Revisiting Labour Market Policy in Recessions*

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Abstract

Should policymakers increase direct insurance to workers during recessions as in the US, or seek to provide insurance to existing employment relationships by subsidising the continuation of matches as in Continental Europe? This paper seeks to shed light on this question through the lens of a variant of the standard Mortensen & Pissarides (1994) matching model with endogenous job destruction, where workers are risk-averse, face uninsurable income risk in the labour market, and make an endogenous search decision when unemployed. In this standard environment, social welfare depends not only on the average level of worker income but all higher-order moments of the worker income distribution, and in particular the degree of income that workers face. Moreover, changes in UI and employment subsidies have opposite effects on the degree of income risk workers face - UI always increases income risk via its effect on job creation and destruction, whereas employment subsidies act in the opposite direction. We use a calibrated version of the model to quantify the importance of the different effects of UI and match subsidies on worker income risk for social welfare during a recession. Overall we find that whilst both policies deliver welfare gains, match subsidies roughly double the welfare gains compared to the increase in UI, suggesting that the impact of policies on worker income risk is indeed quantitatively significant for normative analysis using this standard framework.

*to be added

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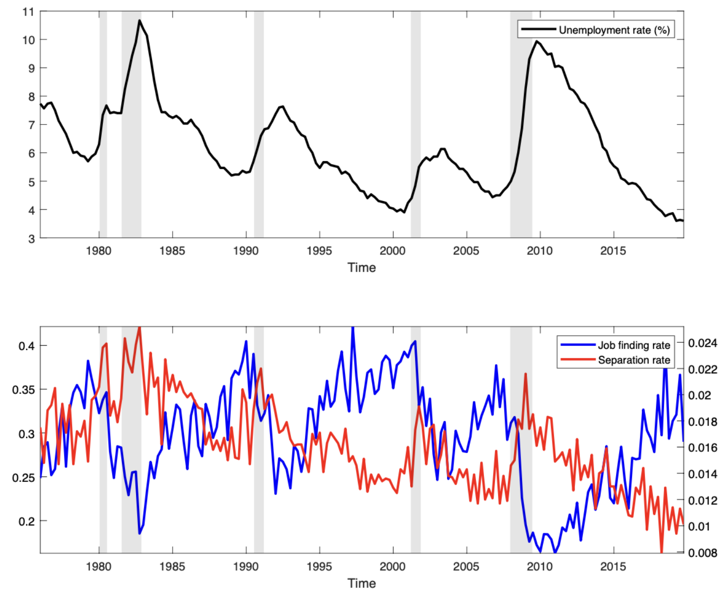

Figure 1. Unemployment rate, job finding rate, and separation rate in the US, 1976Q1-2019Q4. Constructed from the CPS. Shaded periods are NBER-dated recessions.

1 Introduction

Recessions in the labour market are typically characterised by a surge in layoffs and a reduction in labour demand, resulting in a sharp rise in unemployment that can be very persistent. This pattern is depicted in Figure 1 for the US where the upper panel plots the unemployment rate over time and the lower panel plots the two key flow rates driving unemployment dynamics - the job finding rate (unemployment-employment transition rate) and the separation rate (employment-unemployment transition rate).[1] A similar pattern is also found in other advanced economies.[2]

[1]As is well known, for US data different empirical approaches and data sources affect the relative importance of unemployment inflows and outflows for driving the aggregate. Darby et al. (1986) and later Shimer (2012) find that the job finding rate explains the majority of unemployment dynamics (i.e. "the Ins win"), whilst Elsby et al. (2009) and Fujita and Ramsey (2006, 2009) find that both inflows and outflows play an important role.

[2]For instance, Elsby et al. (2013) document the contributions of inflows and outflows to unemployment across all OECD economies, finding that in general outflows play a more important role in unemployment dynamics in Anglo-Saxon economies, whereas variations in both outflows and inflows are important for accounting for unemployment fluctuations across Continental European and Nordic economies. More focused studies include Petrongolo and Pissarides (2008) and Smith (2011) who instead find that both inflows and outflows are important in the context of UK unemployment. Petrongolo and Pissarides (2008) also document a similar pattern in Spain, but in the case of France find that the job finding rate is the main driver of unemployment changes.

There is a long tradition in macroeconomics of viewing high unemployment during large recessions as symptomatic of deeper economic inefficiencies, which policy has a role to play in addressing. For instance, a large body of evidence documents that unemployed workers bear an excessive amount of the cost of downturns which they are unable to fully insure against (e.g. Jarosch 2021), creating a role for the government to provide this insurance in the absence of complete insurance markets. This concern has led to almost all advanced economies establishing some sort of unemployment insurance scheme (hereafter UI) to provide partial income insurance for unemployed workers, though the nature of UI differs hugely across countries and its optimal design is the subject of a burgeoning literature.[3] Other theories stress that high unemployment reflects an inefficient allocation of resources in the economy, or more specifically an under-utilization of labour (e.g. Michaillat and Saez 2021). In practice this has led some countries to adopt employment protection policies such as "short-time work" schemes (hereafter STWs) used in several major European economies (most notably Germany, France, and Italy). These schemes seek to incentivize firms to keep hold of workers during downturns by subsidising the costs of maintaining an employment relationship for participating firms. Compared to UI, such schemes are far from universal across advanced economies.

During very large downturns, policymakers have often intervened to extend these existing policies beyond normal levels of support. This has been particularly evident during the last two major recessions - the Great Recession in 2008 and the Covid-19 pandemic recession in 2020. However, as noted in Giupponi et al. (2022), policymakers across advanced economies have made different *types* of interventions in the labour market. For instance policymakers in the US have (for the most part) have tended to invest more resources into increasing the generosity of UI during recessions. In contrast, Western European economies in particular have opted to invest more resources into extending the generosity of employment protection schemes to prevent 'excess' layoffs which would otherwise lead to higher unemployment.

This paper seeks to address the question posed in Giupponi et al. (2022): should policy focus on providing insurance for workers or employment matches during downturns? To shed light on this question we study the implications of alternative policy responses to a recession in the labour market using a very standard general equilibrium search & matching framework, in the Mortensen and Pissarides (1994) tradition.

[3] see Schmeider and von Wachter (2016) for a recent review of the UI literature.

More specifically, we adopt the framework developed in a series of papers by Jung and Kuester (2015), Ignaszak et al. (2020) and Jung et al. (2021), who extend a standard matching model to allow for endogenous job separations, risk-averse workers unable to fully insure against income risk, and an endogenous search decision. Endogenous separations are an important part of the analysis, as a key rationale of STWs as used in European economies is to preserve a number of existing job matches that would otherwise have separated during the downturn. Uninsurable endogenous income risk from unemployment allows a role for publicly-provided insurance, whilst allowing for an endogenous search choice captures the idea that search effort by non-employed workers is endogenous to UI (reflecting the moral hazard concerns emphasised in the UI literature).

In our baseline policy experiment, we calibrate the model to match salient features of the US labour market, simulate a recession, and study the welfare implications of adopting these two different policy approaches. More concretely we compare the implications of: (i) increasing the level of UI, or (ii) investing the same amount of resources in subsidising existing employment relationships. Our first main result is that under a very standard calibration, a cost-equivalent investment into subsidising matches is preferred to increasing the level of UI. We find that subsidising matches more effectively insures the average consumption level of workers through the stabilization of labour market tightness, by simultaneously reducing the outflow of workers into unemployment whilst preserving incentives to create new jobs. A relatively tighter labour market indirectly benefits those workers who lose their jobs by ensuring that these workers are reallocated into new jobs relatively faster than they otherwise would have been.

In contrast, an increase in UI actually *amplifies* the effect of a negative aggregate shock on labour market tightness. This operates through its effect on the wage bargain via the worker's outside option, what Landais et al. (2018a) refer to as the *job creation* channel. Despite providing more direct insurance to unemployed workers in terms of reducing the income loss upon becoming unemployed, the general equilibrium effects on labour market tightness lead to a larger fall in average consumption than otherwise. In other words, although individual unemployed workers have a higher consumption level due to more generous UI, a greater fraction of workers spend time in unemployment and the average duration of an unemployment spell is longer. Nevertheless, our second main result is that in this environment increasing UI still achieves welfare gains relative to the absence of intervention despite the amplified fall in average consumption. These welfare gains instead come through the reduction in job search disutility and an increase in leisure utility enjoyed by the larger share of non-employed workers, which are features models allowing for a search decision by non-employed workers (e.g. Mitman and Rabinovich 2015).

We then explore the importance of the underlying structure of the labour market our results. To do this, we repeat the policy experiments after re-calibrating the model's structural and policy parameters to instead match key features of the German labour market. Relative to the US labour market, the German labour market historically has been characterised by significantly lower average flow rates between employment and unemployment(i.e. lower worker turnover) and higher average unemployment, suggesting that the German labour market (as well as other European labour markets) is on average more 'rigid'.[4] Again the model framework suggests that providing more insurance for existing matches rather than a cost-equivalent increase in the level of UI is preferable in welfare terms. However, the strength of the job creation channel from increases UI is much smaller under this alternative calibration. In an environment where worker turnover is slower, our results suggest that increasing UI contributes positively to insuring average worker's consumption during a recession, as the direct benefits from higher consumption in unemployment are no longer offset by the increase in the share of workers spending more time in unemployment during the downturn. As a result the relative welfare gains from extending match subsidies versus expanding UI support are smaller than for the US calibration.

