Chapter 1

Insuring Matches or Workers? Labour Market Policy in Recessions

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 the matching framework developed in Jung and Kuester (2015) featuring risk-averse workers, who face uninsurable income risk in the labour market and make an endogenous search decision when non-employed, and endogenous job destruction. In this fairly environment, changes in UI and employment subsidies have opposite effects on labour market tightness via their effects on job creation and destruction, which has welfare implications through its effect on worker income risk. We use a calibrated version of the model to perform a policy experiment where we quantify the importance of the different effects of UI and employment subsidies on worker income risk during a recession. Overall, we find that although expanding UI reduces the cost of job separation to workers, increasing employment subsidies are more effective at offsetting heightened income risk during a recession via their effect on tightness. Moreover, we find that this result is robust to whether the labour market is 'flexible' and characterised by lower levels of policy support and higher worker turnover on average (e.g. the US), or more 'rigid' (e.g. Germany).

Keywords: *UI, Match subsidies, Risk aversion, Search & matching*

JEL Codes: *E24, E32, J63, J64, J65*

1.1 Introduction

Significant rises in job separations accompanied by large falls in labour demand during recessions has long been associated with inefficiencies which policy has a role 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). Recognition of this concern has led to almost all advanced economies establishing some sort of unemployment insurance (hereafter: UI) system to provide partial income insurance for unemployed workers, though the nature of UI differs hugely across countries.[1] The resulting high levels of unemployment are also commonly thought to reflect an inefficient allocation of resources, 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) to incentivize firms to keep hold of workers during downturns by subsidising the costs of maintaining an employment relationship.[2]

In the face of very large recessions, policymakers have frequently sought to intervene to extend existing policy support to the labour market. This has been particularly evident during the last two major recessions: the Great Recession in 2008 and the Covid-19 pandemic recession in 2020. Though as recently emphasised by Giupponi et al. (2022), policymakers across advanced economies have made *different* choices regarding the nature of these interventions. More specifically, policymakers in the US have (for the most part) have tended to invest more resources in providing greater insurance directly to workers during recessions by making existing UI policy more generous.[3] In contrast, Western European economies in particular have opted to invest more resources into extending employment protection schemes in order to prevent 'excess' layoffs which would otherwise lead to higher unemployment and a greater under-utilization of labour.

A common reason put forward for cross-country differences in labour market policy responses to recessions is differences in underlying labour market institutions

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

[2]STWs are used in several major European economies, most notably Germany, France, and Italy. Compared to UI, such schemes are far from universal across advanced economies.

[3]As noted in Chapter 1, notable examples of this are the Emergency Unemployment Compensation (EUC) Act in 2008, as well as the Coronavirus Aid, Relief and Economic Security (CARES) act in 2020.

and structures.[4] For instance, compared to the US 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, all of which contributes to lower turnover rates (separation and job finding) as well as higher average unemployment. The rationale is that in a more 'rigid' labour market with lower turnover rates (such as Germany) it takes unemployed longer to find new jobs, and therefore the welfare gains from preserving matches during downturns are potentially higher.[5]

This paper seeks to address the following questions: Should policy focus on providing insurance for workers or employment matches during downturns? Does this choice depend on existing design of labour market institutions? We answer these questions through the lens of a fairly standard general equilibrium matching model in the Mortensen and Pissarides (1994) tradition, calibrated to match standard labour market moments and then used to simulate policy counterfactuals during a recession and evaluate the welfare implications of policy alternatives. Furthermore, we repeat the analysis for alternative calibrations of the model ('flexible' vs. 'rigid' labour market) in order to examine the effect of existing labour market institutions for the findings.

Given our purposes, 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 who are unable to insure income against unemployment risk, and an endogenous search decision. This environment has several important features for our purposes. Firstly, uninsurable endogenous income risk from unemployment allows a role for publicly-provided insurance to improve welfare of risk-averse workers by alleviating this risk. Secondly, allowing for an endogenous search choice captures the idea that search effort by non-employed workers is endogenous to UI, which captures the moral hazard concerns emphasised in the UI literature. Finally, endogenous separations are an important part of the analysis as a

[4] 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. For notable contributions, see Lazear (1990) and Boeri (2010)).

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

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.

After calibrating the model to match salient features of the US labour market, we simulate a recession and study the welfare implications of adopting several policy alternatives: (i) increasing the level of UI, or (ii) investing the same amount of resources in subsidising existing employment relationships. In the model we find that whilst increasing UI directly reduces the income cost of job separations, it also *amplifies* the effect of the recession on income risk via its effect on job creation and tightness. In contrast, introducing employment subsidies dampens the effect of the recession by reducing job separations. Our first main result is that a cost-equivalent investment into subsidising matches is preferred to increasing the level of UI, as this more effectively insures the average consumption level of workers through the stabilization of labour market tightness which reduces income risk by ensuring that unemployed workers are reallocated into new jobs relatively faster.

