), that documents an average duration of wages of 15 months. In terms of policies, UI is more generous, so we set $b = 0.65$, and we keep assuming that there is no subsidy in steady state.

The seven remaining parameters are set to match the same data objects as in the U.S. calibration, with some of them taking different values compared to the United States. In this case, we target an average unemployment rate that matches the average euro-area unemployment rate of 9.52 percent during the 1998–2019 period, and we put virtually all the unemployed workers in permanent unemployment (9.47 percent) to match the infrequent use of temporary layoffs in the euro area, where employment protection usually requires consensus between firms and workers' representatives for these types of separations. We target monthly transition rates from furlough to employment of 10 percent and from furlough to unemployment of 80 percent. This calibration increases employment rigidity by not allowing furloughs to be a realistic option firms can use to manage their workforce in the euro area compared to the United States. Finally, we target an unemployment-to-employment monthly flow rate of 20 percent, in the mid-range of the estimates presented by Balleer *et al.* (2016) and Hobijn and Şahin (2009), and the same recall share assumed in the U.S. exercise. The estimated parameters for the rigid calibration are presented in the last two columns of Table 5 in the appendix.

4.1.5 Model Assessment: Rigid Labor Market

The model predictions for the rigid economy are presented in the last two columns of Table 3. Once again, the model does a good job of replicating the main labor market outcomes from the euro-area economy. Specifically, we match the unemployment rate very well, and there is an almost negligible fraction of workers in temporary unemployment. We also assess the performance of the model relative to non-targeted moments. The sectoral monthly separation rate is 2.1 percent, which is very similar to the U.S. estimate and in line with the findings from Hobijn and Şahin (2009) that most of the unemployment differences between these economies arise from differences in job-finding rates, not separation rates. It is important to highlight that the replacement rate of UI relative to newly employed workers is higher compared with the flexible economy, resulting in wages representing a larger fraction of a firm's output and reduced profit margins for firms.

5 Model Simulation: A Crisis Experiment

We analyze a short-lived recession that results in an abrupt decrease in output and a rapid increase in unemployment. We aim to recreate the initial shock to the services sector—as well as the initial policy response—observed in the first half of 2020, when public health restrictions aimed at containing the spread of the COVID-19 virus led to a rapid closure of high-contact services. That is, we do not target the whole COVID-19 recession, as many other factors and subsequent closures played a role in the recovery of the economy, but just the initial sectoral shock. Thus, we assume that sectoral productivity x in only one of the sectors falls by Δ_x and returns at rate ρ: $x_1 = \mu_x(1 - \Delta_x)$, and $x_t = (1 - \rho)\mu_x + \rho x_{t-1}$ $\forall t \geq 2$. The other sector remains unaffected. In the flexible labor market, we set $\Delta_x = 0.225$ and $\rho = 0.75$, which generates a 9 percentage point unemployment increase, as observed at the start of the COVID-19 recession in the United States. The flexible labor market calibration includes an extension of the UI policy for about four months that more than doubles the replacement rate for new workers and then returns to the standard amount. This type of UI extension is similar to the policy adopted in the United States at the start of the COVID-19 recession, and the cost of the policy amounts to 1 percent of GDP.[8] In the rigid labor market, we set $\Delta_x = 0.37$ and $\rho = 0.75$, in order to target an unemployment increase of about 0.9 percent. The calibration of the rigid labor market economy includes WS policy for 12 months, amounting also to a cost of 1 percent of GDP. [9] The calibration of the rigid economy aims at mimicking the dynamics of a euro-like labor market and policies adopted at the beginning

[8]Our calibration intends to mimic the introduction of the extension, which took place in mid-April and lasted through the end of July 2020. For that reason, we give workers only half of the more generous extension during the first month and the complete, twice-as-large replacement rate in the next three months. In the figures and the remainder of the paper, we denote this policy as UI extension, but we acknowledge that this policy is a temporary increase in UI. The reported cost of the extended policy (see Ganong *et al.* (2021)) is about 1 percent of annual GDP.

[9]For comparability across exercises, we also use 1 percent as the relevant policy cost. Moreover, this is in line with expenditures during the first 12 months after the COVID-19 shock in countries such as Spain (see "https://www.lamoncloa.gob.es/serviciosdeprensa/notasprensa/trabajo14/Paginas/2021/050521-paroregistrado.aspx") and Germany, as reported in "https://www.economist.com/business/2021/06/26/german-firms-are-conflicted-about-the-kurzarbeit-furlough-scheme". This leads to an implied subsidy of 4 percent to the wage bill for all active firms.

of the COVID-19 recession.[10]

In both the flexible and rigid labor market, we analyze the predictions of the model under three policy alternatives: (a) our benchmark calibration with baseline UI, (b) the UI extension, and (c) WS policy only to the affected sector (sector 2) that lasts for 12 months.

5.1 Policy Alternatives in a Flexible Labor Market

As can be seen in Figure 3, a negative productivity shock results in a strong contraction in output accompanied by a spike in unemployment, increasing both permanent and temporary layoffs. Importantly, the UI extension (light blue line) leads to the strongest contraction on impact but to the fastest recovery afterwards among the three policy alternatives considered.

The UI extensions leads to an initial strong economic contraction because it leads to higher wages, as the top-right panel of Figure 3 shows. Higher wages increase the measure of firms who decide to separate from workers, either permanently or temporarily (furloughed). Additionally, in the presence of rigid wages, many employed workers quit to find jobs with higher wages. Quits are larger in the affected sector but also occur in the unaffected sector.

The job-finding rate decreases sharply in the affected sector, reflecting its lower productivity. Interestingly, the job-finding rate also declines in the unaffected sector, though much less sharply. The reason is that, after the shock, a larger share of unemployed workers are furloughed, and they reject job offers in hopes of being recalled.