Outline The rest of the paper is structured as follows. The remainder of this section reviews the related literature. Section 2 outlines the model framework we utilise for our policy experiments. Section 3 covers the details of our policy analysis, reviewing the calibration and presenting the main results. Section 4 presents the results from an alternative calibration of the model to the German economy. Section 5 concludes.

1.1 Related literature

It is well documented that labour market institutions and policies differ hugely across economies, and that this goes some way to explaining cross-country differences in labour market outcomes (see Lazear 1990, Boeri 2010). The present paper is related to

[4] Historically, since Giersch (1985) the literature has often referred to this characterization of European labour markets compared to the US as 'eurosclerosis'.

several different strands of literature studying the role of unemployment insurance and employment protection policies specifically, and their implications for the aggregate labour market from both a positive and a normative standpoint.

Unemployment insurance There is a vast theoretical and empirical literature studying the effects of UI on the labour market and its optimal design. The key trade-off the literature has focused on has been the benefits of publicly providing income insurance to workers versus the implications of this for the labour market via changing job search incentives both for workers themselves (i.e. moral hazard concerns) as well as job creation incentives for firms (via effects on wages and congestion externalities). Notable theoretical contributions characterising this trade-off, to name a few, are Baily (1978), Hopenhayn and Niccolini (1997), Chetty (2006), Shimer and Werning (2007, 2008), Coles (2008), Mitman and Rabinovich (2015), and Landais et al. (2018a, 2018b).

Empirically it is challenging to reliably estimate the effects of UI changes on the labour market, given the difficulties associated with identifying plausibly exogenous variation in UI. Landais et al. (2018) survey empirical estimates of both the *micro-* and *macro*-elasticity of unemployment with respect to UI in the literature, where the difference between the two reflects general equilibrium effects associated with changes in UI.[5] There is a large amount of evidence suggesting that in the case of individual workers an increase in UI is associated with longer spells in unemployment (Katz and Meyer 1990, Krueger and Meyer 2002), but much less consensus about the size of the macroelasticity, as this itself is difficult to identify (e.g. see Hagedorn et al. 2016, Chodorow-Reich et al. 2019). Landais et al. (2018) suggest that the macroelasticity on average is estimated to be lower than the microelasticity, suggesting that an increase in UI is associated with an increase in labour market tightness, whilst Mitman et al. (2022) use quasi-experiment evidence from Missouri and present findings that suggest the opposite is true.

Employment protection A somewhat smaller literature exists studying employment protection policies. Early theoretical contributions include Hopenhayn and Rogerson (1993), Ljungqvist (2002), and Veracierto (2008), though these papers give

[5]The idea here is that the microelasticity identifies the effect of a change in UI on the unemployment duration of individual workers, taking aggregate conditions (i.e. job finding rates) as given. The macroelasticity captures any additional effects from changes in aggregate conditions. So if the macroelasticity is less than the microelasticity, then aggregate job finding rates (and therefore tightness) must have increased.

mixed messages regarding the desirability of such policies, suggesting that constraining firms' adjustment of their labour inputs can increase or decrease the level and volatility of unemployment depending on modelling choices. These papers tend to model employment protection legislation either in the form of a real resource cost paid by firms, or as a 'layoff tax' which the government collects as revenue. In practice, besides the differences in legislation governing the decision to terminate an employment relationship displayed across countries, the main form of employment protection policy that can be adjusted relatively easily by policymakers in response to recessions are employment *subsidy* policies.

A key example of this sort of policy are STWs, which forms the focus of a small (but growing) literature. Balleer et al. (2016) and Cooper et al. (2017) provide theoretical contributions illustrating quantitatively that STWs are effective at reducing employment volatility as an automatic stabiliser during downturns, but that most of the benefits associated with STWs come from their increased usage during downturns (rather than their increased generosity) and potentially come at the cost of a reduction in allocative efficiency by impeding the reallocation of workers away from lower productivity matches. Empirical contributions by Giupponi and Landais (2018) and Cahuc et al. (2021) using administrative firm-level data provide stronger evidence for the role of STWs in protecting jobs during recessions. Giupponi et al. (2022) survey evidence on the impacts of STWs on the aggregate labour market, finding that increases in their generosity are associated with higher tightness, mainly due to reducing the number of workers flowing into unemployment.

Joint policy design Finally, there is a theoretical literature studying the overall design of labour market policy, and the role of different types of policy in improving welfare. An earlier series of contributions studied joint policy design in general equilibrium environments where search externalities are the only source of welfare losses, as in Mortensen and Pissarides (1994). Notable examples include Millard (1995), Millard and Mortensen (1997), Pissarides (2000), and Mortensen and Pissarides (2003). These papers study how policymakers can alleviate search externalities via a combination of layoff taxes, income taxes, hiring subsidies, and employment subsidies, but abstract from concerns about income insurance for workers. Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008) study the joint design of employment protection policies with UI when workers are risk-averse and cannot fully insure against unemployment in a partial equilibrium setting, and find a positive role for these policies in forcing firms to internalise the social costs of separations such as a higher fiscal cost from increased UI claimants, or a congestion of the job search process. There are very few papers which study the joint design of UI and employment protection policies in general equilibrium environments where policy faces both insurance considerations and congestion externalities in the labour market.

Several important exceptions to this are Michau (2015), Jung and Kuester (2015), and more recently Birinci et al. (2021) and García-Cabo et al. (2022) in the context of Covid-19. Michau (2015) illustrates how in the presence of search externalities and risk-averse workers, the steady state constrained-efficient allocation can be decentralised through a combination of hiring subsidies, layoff taxes and UI. Jung and Kuester (2015) extend this to a business cycle setting and find that there is a limited role for increasing UI during recessions once hiring subsidies and layoff taxes stabilise tightness via their effects on employment inflows and outflows respectively. Both of these papers rely on adjustments in 'layoff taxes' to reduce inefficiently high job separations and implement the optimal policy, however it is far from clear how this would be implemented in practice.

The policy experiments we conduct in this paper are most closely related to Birinci et al. (2021) and García-Cabo et al. (2022), who both study the effects of increases in employment subsidies (in the form of wage subsidies) versus UI during a recession in a similar environment. The quantitative model of the labour market in Birinci et al. (2021) features an epidemiological SIR block, and is also extended to allow for match-specific productivity which grows stochastically over time, though they abstract from moral hazard concerns and also assume wages are unaffected by changes in the worker's outside option. Their principle finding is that UI and employment subsidies are complementary because they benefit different workers: employment subsidies benefit workers higher up the job ladder, whilst UI provides insurance for those workers towards the bottom of the job ladder who are more likely to separate and whose matches are less productive. Moreover, they solve for the optimal budget shares a policymaker should choose for the two policies, suggesting a 20:80 mix in favour of UI as employment subsidies are found to have highly diminishing returns.

The environment utilised in García-Cabo et al. (2022) focuses instead on the effect of the two policies on the allocation of resources in a multi-sector search & matching model with job-specific stochastic productivity where workers are risk-neutral (i.e. there is no role for insurance considerations). The recession in their experiments is driven by a negative productivity shock to one sector, whilst the other is unaffected. In this environment, UI generates more job separations and a higher initial fall in output (due to higher unemployment), but depending on how quickly workers find jobs this can speed up the process of reallocating workers away from low productivity matches towards new, higher productivity jobs in the unaffected sector. In contrast, wage subsidy policies dampen the initial fall in output by protecting employment matches at the cost of hindering the reallocation of workers away from the affected sector. Overall Garcia-Cabo et al. (2022) find that when the labour market is 'flexible' (i.e. the job finding rate is higher) UI policies are preferred, otherwise wage subsidy policies are preferred in environments where worker reallocation is slower.

2 Model

In this section we briefly outline the model framework developed in Jung and Kuester (2015), Ignaszak et al. (2020), and Jung et al. (2021), that we use for our policy analysis. For the most part we retain their notation. The framework deviates in several ways from the standard Mortensen-Pissarides (1994) model which are important our purposes. In the first instance, job separations are allowed to vary endogenously over the business cycle. This is a robust empirical fact (e.g. see Fujita and Ramey 2009), but also allows a role for employment subsidies to stabilise unemployment during recessions by dampening the spike in job separations. Secondly workers are assumed to be risk-averse and are unable to insure against income risk. This allows publicly-provided income insurance for unemployed workers to play a welfare-improving role. Finally, non-employed workers make a job search decision such that the provision of unemployment insurance affects job search incentives. Overall, the policymaker has to trade-off two sources of welfare losses - excess volatility in worker consumption and congestion externalities in the matching market - whilst being constrained from providing full insurance to workers due to the endogenous search decision.

2.1 Environment

Timing Time is discrete and runs forever. The timing of events within a model period is as follows:

1. Aggregate uncertainty resolved.
2. Bargaining between existing worker-firm pairs occurs, determining wages &

separation decisions.

3. Idiosyncratic shocks are drawn, determining how many matches separate & how many non-employed workers search for a job in current period.
4. Production, job creation and matching takes place. New matches do not produce until next period.

Search & matching Workers can either be employed or unemployed. New matches m_t are formed by the meeting of non-employed job searchers and job vacancies in the labour market via a constant returns to scale aggregate matching function:

$$m_t = m(v_t, s_t N_t) \tag{1}$$

where v_t are vacancies posted by new firms, s_t is the share of non-employed workers who search, and N_t is the measure of non-employed workers. Therefore $s_t N_t$ is the measure of "effective searchers". In any period the measure of non-employed is given by the measure of existing unemployed workers from the last period u_t plus the fraction of existing workers who are endogenously separated at the beginning of the period:

$$N_t = \xi_t e_t + u_t \tag{2}$$

where e_t is the measure of employed workers, and ξ_t is the separation rate.