In contrast, even though increasing UI provides more direct insurance to individual unemployed workers such that they enjoy a higher consumption level, a greater fraction of workers spend time in unemployment and the average duration of an unemployment spell is longer than otherwise. We find that this latter effect quantitatively dominates in terms of the overall effect on consumption insurance. Nevertheless, in this environment UI still achieves welfare gains via its effect on non-market channels, or more specifically the reduction in job search disutility and an increase in leisure utility enjoyed by the larger share of non-employed workers, which are typical features of models allowing for a search decision by non-employed workers (e.g. Mitman and Rabinovich 2015).

To examine the role of the underlying labour market institutions for our findings, 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, as an example of a more 'rigid' labour market (in comparison to the US). Our second main finding is that our results appear robust to underlying design of labour market institutions. If anything, the result goes in the other direction: we find that the destabilising effect from increasing UI is much smaller in a rigid labour market. In this environment where worker turnover is slower, increasing UI instead 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 actually slightly smaller than for the US calibration.

Outline. The rest of the paper is structured as follows. The remainder of this section summarises the broadly related literature. Section 1.2 outlines the model framework we utilise for our policy experiments. Section 1.3 details the quantification. Section 1.4 outlines the baseline policy experiment and presents the main results. Section 1.5 studies the impact on the baseline results from an alternative calibration of the model to the German economy. Section 1.6 relates the key results to other key contributions in the literature. Section 1.7 concludes.

1.1.1 Related literature

The present paper is related to 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 theoretical 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 general equilibrium effects such as the job creation incentives for firms (via effects on wages and congestion externalities).[6] Empirically, whilst 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), identifying the *macro* effects of UI is much more difficult owing to the challenge of identifying plausibly exogenous variation in UI at the market level (as opposed to the individual level).[7] As a result, there is no real consensus regarding the general equilibrium effects of UI. For instance, Landais et al. (2018) survey the literature and argue that as on average the *macro*-elasticity of UI is estimated to be lower than the *micro*-elasticity,

[6] Notable theoretical contributions characterising this trade-off (to name but 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).

[7] For further discussion of these difficulties (and some proposed solutions), see Hagedorn et al. (2016) and Chodorow-Reich et al. (2019).

an increase in UI is associated with an increase in labour market tightness[8], 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 mixed messages regarding the desirability of such policies.[9] Moreover, this literature tends 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. Whilst this proxies for differences in legislation governing job separations displayed across countries, in practice these policies cannot be adjusted as easily as *subsidy* policies in recessions. A key example of this sort of policy are STWs, which forms the focus of its own 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, but potentially come at the cost of a reduction in allocative efficiency by impeding the reallocation of workers away from lower productivity firms. 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.[10]

Joint policy design. Finally, there is a theoretical literature studying the overall design of labour market policy. 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).[11] Blan-

[8] Landais et al. (2018) argue that the difference between these two elasticities reflects general equilibrium effects associated with changes in UI. The idea here is that the micro-elasticity 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 macro-elasticity then captures any additional effects from changes in aggregate conditions. So if the macro-elasticity is less than the micro-elasticity, then aggregate job finding rates (and therefore tightness) must have increased.

[9] Quantitative results from these papers suggest that constraining firms' adjustment of their labour inputs can either increase or decrease the level and volatility of unemployment depending on modelling choices.

[10] 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.

[11] 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.

chard and Tirole (2008) and Cahuc and Zylberberg (2008) study the joint design of employment protection policies with UI in a partial equilibrium setting where workers are risk-averse and cannot fully insure against unemployment. 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. Two important exceptions to this are Michau (2015) and Jung and Kuester (2015).[12]

This paper is most closely related to recent contributions by Birinci et al. (2021) and García-Cabo et al. (2023), who conduct similar policy experiments looking at the effects of increases in employment subsidies (in the form of wage subsidies) versus UI during a downturn. Whilst both papers feature search frictions and endogenous labour demand, there are several key differences which are important for their results. Birinci et al. (2021) allow for match-specific productivity which grows stochastically over the duration of a match. They also abstract from moral hazard concerns and assume wages are unaffected by changes in the worker's outside option. In this environment 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 less productive and face greater separation risk. García-Cabo et al. (2022) instead use a multi-sector model with job-specific stochastic productivity where workers are risk-neutral (i.e. there are no insurance considerations), and study the implications for the allocation of resources in response to a sector-specific productivity shock. In this case the labour market flexibility (i.e. the speed of allocation) is crucial for whether UI or employment subsidies are preferred. The analysis in this paper complements these papers by studying a similar policy experiment in an intentionally standard environment, where comparison reveals more clearly the role that these additional assumptions play for the results. We compare our results to these papers in more detail in Section 1.6.