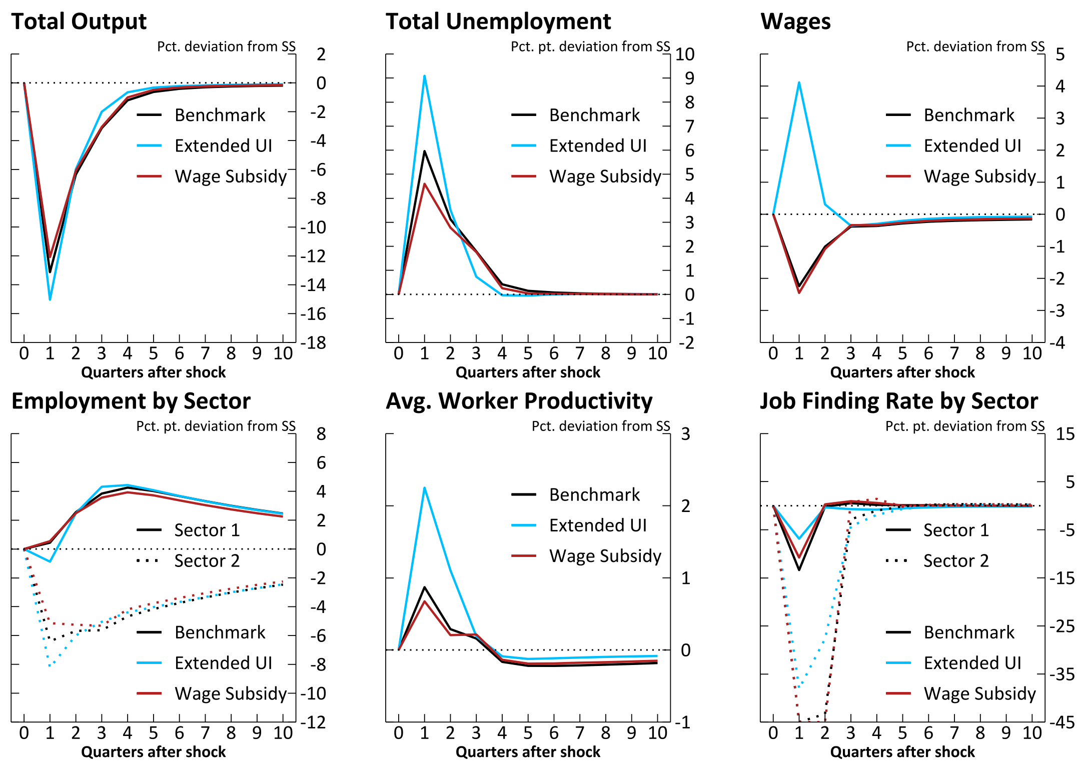
The UI extension leads to a smaller decline in the job-finding rate. The UI extension front-loads quits initially, but later decreases them below the steady state as the economy recovers. As such, firms' expected value of a new job is higher, and thus the number of job posting is higher than in the benchmark policy. At the same time, the average match productivity increases (in line with the cleansing effect), which further helps to speed up the recovery, even as new matches are formed.

A WS policy only to the affected sector[11] reduces temporary layoffs and prevents permanent job destruction (upper-middle panel of Figure 3), resulting in a smaller increase in unemployment.

[10] In the appendix, we present an additional quantitative example of a prolonged recession with a smaller initial shock, which is more similar to the 2008–09 crisis.

[11] A WS cost-neutral policy compared to the UI policy in the flexible economy is given by a 4.5 percent subsidy for all active firms.

Figure 3: Flexible Economy: Policy Alternatives in the Short-Lived Recession



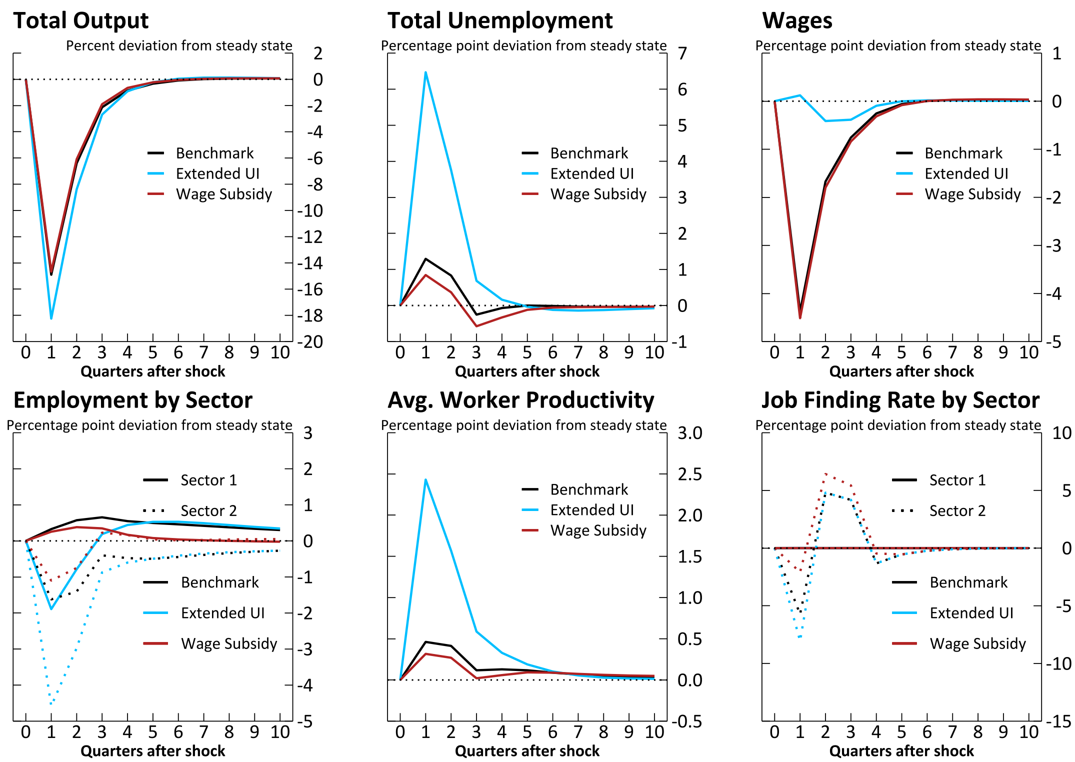
Sector 1 refers to the unaffected sector and sector 2 the sector affected by the shock.

The WS policy leads to a smaller contraction in output, but at the cost of lower labor productivity (lower-middle panel of Figure 3). As low-wage, low-productivity jobs are profitable under the subsidy, there is less of a cleansing effect associated with the recession, and both wages and match productivity fare worse than both the UI and benchmark policies. Overall, the differences between benchmark and WS policies are small, as in this economy firms can always recall furloughed workers as the shock wanes.