As standard, we can express the contact rates between workers and firms as a function of the ratio between vacancies and effective searchers (i.e. labour market tightness, θ_t):

$$\theta_t = v_t/(s_t N_t) \tag{3}$$

where the hiring and job finding rates are given by:

$$q_t = m_t/v_t = m(1, 1/\theta_t), \quad f_t = \theta_t q(\theta_t) \tag{4}$$

Overall the law of motion for aggregate employment is given by:

$$e_{t+1} = (1 - \xi_t)e_t + m_t \tag{5}$$

Separations A worker-firm pair make the decision to separate or not based on an idiosyncratic fixed cost of production ε_j which is i.i.d. and drawn by all worker-firm pairs every period. There exists a threshold cost ε^{ξ} at which workers/firms are indifferent between the match continuing or separating.[6]

We can define the share of matches which separate ξ_t (i.e. the separation rate) as:

$$\xi_t = Pr(\varepsilon_j > \varepsilon_t^{\xi}) = \int_{\varepsilon_t^{\xi}}^{\infty} \varepsilon_j dF_{\varepsilon} \tag{6}$$

where the separation threshold ε_t^{ξ} is defined explicitly below.

Production An individual match produces $\exp\{a_t\}$ units of output, where a_t is (exogenous) labour productivity, i.e. all matches have the same output and productivity. Aggregate output is therefore given by individual match output multiplied by the measure of active matches in period t:

$$Y_t = (1 - \xi_t) e_t \exp\{a_t\} \tag{7}$$

2.2 Workers

Workers There exists a constant mass of *ex ante* identical, risk-averse workers. Workers can either be employed or unemployed.[7] Workers discount the future with the time-discount factor $\beta \in (0, 1)$ and obtain utility from consumption $u(c)$, where $u'(c) \geq 0,\ u''(c) \leq 0$, additive flow utility $\bar{h}$ in non-employment, and idiosyncratic additive disutility ι_i conditional on choosing to actively search for a new match. Workers are unable to self-insure against income risk from unemployment and consume income hand-to-mouth in every period. Recently separated workers receive partial insurance in the form of a one-time severance payout equal to the value of the wage, whilst unemployed workers are paid unemployment insurance (UI) B_t. It is assumed that aggregate firm profits Π_t are redistributed to all workers equally, regardless of employment status. Taken together this implies that $c_{e,t} = w_t + \Pi_t$, and $c_{u,t} = B_t + \Pi_t$.

Job search Non-employed workers decide whether to search for a job based on

[6] In general a separation can either be worker-initiated (a "quit"), firm-initiated (a "layoff"), or mutually agreed. This depends on the surpluses from the match enjoyed by the worker and firm respectively, or more specifically how these surpluses respond to a shock that affects the profitability of the match. For simplicity, we will assume below that wages are determined by Nash bargaining such that workers/firm always enjoy a constant fraction of the joint match surplus. One implication of this is that *all* separations are mutually agreed by both workers and firms, i.e. bargaining is always efficient.

[7] Without loss of generality, we normalize the mass of workers in the economy to 1. This implies that $u_t = 1 - e_t$.

their idiosyncratic cost of job search $\iota_i \sim F_\iota$ which are i.i.d. and drawn by all non-employed workers in every period. There exists a threshold cost ι^s at which point a non-employed worker is indifferent between searching or not, i.e. when the cost of searching is equal to the expected utility gain from searching:

$$\iota_t^s = f_t \beta \mathbb{E}_t \Delta_{t+1} \tag{8}$$

where $\Delta_t \coloneqq V_{e,t} - V_{u,t}$ is the worker's surplus from working, where $V_{e,t}$ is the value of employment and $V_{u,t}$ is the value of unemployment (defined below). The share of non-employed who search is therefore given by:

$$s_t = Pr(\iota \leq \iota_t^s) = \int_{-\infty}^{\iota_t^s} \iota dF_\iota \tag{9}$$

Employment value An employed worker at the beginning of period t will either continue to be employed with probability $(1-\xi_t)$ or will separate with probability ξ_t. Upon separation the worker receives the value of unemployment plus the difference in the flow consumption utility between the employed and unemployed (due to the severance payment). The value of employment can therefore be written as:

$$V_{e,t} = (1-\xi_t)\big[u(w_t + \Pi_t) + \beta \mathbb{E}_t V_{e,t+1}\big] + \xi_t\big[V_{u,t} + u(w_t + \Pi_t) - u(B_t + \Pi_t)\big] \tag{10}$$

Unemployment value An unemployed worker at the beginning of period t consumes and enjoys leisure, and makes a decision about whether to search in the current period or not based on their idiosyncratic utility cost of job search ι_i. If the unemployed worker decides to search for a job they successfully find a match with probability f_t, otherwise they will remain in unemployment. The value of unemployment can therefore be written as:

$$V_{u,t} = u(B_t+\Pi_t)+\bar{h}+\int_{-\infty}^{\iota_t^s}[-\iota_i+f_t\beta\mathbb{E}_tV_{e,t+1}+(1-f_t)\beta\mathbb{E}_tV_{u,t+1}]dF_\iota(\iota_i)+\int_{\iota_t^s}^{\infty}\beta\mathbb{E}_tV_{u,t+1}dF_\iota(\iota_i) \tag{11}$$

2.3 Firms

Job value A firm entering period t matched with a worker will decide (jointly with the worker) whether or not to continue the match in the current period based on their idiosyncratic fixed costs of production. If the worker-firm pair decide to terminate the match, the firm must pay a (constant) layoff tax τ_ξ (which is collected by the government as revenue) in addition to a one-time severance payment to the worker equal to the value of the wage w_t. If the match continues it produces $\exp\{a_t\}$ and receives employment subsidy $\tau_s \geq 0$, whilst the firm pays the worker wages w_t, the idiosyncratic production cost ε_j, and a production tax $\tau_{J,t}$ levied in order to balance the budget. The value of a filled job is therefore given by:

$$\begin{aligned} J_t &= -\int_{\varepsilon_t^\xi}^{\infty} [\tau_\xi + w_t] dF_\varepsilon(\varepsilon_j) \\ &\quad + \int_{-\infty}^{\varepsilon_t^\xi} [\exp\{a_t\} + \tau_s - \varepsilon_j - w_t + \tau_{J,t} + \mathbb{E}_t Q_{t,t+1} J_{t+1}] dF\varepsilon(\varepsilon_j) \end{aligned} \tag{12}$$

where $Q_{t,t+1}$ is the relevant stochastic discount factor for the firm:

$$Q_{t,t+s} = \beta \frac{\lambda_{t+s}}{\lambda_t} \tag{13}$$

and λ_t is the weighted marginal utility of firm owners (which comprises both employed and unemployed workers):

$$\lambda_t = \left(\frac{e_t(1-\xi_t)}{u'(w_t + \Pi_t)} + \frac{u_t}{u'(B_t + \Pi_t)} \right) \tag{14}$$

Job creation There is an infinite measure of identical potential firms who are able to freely enter the market for new match formation by posting vacancies at per-period cost $\kappa_v > 0$. Potential firms will post vacancies until the expected value is equal to the cost. Job creation is therefore pinned down by the standard free entry condition:

$$\kappa_v = q_t \mathbb{E}_t Q_{t,t+1} J_{t+1} \tag{15}$$

2.4 Bargaining

Workers and firms decide on the wage w_t and separation threshold ε_t^ξ using generalized Nash bargaining:

$$\underset{w_t, \varepsilon_t^\xi}{\operatorname{argmax}} \ (\Delta_t)^{1-\eta_t} (J_t)^{\eta_t}$$

where $\eta \in (0,1)$ is the firm's (time-varying) bargaining power, or share of the joint surplus (given by $J_t + \Delta_t$).

Wages The wage paid to workers w_t satisfies the usual Nash sharing rule:

$$(1-\eta_t)J_t = \eta_t \frac{\Delta_t}{u'(w_t + \Pi_t)} \tag{16}$$

Separations The separation threshold ε_t^ξ is defined as the level of ε_j at which a worker-firm pair are indifferent between continuing the match or separating, i.e. ε_t^ξ satisfies the following indifference condition:

$$J_t(\varepsilon_t^\xi) = \Delta_t(\varepsilon_t^\xi) = 0 \tag{17}$$

2.5 Market clearing

Dividends Aggregate firm profits can be expressed as:

$$\Pi_t = e_t(1-\xi_t)[\exp\{a_t\} - \tau_{J,t} - w_t - \int_{-\infty}^{\varepsilon_t^\xi} \varepsilon_j dF_\varepsilon(\varepsilon_j)] - e_t\xi_t[w_t + \tau_\xi] - \kappa_v v_t \tag{18}$$

Market clearing Total resources are allocated between consumption, (fixed) production costs, and the cost of new job creation:

$$Y_t = e_t(w_t + \Pi_t) + u_t(B_t + \Pi_t) + e_t \int_{-\infty}^{\varepsilon_t^\xi} \varepsilon_j dF_\varepsilon(\varepsilon_j) + \kappa_v v_t \tag{19}$$

2.6 Equilibrium

The model equilibrium is defined by the conditions in (1)-(19), in addition to rules specifying the behaviour of labour market policies $\{\tau_{\xi,t}, B_t, \tau_{s,t}\}$. In the baseline case we assume that policy instruments remain constant over the business cycle.[8] Moreover, we also impose the strict condition that $\tau_{J,t}$ fluctuates in order to balance the budget in every period (i.e. there is no tax smoothing).