[12]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.

1.2 Model

In this section we briefly outline the theoretical framework we use to conduct policy analysis, which was developed in Jung and Kuester (2015), Ignaszak et al. (2020), and Jung et al. (2021). For the most part we retain their notation. The framework deviates in several key ways from the standard Mortensen-Pissarides (1994) framework from the perspective of our research question. Firstly, job separations are allowed to vary endogenously over the business cycle, which is a robust empirical fact (e.g. see Fujita and Ramey 2009) and allows a role for employment subsidies to stabilise job separations. Secondly, workers are risk-averse and are unable to insure income against unemployment risk so that UI can improve welfare by stabilising income fluctuations. Finally, non-employed workers make a job search decision such that job search incentives respond to changes in UI.

1.2.1 Environment

Workers. Time is discrete and runs forever. There exists a constant mass of *ex ante* identical, risk-averse workers. Workers can either be employed or unemployed.[13] 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 $\iota_i \sim F_\iota$ conditional on being non-employed and choosing to actively search for a new match. Workers are unable to self-insure against unemployment risk 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 $c_{u,t} = B_t + \Pi_t$.

Firms. Firms post vacancies to form single-worker matches and produce output to earn profits. Vacancies are posted at per period cost $\kappa_v > 0$. If 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 $\varepsilon_j \sim F_\varepsilon$. There exists a threshold value of the cost ε^ξ at which

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

workers/firms are indifferent between the match continuing or separating.[14] If the worker-firm pair decide to terminate the match, the firm must pay a layoff tax τ_ξ (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 $\exp\{a_t\}$ (where a_t is aggregate labour productivity) 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.

Matching. New matches m_t are formed by the meeting of non-employed searchers and job vacancies in the labour market via a constant returns to scale aggregate matching function:

$$m_t = m(v_t, s_t N_t) \tag{1.1}$$

where v_t are vacancies posted by new firms, s_t is the share of non-employed workers who search, N_t is the measure of non-employed workers, and therefore $s_t N_t$ is the relevant 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:

$$N_t = \xi_t e_t + u_t \tag{1.2}$$

where e_t is the measure of employed workers and ξ_t is the separation rate. We 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) as standard:

$$\theta_t = v_t / (s_t N_t) \tag{1.3}$$

where the hiring and job finding rates are given by:

$$q_t = m_t / v_t = m(1, 1/\theta_t), \quad f_t = \theta_t q(\theta_t) \tag{1.4}$$

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

$$e_{t+1} = (1 - \xi_t) e_t + m_t \tag{1.5}$$

Timing. The timing of events within a model period is as follows:

[14] In general a separation can either be worker-initiated (a "quit"), firm-initiated (a "layoff"), or mutually agreed. This depends on the worker and firm surpluses, 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, but an important implication of this is that *all* separations are mutually agreed by both workers and firms, i.e. bargaining is always efficient.

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.

1.2.2 Equilibrium

Job creation. In equilibrium potential firms post vacancies until the expected value is equal to the cost. Job creation is therefore pinned down by the standard free entry condition, equating the cost of posting a vacancy with its expected gain:

$$\kappa_v = q_t \mathbb{E}_t Q_{t,t+1} J_{t+1} \tag{1.6}$$

where $Q_{t,t+1}$ is the appropriately defined stochastic discount factor.

Job search. Non-employed workers decide whether to search for a job based on their idiosyncratic cost of job search $\iota_i \sim F_\iota$, which is 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:

$$\iota_t^s = f_t \beta \mathbb{E}_t \Delta_{t+1} \tag{1.7}$$

The share of non-employed who search is therefore given by:

$$s_t = Pr(\iota \leq \iota_t^s) = \int_{-\infty}^{\iota_t^s} \iota dF_\iota \tag{1.8}$$