To sum up, the UI extension and WS policies produce a tradeoff between higher/lower unemployment and lower/higher productivity. At the same time, as we show in more detail in the following, the UI policy benefits consumers at the expense of firms, while the WS policy protects firms' profits.

5.2 Policy Alternatives in a Rigid Labor Market

Figure 4: Rigid Economy: Policy Alternatives in the Short-Lived Recession



Sector 1 refers to the unaffected sector and sector 2 the sector affected by the shock.

Figure 4 shows the rigid economy response. While the output contraction is similar to that in the flexible economy, unemployment increases less in the rigid economy but takes about the same time to return to its steady-state level. In this economy with low job-finding rates, small increases in unemployment can have persistent effects (Duval and Vogel, 2008). Recall that, in the rigid economy, unemployment is mainly composed of permanent separators, since temporary layoffs and subsequent recall are not possible.

The WS policy (red line) produces a contraction in output similar to the benchmark policy but succeeds in stemming persistent increases in unemployment. Under this policy, unemployment increases for only a couple of quarters relative to steady state, but it overshoots and temporarily declines below its long-run value. The overshoot occurs because, despite the productivity shock, WS policy increases firms' profits, thus leading to more vacancy postings and higher job-finding rates. Note that in this economy, where furloughs are not available, WS alleviate firm's wage bill while keeping workers employed and increasing firms' flexibility.

Compared to the flexible economy, the UI policy results are less attractive in the rigid economy, as it leads to a stronger output contraction but does not result in a faster recovery.[12]. Unemployment in particular takes longer to recover because of a lower job-finding rate and the absence of a recall option.

As in the previous example, the unemployment–productivity tradeoff still exists under these policies. However, firms' losses from permanent separations in the rigid economy will become larger and more persistent. For this reason, WS policy seems ex-ante a preferred option, as it protects firms' profits, which we discuss in more detail below.

5.2.1 Labor Market Policies and the CRW Reallocation Index: Model Predictions

We apply the CRW reallocation index to our model simulated data for the flexible and rigid economies. As Figure 5 shows, our crisis experiment leads to higher reallocation in both economies, consistent with our empirical findings. Moreover, the model predicts lower reallocation in the rigid economy compared with the flexible economy, also in line with the evidence presented.

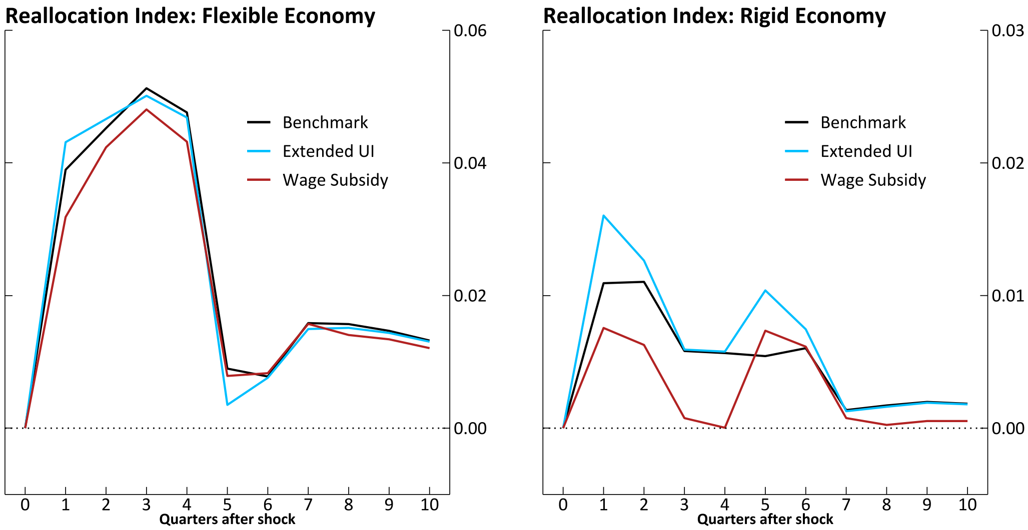
As discussed earlier, UI policy and WS policy have opposite effects on unemployment, with the former encouraging quits and separations and the latter preventing job destruction. Consistently, UI policy leads to larger initial reallocation, while WS policy does the opposite. Yet, the reallocation increase using UI policies would be smaller in the rigid economy than in the flexible one, showing that both policies and labor market features explain the difference in reallocation found empirically between the United States and the euro area.

5.2.2 Welfare Quantification

We quantify the welfare implications of UI and WS policies. We define total welfare as a sum of the present discounted value of consumption (PDVC) for the measure of workers (employed and

[12]A UI cost-neutral policy compared to the WS policy in the rigid economy is given by a 21 percent increase in the replacement rate during the first month, followed by 42 percent increase in the three remaining months of UI extension.

Figure 5: CRW Index in the Short-Lived Recession: Model



unemployed) and the present discounted value of profits (PDVP) for the measure of firms minus the discounted cost of policy (PD cost).[13] We present our results for both the flexible and rigid economy in Table 4.

Table 4: Welfare Comparison: Percentage Loss Relative to Steady State

	Benchmark	UI	WS
A) PDVC - flexible	-0.25%	-0.05%	-0.22%
B) PDVP - flexible	-0.55%	-0.57%	-0.40%
C) PD Cost - flexible	0.05%	0.14%	0.17%
Total = A+B-C	-0.85%	-0.77%	-0.79%
A) PDVC - rigid	-0.13%	-0.07%	-0.12%
B) PDVP - rigid	-0.58%	-0.67%	-0.44%
C) PD Cost - rigid	0.01%	0.14%	0.13%
Total = A+B-C	-0.73%	-0.87%	-0.69%

Note: Columns may not add up due to rounding.

We find that for the flexible economy, UI and WS produce similar total welfare gains relative to the benchmark policy. Yet, the decomposition of gains into consumption and firms' profits

[13] We calculate welfare for 120 periods following the shock once the economy has arguably returned to steady state.

differs significantly. WS improves mainly firms' profits and to a lesser extent consumption because PDVP is minimized when jobs are protected (under WS policy) and match-specific human capital is preserved. On the contrary, UI policy improves consumption at the expense of lower profits. UI policy, by construction, insures consumption and increases wages in both sectors, thus delivering the highest consumption gains. WS policy, despite protecting jobs, maintains low-productivity matches with lower wages. Although the consumption loss relative to the benchmark policy is smaller, consumers are worse off under the WS policy than under the UI policy.