[8] One slight deviation here from Jung and Kuester (2015) is that in their baseline case they assume the government ensures that $b := c_u/c_e$ is constant, rather than B. This requires the policymaker to constant adjust B in order to ensure the consumption replacement rate b is constant in response to aggregate shocks.

3 Quantitative Analysis

In this section we use a calibrated version of the Jung-Kuester (2015) framework outlined above to conduct a simple policy experiment. More specifically, we simulate a recession in the model (via a fall in labour productivity, a_t) and assess the implications of different labour market policy responses. Firstly we present the US calibration of the model used in Jung and Kuester (2015), comparing the decentralized stationary equilibrium to that implemented by a social planner. Second, we describe the policy experiment in detail, illustrate the dynamic response of the labour market to the aggregate shock, and compute welfare analysis of the different policy responses. Finally, we summarise and contextualise our results.

3.1 Parameterization

Jung and Kuester (2015) parameterize the model by targeting key features of the US labour market for the period 1976Q1-2011Q1. A model period is equal to 1 month. Details of the calibration are provided below. A summary of calibration is provided in Table A1.

Functional forms The aggregate matching function is assumed to be Cobb-Douglas:

$$m_t = \chi v_t^{\alpha}(s_t N_t)^{1-\alpha}$$

where $\alpha \in (0,1)$ is the elasticity of matches with respect to vacancies, and $\chi > 0$ is a match efficiency constant. This implies the following expressions for the job finding and hiring rates:

$$f(\theta) = \chi\theta^{\alpha}, \quad q(\theta) = f(\theta)/\theta$$

The utility function for consumption is assumed to be a simple log utility function:

$$u(c) = \log(c)$$

Idiosyncratic shocks are logistically distributed, i.e. F_ι and F_ε are given by:

$$F_\iota = F\Big(0, \pi\frac{\psi_s^2}{3}\Big), \quad F_\varepsilon = F\Big(\mu_\varepsilon, \pi\frac{\psi_\varepsilon^2}{3}\Big)$$

where F is the logistic CDF, $\{\psi_s, \psi_\varepsilon\}$ control dispersion, and π is the mathematical constant. Under these assumptions the share of non-employed searchers s_t and the separation rate ξ_t are given by the following expressions:

$$s_t = \frac{1}{1+\exp\{\frac{-f_t\beta\mathbb{E}_t\Delta_{t+1}}{\psi_s}\}}, \quad \xi_t = \frac{1}{1+\exp\{(\varepsilon_t^{\xi}-\mu_\varepsilon)/\psi_\varepsilon\}}$$

The logistic distribution is a convenient choice as it permits a closed-form expression for the conditional expectation. For instance, the average production costs paid by continuing matches in any period are given by:

$$\int_{-\infty}^{\varepsilon_t^{\xi}} \varepsilon_j dF_\varepsilon(\varepsilon_j) = \Psi(\xi_t) = -\psi_\varepsilon\Bigg[(1-\xi_t)\log(1-\xi_t)+\xi_t\log(\xi_t)\Bigg]$$

whilst average disutility costs of job search can be defined analogously, denoted by the function $\Psi(s_t)$.

Externally calibrated parameters Several parameters are set to standard values. The time discount factor is set to $\beta = 0.996$. The elasticity of matches with respect to vacancies is set to $\alpha = 0.3$ based on Pissarides and Petrongolo (2001). The steady state value of the firm's share of the joint surplus is set to $\eta = 0.3$ such that the Hosios' (1990) condition is satisfied in the stationary equilibrium.[9]

Internally calibrated parameters Remaining parameters are set to match key moments in the data for the US labour market. Flow utility from non-employment is set to $\bar{h} = 0.382$ to match a non-employment rate of 7.5%. The dispersion parameter for the job search cost shock is set to $\psi_s = 0.216$ to target an elasticity of average unemployment duration to a change in UI equal to 0.8 based on Meyer (1990). The vacancy posting cost is set to $\kappa_v = 0.176$ to match a 6.4% average unemployment rate. The match efficiency constant is set to $\chi = 0.298$ to match a 71% quarterly hiring rate as in Den Haan et al. (2000). The location parameter for the production cost distribution is set to $\mu_\varepsilon = 0.063$ such that the mean production costs of surviving firms is zero. The dispersion parameter for the production cost shock is set to $\psi_\varepsilon = 0.659$ to target a 28% monthly job finding rate.

Policy Policy parameters to replicate features of the US labour market. The level of match subsidies is set to zero, i.e. $\tau_s = 0$. The level of UI is set to $B = 0.425$ to

[9]This is assumed for convention. In this particular model the Hosios' (1990) condition does not ensure efficiency of the stationary equilibrium as the social planner is no longer trying to maximise output, but has to take into account insurance concerns of risk-averse workers.

target a 45% wage replacement rate as in Engen and Gruber (2001). The layoff tax is set to $\tau_\xi = 0.680$ to target a value equal to 50% of UI payments a worker receives during an average unemployment spell. The production tax is set to $\tau_J = 0.013$ to ensure the government budget constraint is satisfied.

Wage rigidity The firm's share of the joint match surplus (i.e. their bargaining power) η_t varies procyclically over the business cycle in order to ensure a degree of wage rigidity that generates realistic volatility in labour market tightness without introducing the possibility of privately inefficient job separations. η_t is assumed to be an increasing function of aggregate productivity a_t:

$$\eta_t = \eta \exp\{\gamma_w a_{t-1}\}$$

where γ_w controls the degree of wage rigidity and is set to target the unconditional volatility in the job finding rate in the data.[10] This requires setting $\gamma_w = 14.81$.[11]

3.2 Baseline vs. Constrained-efficient Equilibrium

Table 1. Stationary equilibrium: Baseline vs. Efficient

Variable	Baseline	Efficient
c_e	0.945	0.945
c_u	0.427	0.429
θ	0.834	2.050
v	0.053	0.054
f	0.282	0.369
s	0.843	0.846
N	0.075	0.031
ξ	0.019	0.010
$urate$	0.064	0.026

How does the baseline stationary equilibrium compare to the constrained-efficient

[10]To calibrate γ_w we need to simulate a process for a_t and compute theoretical moments based on a stochastic solution of the model. Following Jung and Kuester (2015) we assume that a_t follows an AR(1) with $\rho_a = 0.983$ and $100 \cdot \sigma_a = 3.4$, and solve for a log-linear stochastic solution of the model. We report moments and correlations from model simulations compared to the data in Table A2 in the Appendix.

[11]Note that this is different from the value computed by Jung and Kuester (2015). This is because in their simulations they assume that the policymaker keeps the consumption replacement rate constant, i.e. $b = \frac{c_u}{c_e} = \frac{B+\Pi}{w+\Pi}$, rather than the level of UI, B. Interestingly, this actually slightly reduces the ability of the model to fit the data by increasing the volatility of wages relative to the simulated model in Jung and Kuester (2015), which then leads to separations and unemployment being too volatile compared to the data.

allocation chosen by a social planner? Table 1 compares the values of key endogenous variables in the stationary equilibrium with their corresponding values in the constrained-efficient allocation. The social planner only chooses to provide marginally more direct insurance to unemployed workers, where c_u is 0.47% higher in the efficient allocation whilst c_e is unchanged. Instead the planner prefers a much tighter labour market than achieved in the decentralised equilibrium on average. This has the effect of easing search congestions on the worker side (the job finding rate f is significantly higher) which indirectly provides insurance to unemployed workers by significantly reducing the share of the labour force in unemployment as well as the average unemployment duration. This is achieved partly through more job creation (i.e. higher levels of vacancy posting, v), but mostly through the reduction in effective searchers via the number of non-employed N, driven by the reduction in the separation rate, ξ.

3.3 A Simple Policy Experiment

For the policy experiment, we simulate a recession in the labour market and analyse the implications of alternative policy responses. Specifically, we analyse 4 different policy responses:

1. No policy response, government balances budget
2. No policy response, government runs deficit
3. An (deficit-financed) increase in UI
4. Introduction of (cost-equivalent) match subsidies

The shock driving the recession is a 1% fall in labour productivity $\exp\{a_t\}$ which lasts for T periods before returning to steady state:

$$\exp\{a_t\} = \begin{cases} 0.99 & \text{for} \quad t = 1, ..., T \\ 1 & \text{for} \quad t = T+1, ... \end{cases} \tag{20}$$

where it is assumed that the shock is unexpected but its structure is common knowledge after the shock arrives (i.e. agents have perfect foresight).