Welfare tradeoffs are similar for the rigid economy, but their quantification changes. The UI policy, while improving consumer welfare, generates a large decline in firms' PDVP such that overall welfare worsens relative to the benchmark policy. The large decline of PDVP under UI policy in the rigid economy is due to lower job-finding rates and a higher replacement rate. In this scenario, WS policy remains the only welfare-improving policy option despite being less preferred by consumers compared to UI policy. WS prevents the persistent losses from job destruction and thus delivers the smallest total welfare loss.

These welfare results seem to rationalize why the United States typically relies on UI policies, whereas the euro area relies more on WS policies. Next, we discuss how the benefits of UI policy may vary with the persistence of the recession.

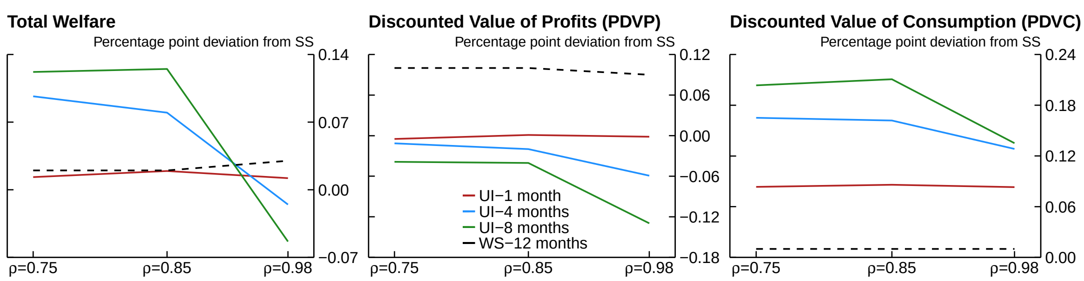
6 Discussion: UI Policy Design and Persistence of Recession

Our previous analysis shows that an increase in UI benefits promotes reallocation at the start of the recession. Thus, a UI policy could be particularly useful in a long-lived recession, when reallocation to the unaffected sector is more desired. However, as we discussed, a UI policy affects reservation wages and firms' profits and thus generates distortions in job creation. In this section, we discuss in more detail the effects of UI and WS by inspecting the role of shock persistence and policy design in the economy.

We focus on the flexible economy, where we found UI and WS policies to be welfare improving. We feed the economy the same initial shock Δ_x as before but consider different persistence levels: $\rho = [0.75, 0.85, 0.98]$. We first analyze three different durations of the UI policy: (1) a front-loaded one-month UI policy such that $b_{new} = 3.75 \times b$, (2) a four-month policy such that $b_{new} = 1.9 \times b$, and (3) an eight-month policy such that $b_{new} = 1.4 \times b$. The three policy durations generate a similar fiscal cost. We compare these policies with a twelve-month WS under the three levels of persistence.

Figure 6 shows the welfare values of each UI and the WS policy for a different recession persistence ρ. We present the three welfare measures discussed before: consumers (PDVC), firms (PDVP), and total welfare by netting out the policy cost (PDVC+PDVP-Cost). The welfare values are presented relative to the benchmark so that a positive number means it is preferred to benchmark.

Figure 6: Welfare Differences between UI and Benchmark Policy



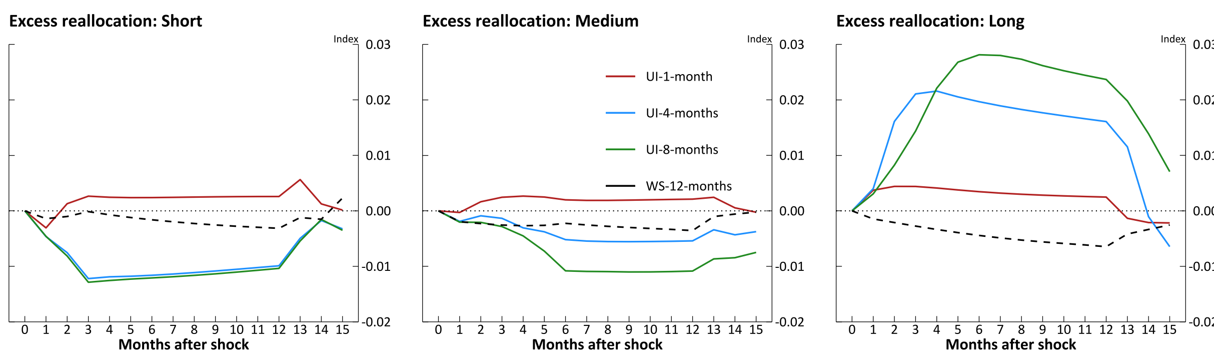
Note: All values are expressed as percentage point difference in welfare under the UI policy relative to the benchmark policy. Welfare under each policy is calculated as percent deviations from steady state.

Front-loading UI extensions (one-month UI policy; red line, left panel) is the safest option: It helps consumers while not depressing firms' profits, regardless of the recession persistence. At the same time, such a policy does not produce significant welfare gains relative to the benchmark policy, as consumers' gains are almost offset by the cost of the policy (not shown). Increasing UI duration can improve total welfare when the recession persistence is shorter, although the higher consumer welfare gains are offset by larger losses for firms. Yet, in very persistent recessions, front-loading becomes the best option, as a larger UI duration hurts firms' profits and diminishes gains for workers. This finding is in line with Mitman and Rabinovich (2015), who study the optimal UI policy design and find it is optimal to front-load UI extensions in long-lived recession in order to minimize job creation distortions.

Contrary to UI, we find that welfare gains under WS do not change much with the persistence of the recession (dashed-line) and with the design of the policy (figures available upon request). WS preserve firms' profits relative to the benchmark policy and do not change the outside option of workers, thus leading to fewer distortions in vacancy posting irrespective the length of the recession.[14]

The relation between UI duration and reallocation is also not straightforward. While WS always reduce reallocation relative to the benchmark scenario, a larger UI duration does not necessarily lead to more reallocation, as Figure 7 shows. The one-month UI duration actually leads to higher reallocation for most recession persistence levels, except for the very persistent one. That is, the distortion effect of a more generous UI policy could lead to lower reallocation. Moreover, higher reallocation does not necessarily mean higher welfare: Higher reallocation occurs with longer UI duration in a very persistent recession, while welfare is larger under the one-month UI duration.