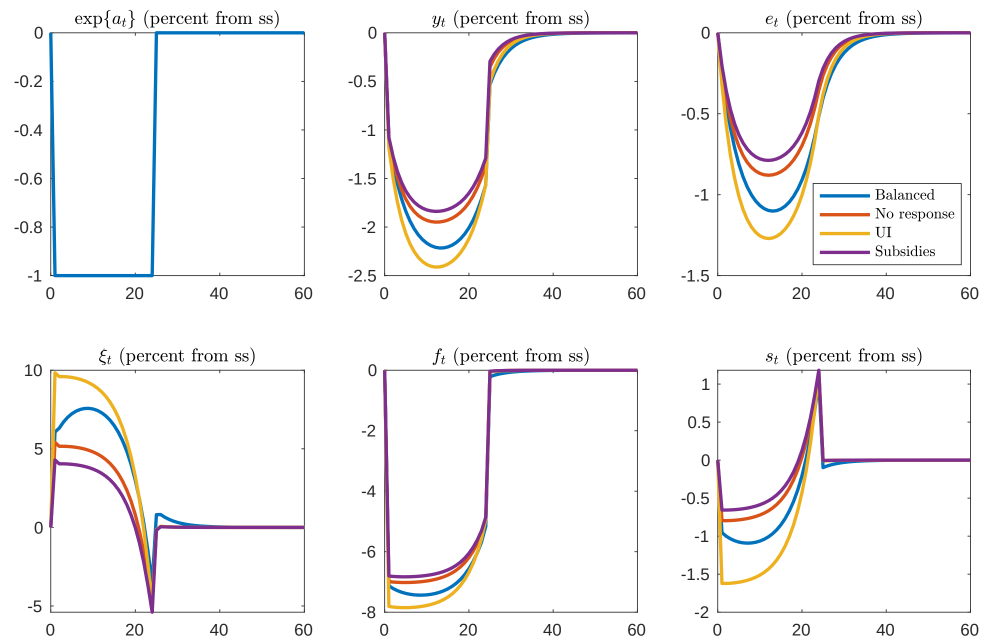

Figure 2. Labour market responses under different policies.

3.3.1 Labour Market Responses Under Alternative Policies

Figure 2 presents the responses of key endogenous variables under the 4 different policy responses discussed above. We review each one in turn.

Balanced budget We first analyse the response of the economy where the policy-maker does not adjust policy tools in response to the aggregate shock, apart from adjusting τ_J to balance the budget. The main effect of the aggregate shock is to reduce the value of a filled job, J_t. This has implications for both existing jobs and new job creation. In the first instance, the fall in aggregate productivity makes many marginal matches unviable that would have otherwise produced (i.e. the separation threshold ε_t^{ξ} increases), increasing the number of separations (bottom left panel, Figure 2). Secondly, the reduction in J_t disincentivises new job creation. This drives the fall in labour market tightness, reflected in the falling job finding rate (bottom middle panel). The overall outcome of an increase in separations and a reduction in job finding is an increase in the number of unemployed workers (i.e. employment falls, top right panel) and a fall in aggregate output (top middle panel).

How does the production tax $\tau_{J,t}$ respond to balance the budget? The increase in the number of unemployed means a greater amount of resources spent on UI even though B is held constant, whilst an increase in separations increases the amount of revenue taken from the layoff tax. Quantitatively the former dominates the latter so $\tau_{J,t}$ has to rise to balance the budget. This puts further downward pressure on J_t as the production tax also reduces the flow benefit from a filled job, and therefore amplifies the effect of the initial shock on the labour market.

No response Next we analyse how the labour market responds when the policymaker doesn't change *any* policy instruments, including $\tau_{J,t}$. That is to say, we allow the government to run a deficit to meet the additional fiscal expenditure from rising unemployment. This exercise effectively identifies the contribution of increasing $\tau_{J,t}$ to the dynamic response of the labour market in the previous scenario. Relative to the balanced-budget case, the increase in separations and fall in job finding rate are reduced as the impact of the shock is dampened. This highlights the benefits associated with the government being able to smooth taxes over time, rather than being forced to balance the budget.

UI How do the things change when the government increases the generosity of UI during the recession? We allow the level of UI to increase by 1% in response to a 1% fall in aggregate productivity. Figure 2 illustrates that in this environment an increase in UI actually *amplifies* the effect of the recession in the labour market. This occurs through the effect on the worker's surplus - as wages are determined via Nash bargaining, a reduction in the worker's flow surplus from working increases the bargained wage, which in turn reduces the value of a filled job, increases separations and reduces job creation. Moreover, the reduction in the worker's surplus also amplifies the fall in the share of non-employed workers who search (bottom left panel, Figure 2), which exacerbates the congestion externalities faced by firms and further reduces job creation incentives relative to an environment where the share of non-employed searchers was constant over time.

Match subsidies What would be the effect if instead the government decided to invest the same amount of resources into subsidising existing employment relationships? To answer this we also analyse the responses when the policymaker introduces match subsidies $\tau_s > 0$, where τ_s is chosen such that the policy is cost-equivalent to the increase in UI over the simulation period. Increasing match subsidies at the onset of the recession directly counteracts the effects of the aggregate shock by reducing the fall in J_t. As a result there are fewer separations, the fall in tightness is

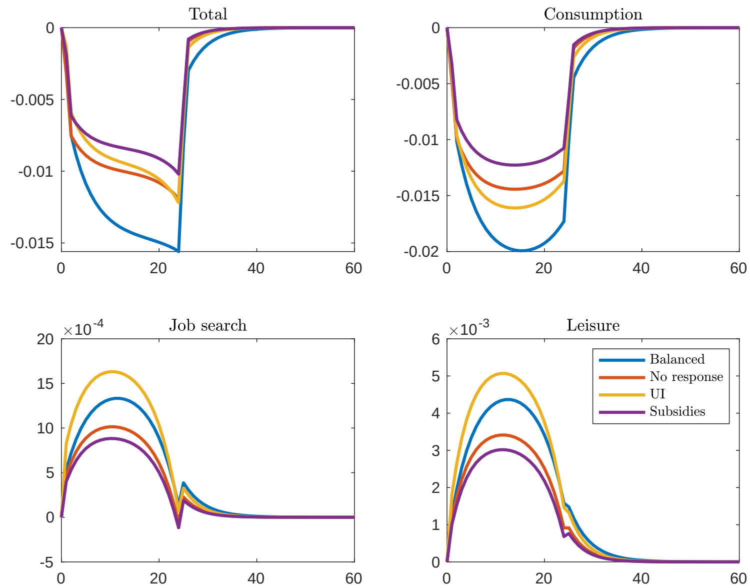

Figure 3. Decomposing the social welfare response

dampened, and the increase in unemployment is not as large relative to the no response case. Quantitatively the dampening predominantly comes from the reduction in separations, as the impact on tightness itself is quite small.

Summary Overall the results suggest that, in this simple model environment under a standard calibration for the US, the introduction of match subsidies dampens labour market volatility by both reducing unemployment inflows and supporting unemployment outflows. In contrast, increasing UI adds to labour market volatility by reducing the worker's employment surplus, adding upward pressure to market wages and exacerbating the fall in new job creation.

3.3.2 Welfare

Which policy response is preferred in welfare terms? In this environment the period social welfare function is given by the following:

$$\mathbb{W}_t = \underbrace{e_t \log(w_t + \Pi_t) + u_t \log(B_t + \Pi_t)}_{\text{Consumption}} + \underbrace{(\xi_t e_t + u_t)\Psi(s_t)}_{\text{Job search}} + \underbrace{(\xi_t e_t + u_t)\bar{h}}_{\text{Leisure}}$$

Social welfare can be decomposed into three constituent elements:

1. Utility from consumption
2. Disutility from job search
3. Utility from non-employment (i.e. leisure)

Table 2. Welfare decomposition: Shares

	Consumption	Job search	Non-employment
Equilibrium:			
Decentralised	74.0%	5.1%	20.9%
Efficient	83.3%	3.3%	13.4%

Table 2 displays the contribution shares of the (absolute) value of social welfare for each constituent element in both the decentralised equilibrium and the efficient equilibrium. In both cases utility from consumption is the main contributor to social welfare. Flow utility from non-employment plays a smaller role, whilst (dis)utility from job search turns out to be a very small determinant of social welfare. Aggregate social welfare is around 11.4% higher in the efficient equilibrium relative to the decentralised equilibrium. Table 2 suggests that the social planner achieves these welfare gains primarily by reducing the share of workers in non-employment, thereby increasing the average worker's consumption utility.

In general, labour market policies will affect social welfare in different ways depending on how they influence these three channels. To illustrate this Figure 3 plots the responses of each component of social welfare (in deviation from steady state) for each of the policy responses studied above. In all cases social welfare falls during the recession, driven by the falling level of average consumption due to the increasing share of workers in unemployment. However in all cases this fall in average consumption is partially offset by reduced job search disutility and increased flow utility from non-employment.

Relative to the baseline case where the government must balance the budget, the no response case achieves better welfare outcomes through higher average consumption of workers, despite this resulting in lower utility from job search and leisure channels. In contrast, despite providing greater direct insurance for the unemployed, increasing UI actually delivers a *larger* peak fall in average consumption utility due to indirect effects amplifying the fall in tightness, but this is counteracted by reduced disutility from job search and increase utility from leisure. Finally, the introduction of match subsidies improves on the no response case by further offsetting the effects of the aggregate shock on average consumption as highlighted above, but at the cost of further reducing the welfare gains associated with reduced job search and increased utility associated with non-employment.