Figure 7: Excess Reallocation under UI Relative to Benchmark Policy



7 Conclusions and Agenda

In this paper, we developed a multi-sector search and matching model of the labor market subject to sector-specific shocks and wage rigidity. We calibrated the model to match key labor market

[14]Consistently, front-loading WS does not necessarily improve welfare under more persistent recessions, as withdrawing firm support early on the recession can lead to job destruction when sector productivity remains low. While we have not analyzed subsidies of a duration longer than a year, prolonged subsidizing of industries could lead to labor misallocation, especially when the decline in productivity is persistent or even permanent.

features of the United States (*flexible* economy), and the euro area (*rigid* economy). We used the model to evaluate UI and WS policies, the two labor market policies most commonly used in recent years. We focused on sector-specific shocks to account broadly for the nature of recent recessions, such as the COVID-19 recession. We showed that, in such recessions, UI policies are preferred in a flexible economy, whereas WS policies are preferred in a rigid economy. Thus, our results rationalize the difference in policies usually implemented in the United States versus the euro area.

We argued that UI extension can lead to higher sectoral reallocation, which may be desirable in the presence of sector-specific shocks. However, a UI extension can also distort job creation, as the larger benefits increase wages and thus decrease firms' profits. Moreover, we argued that higher reallocation does not necessarily imply higher welfare, as high reallocation may occur because of a sector's job-finding rate being particularly low. Overall, UI extension trades welfare gains for workers with profit losses for firms. We found that front-loading UI extensions may help make this trade-off more favorable when designing policies.

We focused on simple labor market policies that resemble those implemented by several countries. Going forward, we think there are several paths in which our analysis could be enriched. First, one could extend the model to include: within-sector firm-heterogeneity, worker-specific human capital, and sector-specific business cycle shocks. Second, one could compute the optimal mix of UI and WS policies in this extended sector model. Third, one could derive what optimal reallocation should be in the presence of sector-specific shocks. We think of the optimal design of labor market policies in such a rich model as a top priority for future research.

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A Data Description and Evidence on Reallocation

Our main data sources are pulled from Haver Analytics and described next. For the United States, we use the Bureau of Labor Statistics for aggregate and industry employment and the Current Population Survey (CPS) for the unemployment rate. We construct productivity as output per employee using real GDP from the National Accounts. Then we index this series such that 2019:Q4 = 100. The time span for these variables is 1990:Q3–2022:Q2.

For the euro area, the main data source is Eurostat, as they aggregate national country data for employment, unemployment, and national accounts. Eurostat provides a measure of real output per employee, indexed such that 2015 = 100, that we use in the empirical section. The time span covered is 1995:Q3–2022:Q2.

For estimating the SVAR, productivity enters the system in log-differences, unemployment rate in differences, and the CRW reallocation index in levels.

Figure 8: Reallocation Index: Euro Area and United States (NAICS Industry Classification)

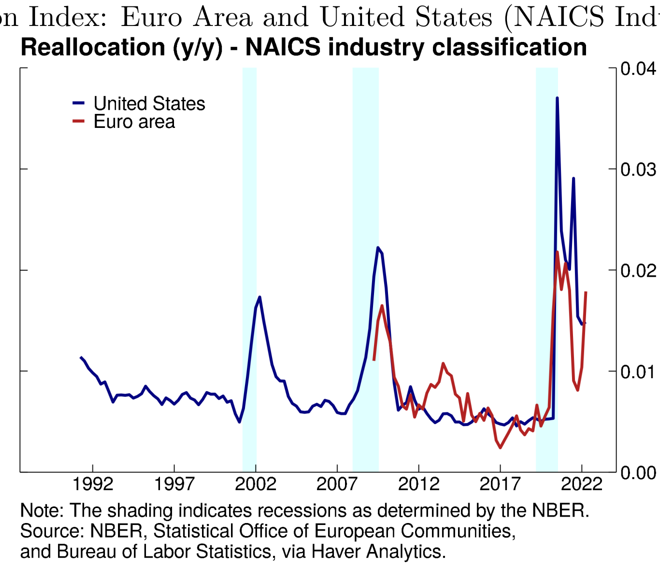
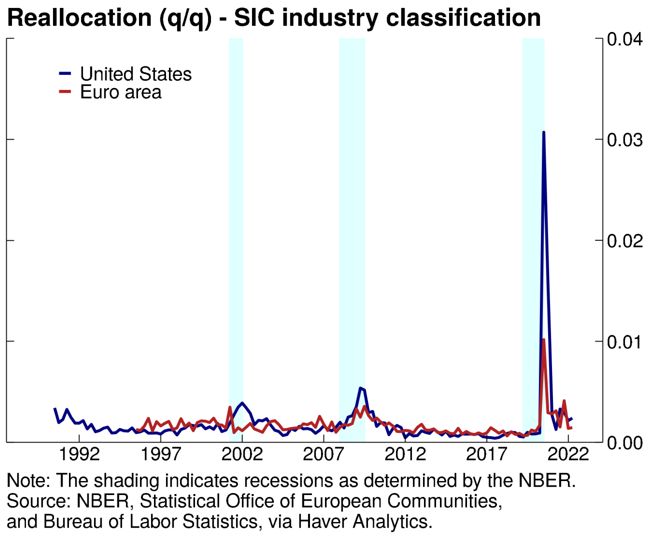


Figure 9: Reallocation Index: Euro Area and United States (SIC Industry Classification, quarterly)



B Model: Quantitative Extension

Let $J_t(z, w, s)$ be the maximal attainable value for an active firm in a match with productivity z, wages w, and sector s at time t. Analogously define $V_t(z, w, s)$ as the value of an idle match. We assume a Gumbel shock for each value, respectively denoted ϵ^J and ϵ^V. Let $M_t(z, w, s)$ be the expected value over the maximum of $J_t(z, w, s)$ and $V_t(z, w, s)$ integrated over the Gumbel shocks:

$$M_t(z, w, s) = \mathbb{E}\left[\max\left\{J_t(z, w, s) + \epsilon^J, V_t(z, w, s) + \epsilon^V\right\}\right]. \tag{22}$$

The value for an active firm is

$$J_t(z, w, s) = \Pi + \beta \mathbb{E}_t\left[\left(1 - \eta^a_{t+1}(z', w', s)\right) \max\left\{M_{t+1}(z', w', s) + \epsilon^M, 0 + \epsilon^0\right\} |z\right] \tag{23}$$

$$\Pi = y_t(z, s) - (1 - \sigma_t)w - c_o$$

$$w' = \begin{cases} w & \text{w.p. } \lambda \\ w^*_{t+1}(z', s) & \text{w.p. } 1 - \lambda \end{cases}$$

where $\eta^a_t(\cdot)$ is the probability that a worker in an active match will quit.

The value for an idle match is

$$V_t(z,w,s) = -c_i + \beta \mathbb{E}_t \left[\left(1 - f^i_{t+1}(z',w,s)\right) \left(1 - \eta^i_{t+1}(z',w',s)\right) \max \left\{ M_{t+1}(z',w',s) + \epsilon^M, 0 + \epsilon^0 \right\} |z \right] \tag{24}$$

where $f^i_t(\cdot)$ is the probability that an idle/furloughed worker will find and accept another job offer (more on this later). Note that the continuation value for an idle firm in equation (24) is the same as for an active firm, although the stochastic process for z may be different.

$$f^i_t(z,w,s) = \sum_{s'} \pi_F(s,s') \zeta f_t(s') \mathbb{E} \left[\mathbb{I} \left\{ H^i_t(z,w,s) + \epsilon^H < W_t(z_0,w_0,s') + \epsilon^W \right\} \right] \tag{25}$$

where $\pi_F(s,s')$ is the probability that an idle worker in sector s is able to search for a job in sector s', and ζ represents the search intensity relative to an unemployed worker. $\zeta = 1$ if the worker searches with the same intensity as an unemployed worker; otherwise, $\zeta < 1$, and it is bounded below by 0. Let $W_t(z,w,s)$ be the maximal attainable value for an active worker in a match with productivity z, wages w, and sector s at time t. Analogously define $F_t(z,w,s)$ as the value of a worker in an idle match. We assume a Gumbel shock for each value, respectively denoted ϵ^W and ϵ^F. Let $U_t(s)$ be the value of being unemployed in sector s at time t. We also add a preference shock ϵ^U to unemployment.

Let $H^a_t(z,w,s)$ be the expected value to a worker of being active at the beginning of the period.

Similarly define $H^i_t(z,w,s)$ as the expected value of an idle worker. Then,

$$H^a_t(z,w,s) = \mathbb{E}\left[\max\left\{\hat{W}_t(z,w,s)+\epsilon^{\hat{W}}, U_t(s)+\epsilon^U\right\}\right] \tag{26}$$

$$\begin{aligned}\hat{W}_t(z,w,s) &= (1-e^a_t(z,w,s))\left[(1-d_t(z,w,s))W_t(z,w,s)+d_t(z,w,s)F_t(z,w,s)\right] \\ &\quad + e^a_t(z,w,s)U_t(s)\end{aligned}$$

$$H^i_t(z,w,s) = \mathbb{E}\left[\max\left\{\hat{F}_t(z,w,s)+\epsilon^{\hat{F}}, U_t(s)+\epsilon^U\right\}\right] \tag{27}$$

$$\begin{aligned}\hat{F}_t(z,w,s) &= \left(1-e^i_t(z,w,s)\right)\left[r_t(z,w,s)W_t(z,w,s)+(1-r_t(z,w,s))F_t(z,w,s)\right] \\ &\quad + e^i_t(z,w,s)U_t(s)\end{aligned}$$

where $\hat{W}_t(z,w,s)$ and $\hat{F}_t(z,w,s)$ are the values of respectively active and furloughed workers after quit decisions have occurred and before the firm's decisions have taken place.

We define the value of working, being furloughed and being unemployed from the production and consumption stage using the following formulas. First, a worker with an active job receives wage w and the expected discounted value $H^a_t(z,w,s)$ from starting next period attached to the firm:

$$W_t(z,w,s) = w + \beta\mathbb{E}_t\left[H^a_{t+1}(z',w',s)|z\right]. \tag{28}$$

A furloughed worker receives unemployment benefit b and has an expected discounted value of continuation that depends on sectoral job-contact probability $f_t(s)$ and sectoral switching probability $\pi_F(s,s')$. If the furloughed worker does not find a firm, they start next period attached to the firm as a furloughed worker $H^i_t(z,w,s)$. If the worker contacts a firm, then they can decide whether to remain attached to the current employer or accept the new offer and start next period attached to a new firm with productivity z_0 and wage w_0:

$$\begin{aligned}F_t(z,w,s) = b + \beta\mathbb{E}\Bigg[\sum_{s'}\pi_F(s,s')\Big\{&(1-\zeta f_{t+1}(s'))H^i_{t+1}(z',w,s) \\ &+ \zeta f_{t+1}(s')\max\left\{H^i_{t+1}(z',w,s)+\epsilon^H, W_{t+1}(z_0,w_0,s')+\epsilon^W\right\}|z\Bigg].\end{aligned} \tag{29}$$

Finally, an unemployed worker receives unemployment benefit b and has an expected discounted value of continuation that depends on sectoral job-contact probability $f_t(s)$ and sectoral switching probability $\pi_U(s,s')$. If the unemployed worker finds a job, they can decide whether to accept it or to reject it and continue being unemployed for an additional period. If they do not find a job, they remain unemployed and attached to their last sector of employment s.

$$\begin{aligned} U_t(s) = b_t + \beta \sum_{s'} \pi_U(s,s') \times & \\ \times \left\{ f_{t+1}(s') \mathbb{E} \left[\max \left\{ W_{t+1}(z_0, w_0, s') + \epsilon^W, U_{t+1}(s) + \epsilon^U \right\} \right] + \left(1 - f_{t+1}(s')\right) U_{t+1}(s) \right\} & \end{aligned} \tag{30}$$