To quantify and compare the welfare benefits from the different policy responses, we compute present-discounted welfare under each policy response over the duration of the simulation period. Table 3 summarises welfare results from the simulated recession under the baseline calibration, presenting welfare gains as a percentage relative to the balanced-budget scenario. In the first instance, allowing the government to run a deficit over the simulation period rather than having to balance the budget achieves sizeable welfare gains of 1.43%, highlighting the benefits of being able to tax smooth for the government during recessions. Both the increase in UI and the introduction of match subsidies achieve further welfare gains on top of this, but as noted above these welfare gains come through different channels. Match subsidies achieve further welfare gains by providing better overall insurance of average worker consumption to the aggregate shock via the stabilisation of tightness, whilst the gains from increased UI actually come from reduced job search and increased leisure. Under the baseline calibration, the introduction of match subsidies is preferred in welfare terms over a cost-equivalent increase in the level of UI, achieving a further 0.64% in welfare gains (on top of the gains from tax smoothing) compared to the additional 0.23% achieved by UI.

Summary Overall in this standard model environment under a relatively calibration, in welfare terms the government achieves better outcomes through the introduction of employment subsidies than from increasing the level of UI during a simulated recession. Crucially this is due to the fact that while increasing the level of UI provides greater direct insurance to workers losing their jobs, in equilibrium it is actually worse for consumption insurance due to the strong general equilibrium effect on labour market tightness, operating through the job creation channel by affecting the workers' outside option and therefore the Nash bargained wage. Nevertheless, increasing the generosity of UI in this environment still delivers welfare gains by reducing the disutility associated with job search, and increasing the fraction of workers who experience the flow utility associated with non-employment.

Table 3. Welfare gains under alternative policy responses.

Policy response	None (deficit)	UI	Subsidies
Welfare gain (%)	1.43	1.66	2.07
	-	(+0.23)	(+0.64)

3.4 Relationship with Birinci et al. (2021)

In this section we discuss in detail the relationship between the results presented above and those presented in Birinci et al (2021), who perform a very similar policy experiment comparing the relative benefits of an expansion in UI during a downturn versus a cost-equivalent increase in employment subsidies (or more specifically payroll subsidies in their case).

Environment Whilst there are some similarities between the two different environments (risk-averse workers, endogenous separations, search frictions), there are also some key differences which are important for interpreting results. Firstly, the model in Birinci et al. (2021) is an "epi-macro" model where the spread of an epidemic among workers (captured through a standard SIR model) interacts with the labour market. Matches are heterogeneous in productivity for two reasons: (i) workers differ in their infection status, which affects their productivity, and (ii) matches stochastically become more productive over time. This second assumption captures the idea that employment subsidy schemes deliver benefits by protecting higher productivity matches that have accumulated more 'match-specific capital', which would otherwise be lost upon separation.[12] In contrast, in the Jung and Kuester (2015) framework all matches are equally productive and only differ in their idiosyncratic fixed cost of production (which determines the separation decision). Secondly, wages are downwardly rigid and assumed to be an exogenous function of productivity, rather than a function of the joint match surplus. This is important because a key channel in our analysis is the effect of UI on tightness via the job creation channel operating through the effect on wages, which is absent in Birinci et al. (2021). Moreover, the combination of downward wage rigidities and financial constraints faced by firms leads to the presence of inefficient separations, i.e. matches that separate even though the joint surplus of the match is *positive*.[13] As discussed above, we abstract from this possibil-

[12] For a discussion of this in the context of Covid-19, see Fujita et al. (2020): https://cepr.org/voxeu/columns/labour-market-policy-response-covid-19-must-save-aggregate-matching-capital.

[13] If the joint surplus of a match is positive, then in general there exists a wage that will induce both the worker and the firm to continue in the match. Therefore inefficient separations represent

ity by assuming wage rigidity as the outcome of exogenous shifts in firm bargaining power.

Policy Effects Policy interventions have similar implications for the labour market across the two different environments, but for slightly different reasons. In both cases increasing UI amplifies the effect of the downturn on unemployment and aggregate output relative to the case of no fiscal response. In Birinci et al. (2021) an increase in UI leads to a reduction in the worker's surplus, which generates an increase in worker-initiated job separations and amplifies the increase in unemployment. In contrast in the Jung-Kuester framework all job separations are efficient, and the rise in separations reflects higher wage demands of workers in response to the reduction in their employment surplus. Similarly in both environments the introduction of employment subsidies dampens the response of unemployment and output. In Birinci et al. (2021) this is because payroll subsidies reduce the number of layoffs that firms initiate, which means the more higher productivity matches are saved such that the fall in aggregate output is less severe[14]. In the Jung-Kuester environment, match subsidies simply counteract the fall in the value of a filled job which reduces the separation threshold and dampens the fall in new job creation, leading to a stabilisation aggregate labour market tightness relative to no fiscal response.

Welfare Whilst the implications for the policy responses are similar across the two environments, the welfare results differ slightly. In the first instance, Birinci et al. (2021) also find that in isolation cost-equivalent employment subsidies deliver better welfare outcomes than an increase in the level of UI. However they emphasise that this is because payroll subsidies protect higher productivity matches, which means a less severe fall in average labour productivity and a much faster recovery of the economy, whilst increasing UI leads to losses in match capital despite providing consumption insurance for those workers who lose their jobs. Moreover, they emphasise that the two policies are *complements*. Solving for the optimal allocation of a fixed budget between the two policies, they find that only 20% should be allocated to payroll subsidies and the rest to greater UI. This is because there are high diminishing returns to payroll subsidies: once the highest productivity matches are saved, the gains from preserving lower productivity matches diminish, and it is better to let these matches

inefficient *bargaining* over the wage between the worker and the firm. See Jäger et al. (2019) for a nice discussion.

[14] Birinci et al. (2021) actually make a modelling distinction between matches that are temporarily inactive ('temporary layoffs') with a positive probability of recall, and permanently separated matches with zero possibility of recall.

separate but provide workers with greater insurance.

In the Jung-Kuester environment with homogeneous matches, the dynamics of average consumption are instead driven by labour market tightness. Moreover there are additional sources of welfare pertaining to disutility from job search and flow utility from non-employment which are absent in the Birinci et al. (2021) framework owing to the fact that there is no endogenous search decision. Employment subsidies help to offset some of the increase in separations and the fall in job creation, which helps to stabilise tightness and ensures that workers who are separated spend a short average amount of time in unemployment, even though these workers do not directly benefit in terms of higher consumption. Increasing UI in this environment actually has the opposite effect on tightness, and actually leads to worse outcomes in terms of average consumption. However an increase in UI still delivers welfare benefits through reduced job search disutility and increased flow utility associated with non-employment. As a result in the Jung-Kuester environment we find that UI and employment subsidies are actually *substitutes*: employment subsidies provide greater consumption insurance by reduced volatility in tightness but reduce utility from non-employment and higher job search disutility, whilst higher UI leads to worse average consumption insurance outcomes but delivers welfare gains from non-employment flow utility and reduced job search.

4 Flexible vs. Rigid Labour Market

How important is the structure of the labour market for determining the appropriate policy response to a recession? Do our results markedly change in the context of a more 'rigid' labour market characterised by lower worker turnover but a higher level of average policy support? In this section we repeat the analysis above, but instead adopt an alternative calibration of the model where we target key moments of the German labour market based on comparative evidence presented in Jung and Kuhn (2014). Compared to the US, the German labour market has significantly lower inflow and outflow rates from unemployment, as well as a higher average level of unemployment. Differences in the design of labour market institutions likely play a key role in explaining cross-country differences in labour market outcomes - the German labour market is characterised by employment subsidies in the form of *Kurzarbeit* (a longstanding short-time work scheme), greater employment protection legislation, a higher degree of collective bargaining, and higher replacement rates than compared to the US.

We first present an alternative calibration of the model, retaining the same choices for functional forms as used above to facilitate comparison. We then present the responses of the labour market to the same aggregate shock and compare the results with those obtained from the US calibration. Finally we again present welfare results from the same policy experiment and discuss the findings.

4.1 Alternative Calibration

Below we outline details of the alternative calibration of the model. A summary of the calibration is given in Table A3.

Externally calibrated parameters Again we assume a model period is equal to 1 month. We retain the same value for the time discount factor β. The elasticity of matches with respect to vacancies is instead set to $\alpha = 0.25$, based on the aggregate matching function estimation in Jung et al. (2021), and again we fix $\eta = \alpha$ for convention.

Steady state targets Remaining structural parameters are set to target moments corresponding to the German labour market based on evidence on German labour market flows, stocks and transitions data between 1980-2004 as documented in Jung and Kuhn (2014) (unless otherwise stated). We match the following steady state moments: an 8.4% average unemployment rate; a 6.2% monthly job finding rate; a 70% quarterly hiring rate based on Christoffel et al. (2009); 81% non-employed workers search, based on Jung et al. (2021); an elasticity of unemployment duration to a change in benefits $\epsilon_{D_u} = 0.5$, based on the range of estimates reported in Schmeider and von Wachter (2016).

Policy Policy parameters are set to match salient features of German labour market institutions. We set B to target a 67% wage replacement rate. The layoff tax τ_ξ is set to equal 6 times the monthly equilibrium wage, again based on Jung et al. (2021). Finally we set τ_s to match the average employment support provided by *kurzarbeit*. As documented in Balleer et al. (2016), since its inception in 1975 an average of 0.83% of the workforce have been enrolled on the STW scheme, where the government covers 60% of their wage.