C Model Simulation: Additional Results

Table 5: Calibration: Internal Parameters

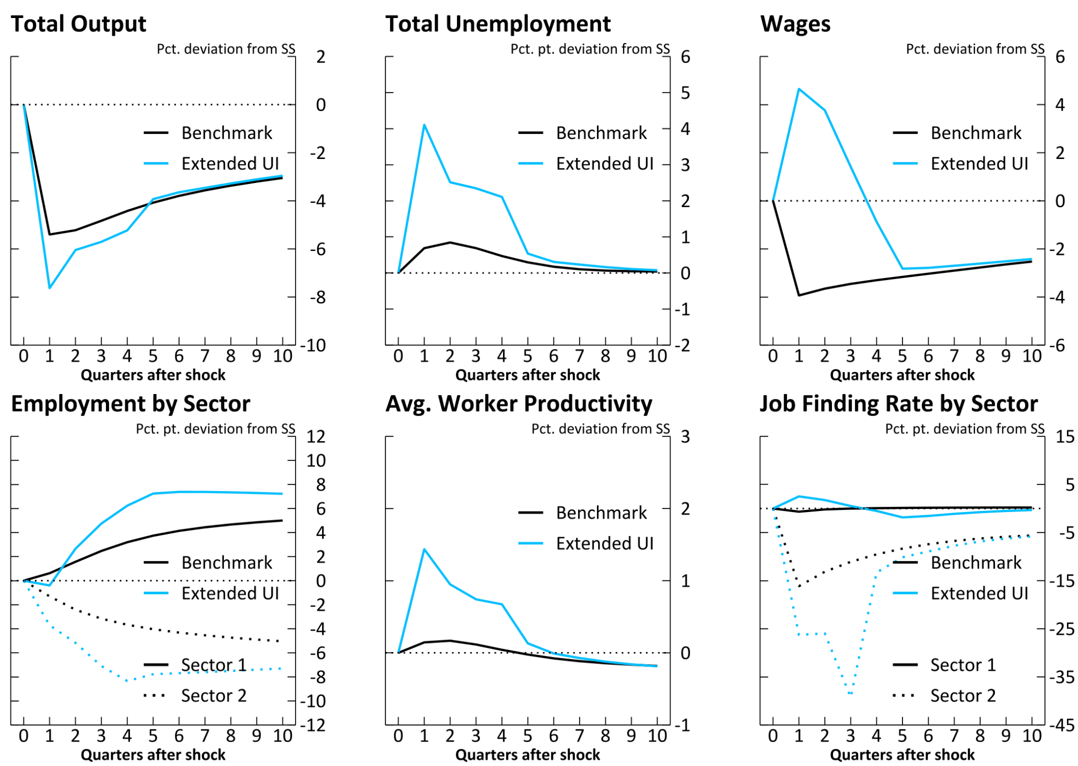
Parameter	Description	Flex value	Rigid value
δ_F	Monthly exogenous separation rate: furlough	0.061	0.987
$\rho_{J,V}$	Gumble shock firm: active/inactive	0.075	0.020
$\rho_{M,0}$	Gumble shock firm: remain open/close	0.066	0.071
$\rho_{W,U}$	Gumble shock worker: remain employed/quit	0.078	0.017
$\rho_{F,U}$	Gumble shock worker: remain furloughed/quit	0.120	0.044
ρ_{H,W_0}	Gumble shock worker: remain employed/accept new job	0.073	0.027
ρ_{U,W_0}	Gumble shock worker: remain unemployed/accept new job	0.113	0.027

C.1 Experiment 2: Long-Lived Recession

C.1.1 Long-Lived Recession: UI Extension in a Flexible Labor Market

Our second experiment explores how the persistence of the shock interacts with the policies. We set $\Delta_x = 0.10$ and $\rho = 0.983$ so the drop is much smaller but with a sluggish recovery. We compare the response of the economy under a smaller increase in the replacement rate compared to the short-lived recession but for equal expenditures (as it now lasts for 12 months) and a benchmark economy with no additional policies. The cost of the policy still accounts for around 1 percent of annual GDP. We present the results in Figure 10. As in the short-lived recession, the UI policy continues to increase unemployment and leads to a larger contraction in output, though it does not produce a faster recovery. Reallocation is rapid and persistent. A WS policy (shown in Figure 11) would continue to limit the increase in unemployment but limit reallocation when an industry experiences a long-lasting shock. The welfare analysis, presented in Table 6, confirms our analysis in section 6 that the UI extension generates significant profit losses that result in welfare loss compared with the benchmark policy.

Figure 10: Benchmark and UI Policy Response in a Flexible Economy (Long-Lived recession)

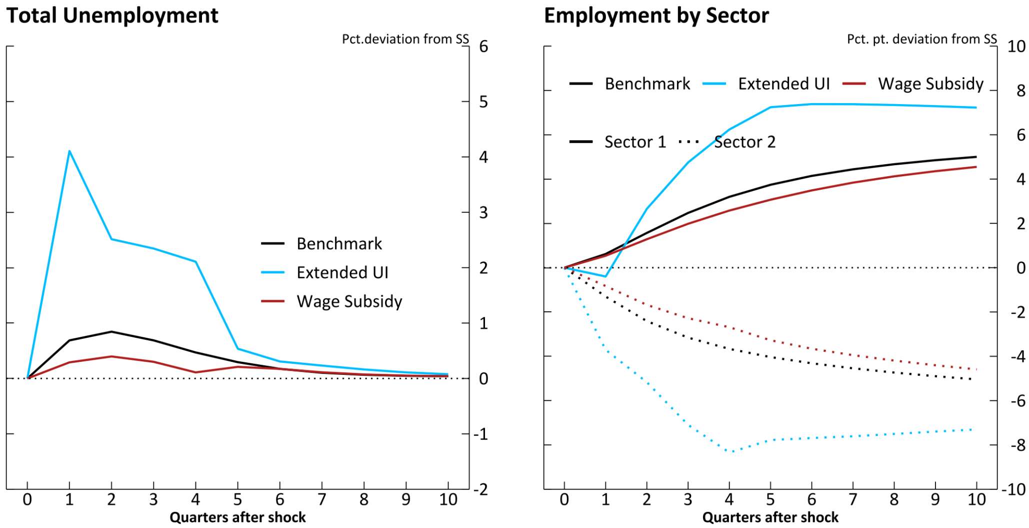


Note: Sector 1 refers to the unaffected sector, and sector 2 the sector affected by the shock. SS is steady state.