Wage rigidity We set the degree of wage rigidity γ_w in the same way as before, this time targeting $100 \cdot \sigma_f = 10.4$.[15]

Table 4. Structural parameters under alternative calibrations

Parameter	Symbol	US	Germany
Preferences:			
Discount factor	β	0.996	0.996
Non-employment flow utilty	$\bar{h}$	0.382	-0.349
Firm bargaining power	η	0.3	0.25
Search cost dispersion	ψ_s	0.216	0.395
Labour market:			
Match elasticity	α	0.3	0.25
Match efficiency	χ	0.298	0.094
Vacancy cost	κ_v	0.176	0.930
Production cost location	μ_ϵ	0.063	0.117
Production cost dispersion	ψ_ϵ	0.659	3.33
Policy:			
UI	B	0.425	0.605
Match subsidies	τ_s	0	0.005
Layoff tax	τ_ξ	0.680	5.415
Production tax	τ_J	0.013	0.039

How do the structural parameters of the labour market compare to those used for the US calibration? Table 4 compares the implied values of the structural parameters used in the two different calibrations, whilst Table 5 presents the values of key endogenous variables in the stationary equilibrium for the two different economies.

In order to match a higher average unemployment rate and lower average job finding rate, the model requires a much lower level of labour market tightness in equilibrium, which is achieved through a combination of lower vacancy posting (requiring a higher vacancy cost κ_v) and a lower degree of match efficiency χ. The separation rate consistent with this is comparable with that the data[16], and is achieved by a significantly higher cost of job separation for firms, τ_ξ. The higher level of B ensures replacement rate target is matched, and as a consequence unemployed workers are much better off under the German calibration (around 37% in consumption utility terms). In order to match the higher level of UI support with a share of non-employed searchers

[15]Table A4 reports moments and correlations compared to what we see in the data.

[16]The average EU transition rate in the data is reported to be 0.005 in Jung and Kuhn (2014), whilst in the EU rate (ξ) implied by the model under this calibration is 0.006.

equal to 81%, the model requires $\bar{h} = -0.349$. Finally, to achieve the lower elasticity of unemployment duration with respect to UI the model requires a higher degree of dispersion in the job search utility cost ψ_s.

How does the competitive stationary equilibrium compare to the efficient equilibrium under the German calibration? Table 5 also contains the values of key variables chosen by the social planner. Tightness is still inefficiently low in the German calibration, though not by as much as for the US calibration. Interestingly, the social planner would choose to increase tightness by significantly reducing the amount of non-employed workers (and hence the unemployment rate), rather than by stimulating more job creation on the firm side - in fact, vacancies are inefficiently *high* in the decentralised equilibrium. Lower tightness is achieved primarily through a much lower amount of job separations. This requires existing matches to pay higher costs of production, and for workers to consume less in absolute terms (and actually a slightly lower replacement rate, which is inefficiently high in steady statex).

Table 5. Comparing stationary equilibria

Variables	US	Germany	Efficient
c_e	0.945	0.913	0.899
c_u	0.427	0.615	0.601
θ	0.834	0.188	0.440
v	0.053	0.016	0.009
f	0.282	0.062	0.077
s	0.843	0.810	0.832
N	0.075	0.102	0.026
ξ	0.019	0.006	0.002
$urate$	0.064	0.084	0.021

Figure 4 plots the responses of the labour market under the two different calibrations to the same recession shock. Overall labour market volatility (and hence the job finding rate) is lower under the German calibration by construction, as we target the lower observed volatility in the data. This leads to a less severe recession in terms of employment and output deviations from steady state. In the model this is also driven by lower average increase in separations - which spike immediately in response to the recession but do not remain elevated for as long. Crucially, the recovery in employment and output is much more protracted under the German calibration, reminiscent of the results in Jung and Kuhn (2013). This is due to the monthly job finding rate being much lower in the German calibration - for a given level of tightness

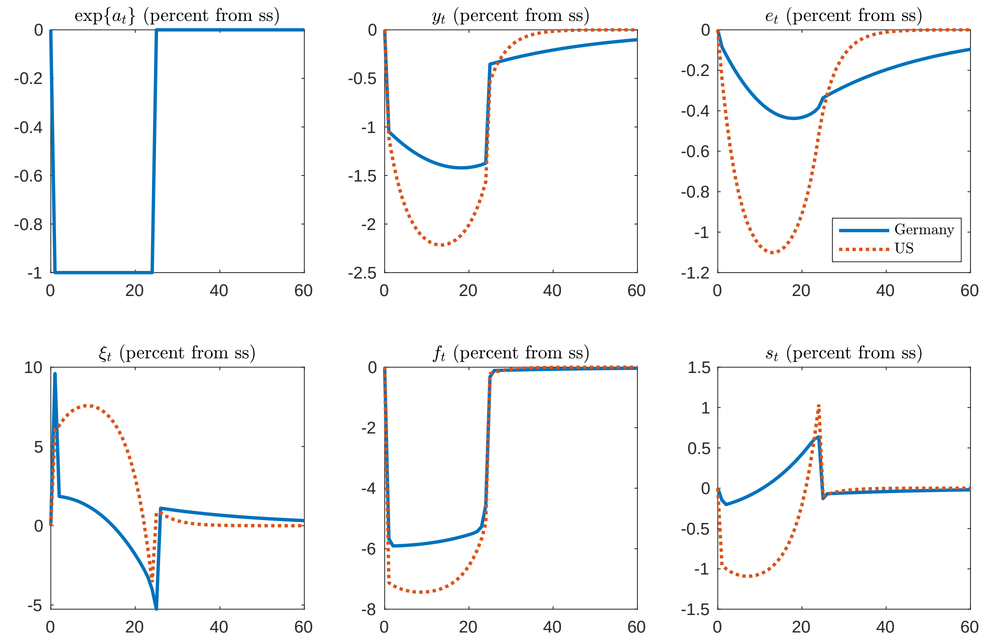

Figure 4. Comparing the response of the labour market under different calibrations.

it takes much longer on average for the non-employed to find jobs, and therefore for the stock of non-employed workers to reduce back to its equilibrium level.

4.2 Policy experiment

We repeat the same analysis as above, where we assume the labour market is hit with a one-off negative aggregate shock and study how its behaviour changes under alternative policy responses.[17] Figure 5 plots the results.

In general we see a fairly similar story to the results plotted for the US calibration in Figure 2. Allowing the government to run a deficit dampens the response, but in this case also significantly reduces the persistence of the effects of the aggregate shock on the labour market due to the lower average flow rates between employment and unemployment. The increase in employment subsidies directly counteracts the effects of the negative shock to provide further stabilisation on top of this. Whilst the

[17]There is one slight difference in our policy experiments. We instead assume that for the subsidy response, the employment subsidy increases by 10% in response to the 1% negative shock to aggregate productivity. We then compute the cost-equivalent increase in the level of UI for the increase in UI scenario. This turns out to be equivalent to a 0.83% increase in the level of UI.

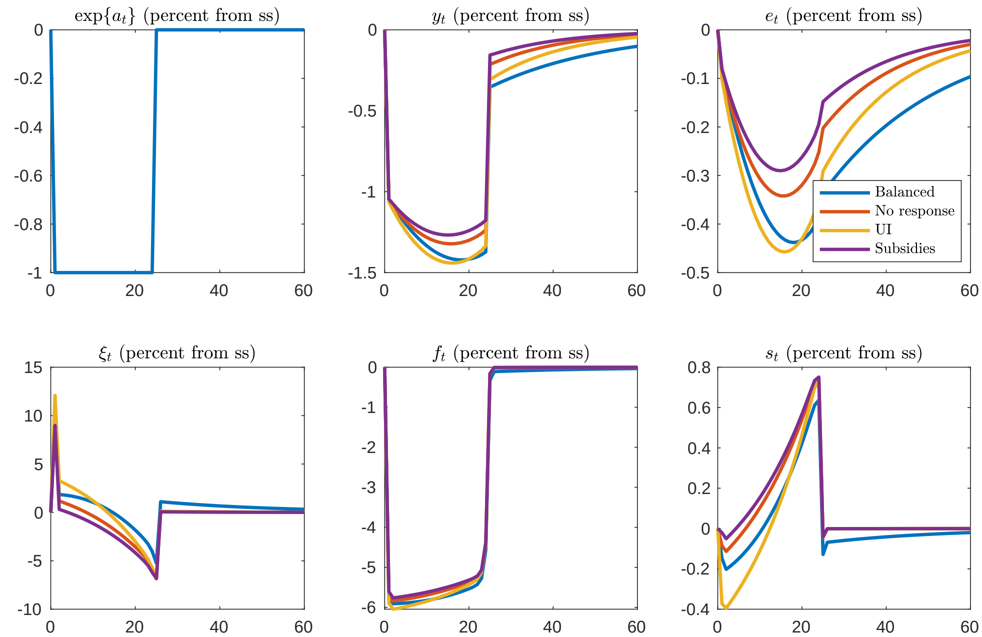

Figure 5. German calibration: Policy responses

Table 6. Welfare decomposition: Shares

	Consumption	Job search	Non-employment
Equilibrium:			
Decentralised	70.2%	10.6%	19.2%
Efficient	89.6%	3.5%	6.9%

increase in UI again amplifies the shock through its effect on the worker's employment surplus, this channel is less strong relative to the US calibration (for a comparable increase in UI in percentage terms).

The story in terms of the welfare decomposition is slightly different. The steady state shares of the contribution of each channel to social welfare in absolute terms are reported in Table 6, where again utility from consumption is the key determinant of social welfare, though job search disutility plays a more significant role under the German calibration. The dynamic responses of each channel during the simulation are plotted in Figure 6. In all cases the dynamics of social welfare are driven almost entirely by average consumption. The contributions of leisure and job search ap-

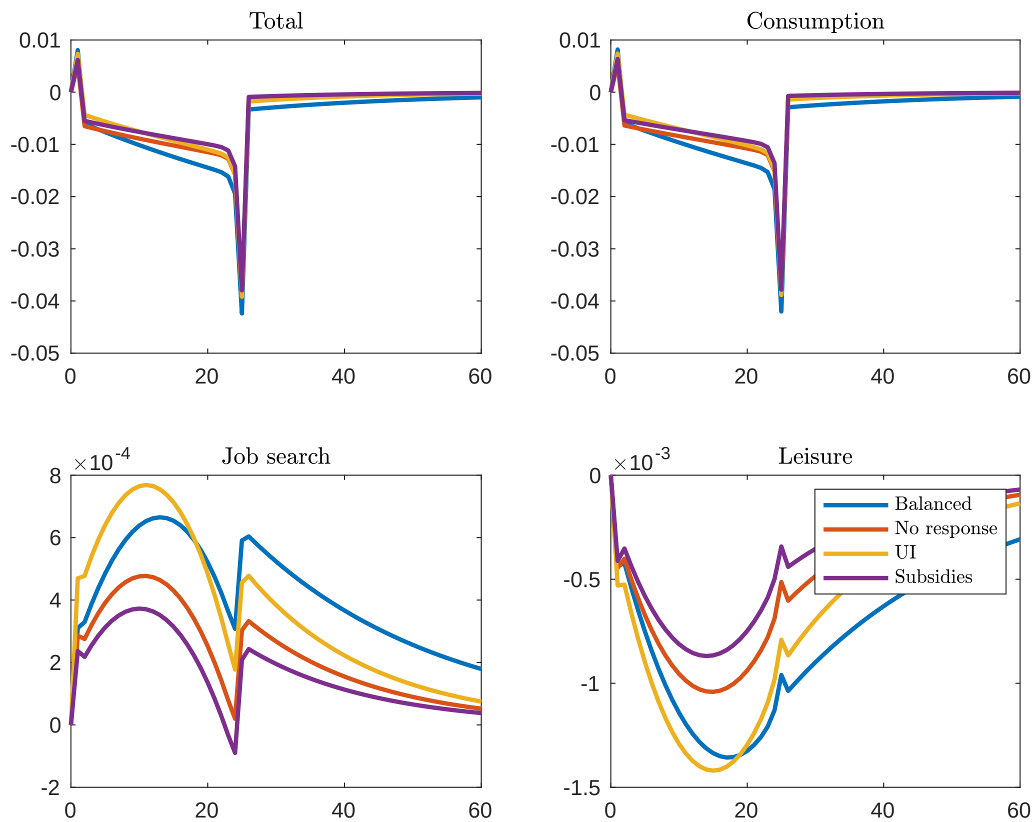

Figure 6. German calibration: Welfare decomposition

Table 7. Welfare gains under alternative policy responses.

Policy response	None (deficit)	UI	Subsidies
Welfare gain (%)	0.74	0.88	1.03
	-	(+0.14)	(+0.29)

pear to be quantitatively irrelevant.[18] The average consumption level actually *rises* upon the impact of the shock due to the assumption that the firm's bargaining power sharply falls in line with a_t[19], which increases wages for one period before they subsequently decline in line with the present discounted value of the joint surplus. As with the US calibration, we find that the fall in average consumption is mitigated more significantly when labour market tightness is stabilised to a greater degree. Again this emphasises the importance of stabilising the composition of the labour force for consumption insurance over the direct provision of insurance in this environment. However as the increase in UI has a less destabilising effect under this alternative calibration (e.g. see the top right panel of Figure 6), welfare losses from consumption are actually mitigated by the increase in direct insurance provision to workers under this calibration.

Table 7 reports the computed welfare gains of each of the policy responses relative to the balanced budget case. Again the ordering of policy preference is not altered by the calibration - increasing employment subsidies is still preferred as they are more effective at insuring average consumption by stabilising tightness. However we see that a cost-equivalent expansion in UI achieves welfare gains through its role in insuring workers' consumption, rather than through its effects on reducing job search disutility or increasing leisure/non-employment flow utility. This is a direct result of the fact that the destabilising effect of UI through the job creation channel is much weaker under a calibration targeting lower average worker flow rates. As a result, the *relative* gains from employment subsidies compared to a cost-equivalent increase the level of UI support are smaller for the German calibration than for the US calibration.

Summary The above results suggest that while qualitatively the effects of differ-

[18]Note that under the German calibration we actually required a *negative* flow utility value associated with non-employment, $\bar{h}$. This is in line with Jung et al. (2021). This means that this channel now contributes negatively to welfare, rather than positively in the US case where we needed $\bar{h} > 0$. One could interpret $\bar{h} < 0$ instead as disutility associated with non-employed independent of that induced from active job search.

[19]This is a result of the fact that under the German calibration the degree of wage rigidity required to match the observed volatility in labour market tightness and job finding rate is larger ($\gamma_w = 17.78$) than it is for the US calibration ($\gamma_w = 14.81$).

ent policy responses on the labour market and the associated welfare conclusions are unchanged, quantitatively the effects are somewhat different. In particular we find that under a more 'rigid' calibration of the model to match features of the German labour market, the strength of the job creation channel to a change in UI is much reduced, to the extent that the direct insurance provided to workers when we increase UI during the downturn is not offset by the increased fall in labour market tightness in terms of its effect on average worker consumption. Therefore, whilst stabilising tightness through match subsidies is still preferred overall, the relative welfare gains from adopting this approach relative to investing the equivalent resources into increasing UI for unemployed workers are significantly smaller compared to the baseline US calibration.

5 Conclusion

(to be added)

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A Additional Tables & Figures

Table A1. Calibration: US Labour market

Parameter/Value	Description	Source/Target
Externally calibrated:		
$\beta = 0.996$	Discount factor	Standard
$\alpha = 0.3$	Match elasticity	Petrongolo and Pissarides (2001)
$\eta = 0.3$	Firm's joint surplus share	Hosios' (1990) condition
Internally calibrated:		
$\bar{h} = 0.382$	Leisure utility	$N = 0.075$
$\psi_s = 0.216$	Job search cost dispersion	$\varepsilon_{D_u} = 0.8$
$\kappa_v = 0.176$	Vacancy posting cost	6.4% unempl. rate
$\chi = 0.298$	Match efficiency	71% (quarterly) hiring rate
$\mu_\varepsilon = 0.063$	Production cost scale	$\int^{\varepsilon^\xi} \varepsilon F_\varepsilon(\varepsilon) = 0$
$\psi_\varepsilon = 0.659$	Production cost dispersion	$f = 0.282$
Policy:		
$\tau_s = 0$	Match subsidies	-
$\tau_\xi = 0.680$	Layoff tax	50% average UI claims
$\tau_J = 0.013$	Production tax	Balanced budget
Wage rigidity:		
$\gamma_w = 14.81$	Wage rigidity	$100 \cdot \sigma_f = 12.29$

Table A2. Model evaluation: Theoretical vs. Empirical Moments

Variable		y	a	$urate$	v	f	ξ	w	θ
σ_x	*Model*	3.43	1.59	22.20	21.36	12.29	12.15	2.74	40.96
	Data	3.34	1.85	17.46	18.55	12.29	8.52	1.94	13.85
$\rho_{x,y}$	*Model*	1	0.98	-0.99	0.88	0.99	-0.99	0.61	0.99
	Data	1	0.62	-0.89	0.80	0.86	-0.73	0.64	0.87

Table A3. Calibration: German Labour market

Parameter/Value	Description	Source/Target
Externally calibrated:		
$\beta = 0.996$	Discount factor	Standard
$\alpha = 0.25$	Match elasticity	Jung et al. (2021)
$\eta = 0.25$	Firm's joint surplus share	Hosios' (1990) condition
Internally calibrated:		
$\bar{h} = -0.349$	Leisure utility	$s = 0.81$
$\psi_s = 0.395$	Job search cost dispersion	$\varepsilon_{D_u} = 0.5$
$\kappa_v = 0.930$	Vacancy posting cost	8.4% unempl. rate
$\chi = 0.094$	Match efficiency	70% (quarterly) hiring rate
$\mu_\varepsilon = 0.117$	Production cost scale	$\int^{\varepsilon^\xi} \varepsilon F_\varepsilon(\varepsilon) = 0$
$\psi_\varepsilon = 3.334$	Production cost dispersion	$f = 0.062$
Policy:		
$\tau_s = 0.005$	Match subsidies	$\tau_s = 0.6 \cdot 0.0083 \cdot w$
$\tau_\xi = 5.415$	Layoff tax	$\tau_\xi = 6 \cdot w$
$\tau_J = 0.039$	Production tax	Balanced budget
Wage rigidity:		
$\gamma_w = 17.78$	Wage rigidity	$100 \cdot \sigma_f = 10.4$

Table A4. German calibration: Model evaluation

Variable		y	a	$urate$	v	f	ξ	w
σ_x	*Model*	3.3	1.6	16.5	30.7	10.4	11.3	14.3
	Data	2.4	1.6	18.1	33.1	10.4	15.1	1.7
$\rho_{x,y}$	*Model*	1	0.93	-0.94	0.78	0.94	-0.97	0.06
	Data	1	0.77	-0.76	0.82	0.40	-0.81	0.84