C.1.2 Long-Lived Recession: WS in a Rigid Labor Market

We now analyze the differences for a similar recession in a rigid labor market. We set $\Delta_x = 0.125$ and $\rho = 0.983$, and in this case we compare the response of the economy under a 12-month WS policy in the affected sector and the benchmark economy with no additional policies. The cost of the

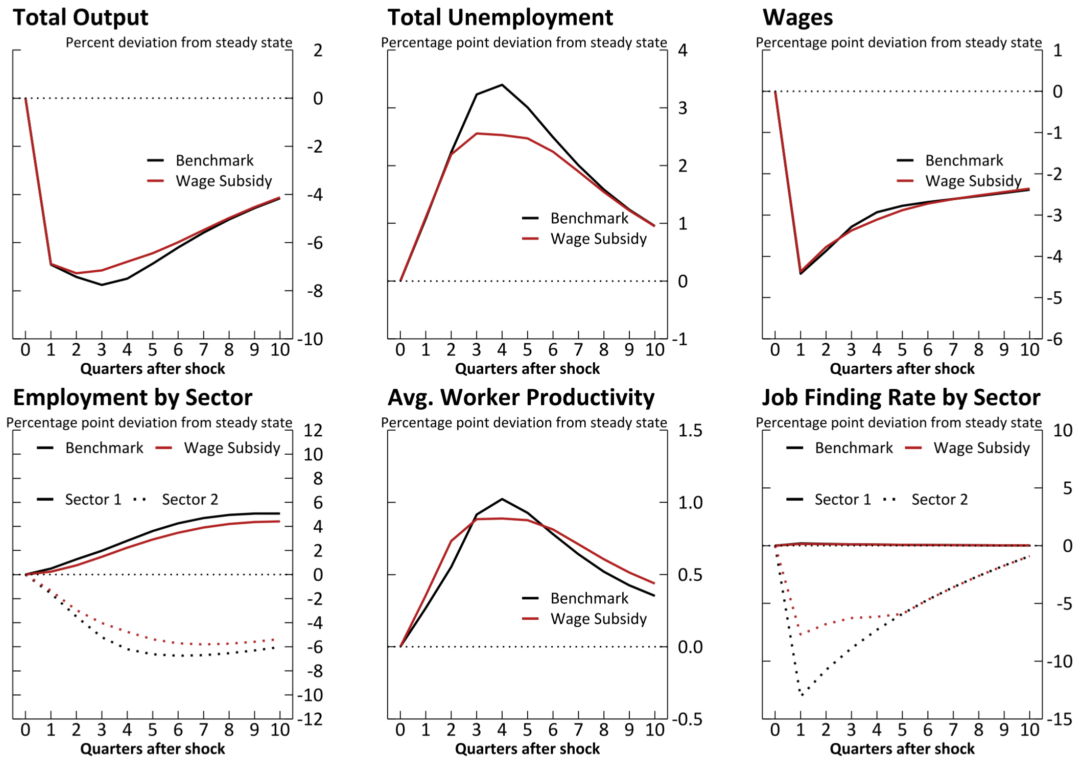
Figure 11: Flexible Economy: Counterfactual Policies in the Long-Lived Recession



Note: Sector 1 refers to the unaffected sector, and sector 2 the sector affected by the shock. SS is steady state.

policy accounts still for around of 1 percent of annual GDP. Figures for these results are presented in Figure 12 and Figure 13. As in the short recession, the WS policy limits job destruction, leading to a smaller contraction in output and a contained unemployment rate. However, the lower job-finding rate makes the recession even more persistent despite the smaller increase in unemployment relative to the flexible economy. Reallocation toward the unaffected sector is more sluggish relative to the benchmark policy. A counterfactual UI policy produces higher unemployment at the beginning but induces a faster recovery relative to benchmark. Overall, firms' losses under the UI policy are higher, making the WS policy a preferred option.

Figure 12: Benchmark and WS Response in a Rigid Economy (Long-Lived Recession)



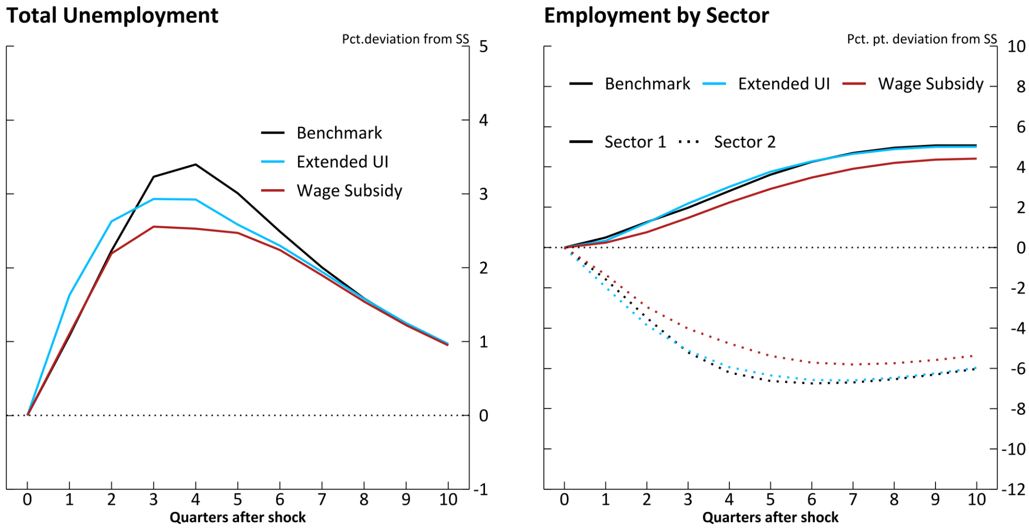
Note: Sector 1 refers to the unaffected sector, and sector 2 the sector affected by the shock. SS is steady state.

Table 6: Welfare Comparison: Percentage Loss Relative to Steady State

	Benchmark	UI	WS
A) PDVC - flexible	−0.91%	−0.56%	−0.89%
B) PDVP - flexible	−1.20%	−1.48%	−1.06%
C) PD Cost - flexible	0.03%	0.15%	0.15%
Total = A+B-C	−2.14%	−2.19%	−2.10%
A) PDVC - rigid	−1.00%	−0.81%	−0.96%
B) PDVP - rigid	−1.30%	−1.38%	−1.14%
C) PD Cost - rigid	0.14%	0.18%	0.24%
Total = A+B-C	−2.43%	−2.37%	−2.34%

Note: Columns may not add up due to rounding.

Figure 13: Rigid economy: Counterfactual Policies in the Long-Lived Recession



Note: Sector 1 refers to the unaffected sector, and sector 2 the sector affected by the shock. SS is steady state.

Figure 14: CRW Index in the Long-Lived Recession: Model Predictions