Wages. Wages are assumed to be determined by Nash bargaining between workers and firms:

$$\underset{w_t x}{\text{argmax}}\ (\Delta_t)^{1-\eta_t} (J_t)^{\eta_t}$$

where $\eta_t \in (0,1)$ is the firm's (time-varying) bargaining power, J_t is the firm surplus and $\Delta_t := V_{e,t} - V_{u,t}$ is the worker's surplus, where $\{V_{e,t}, V_{u,t}\}$ are the values of employment and unemployment respectively (defined below). The wage paid to workers w_t satisfies the usual Nash sharing rule:

$$(1-\eta_t)J_t = \eta_t \frac{\Delta_t}{u'(w_t+\Pi_t)} \tag{1.9}$$

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:

$$J_t(\varepsilon_t^{\xi}) = \Delta_t(\varepsilon_t^{\xi}) = 0 \tag{1.10}$$

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

$$\xi_t = Pr(\varepsilon_j > \varepsilon_t^{\xi}) = \int_{\varepsilon_t^{\xi}}^{\infty} \varepsilon_j dF_\varepsilon \tag{1.11}$$

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

$$Y_t = e_t \cdot (w_t + \Pi_t) + u_t \cdot (B_t + \Pi_t) + e_t \int_{-\infty}^{\varepsilon_t^{\xi}} \varepsilon_j dF_\varepsilon(\varepsilon_j) + \kappa_v v_t \tag{1.12}$$

where aggregate firm profits can be expressed as:

$$\Pi_t = e_t(1-\xi_t)[\exp\{a_t\} - \tau_{J,t} - w_t - \int_{-\infty}^{\varepsilon_t^{\xi}} \varepsilon_j dF_\varepsilon(\varepsilon_j)] - e_t\xi_t[w_t + \tau_\xi] - \kappa_v v_t \tag{1.13}$$

Definition 2.1 (Equilibrium). *For a given realization of $\{a_t\}_{t=0}^{T}$, initial unemployment level u_0, and policy rules for $\{\tau_{\xi,t}, B_t, \tau_{s,t}\}$, an equilibrium is defined as a sequence for the threshold production cost ϵ_t^{ξ} and separation rate ξ_t, the threshold job search cost ι_t^{s} and share of non-employed searchers s_t, wages w_t, firm profits Π_t, vacancies v_t, tightness θ_t, labour market stocks $\{e_t, u_t, N_t\}$ which satisfy: the job creation condition in 1.6, the Nash sharing rule in 1.9, the separation condition in 1.10 and definition of separation rate in 1.11, the job search condition in 1.7 and definition for share of non-employed searchers in 1.8, the market clearing condition in 1.12 and the definition of firm profits in 1.13.*

In the baseline case we assume that policy instruments remain constant over the business cycle.[15]

[15] 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.

1.3 Quantification

In this section, we first outline a calibration of the model to fit key moments in the US labour market, following the strategy in Jung and Kuester (2015). Next, we compare the decentralized stationary allocation to that which would be implemented by a social planner and comment on the inefficiencies generated by the presence of search frictions and incomplete markets.

1.3.1 Calibration

A model period is equal to 1 month. A summary of calibration is provided in Table 1.8. Details of the calibration are provided below.[16]

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:

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

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

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

Idiosyncratic shocks $\{\iota_i, \varepsilon_j\}$ are logistically distributed, i.e. F_ι and F_ε are given by:

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

where F is the logistic CDF, $\{\psi_s, \psi_\varepsilon\}$ control dispersion, and π is the mathematical constant.[17] The share of non-employed searchers s_t and the separation rate ξ_t are

[16] For the purposes of simulating the model for calibration purposes, we impose the strict condition in equilibrium that $\tau_{J,t}$ fluctuates in order to balance the budget in every period (i.e. there is no tax smoothing).

[17] 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:

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

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

therefore given by the following expressions:

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

Externally calibrated parameters. Several parameters are set to standard values in the literature. The 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 α.[18]

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 are set to replicate US labour market institutions. 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 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. Finally, the production tax is set to ensure the government budget constraint is satisfied.

Wage rigidity. The firm's share of the joint match surplus (i.e. 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.[19] Specifically, η_t evolves according to:

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

[18] 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.

[19] This is a convenient way of allowing for wage rigidity without introducing the possibility of privately inefficient job separations.

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.[20] This requires setting $\gamma_w = 14.81$.[21]

1.3.2 Stationary Equilibria: Baseline vs. Constrained-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

Table 1.1. Stationary equilibrium: Baseline vs. Efficient

How does the baseline stationary equilibrium compare to the constrained-efficient allocation chosen by a social planner? Overall the social planner has to trade-off two sources of welfare losses: (i) excess volatility in worker consumption due to incomplete markets, and (ii) congestion externalities due to search frictions in the matching market. Moreover, the planner is unable to provide full insurance to workers due to the presence of the endogenous job search decision.

Table 1.1 compares the values of key endogenous variables in the stationary equilibrium with their corresponding values in the constrained-efficient allocation.[22] 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

[20]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 1.9 in the Appendix.

[21]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.

[22]We compute the allocation chosen by the social planner utilising the results derived in Jung and Kuester (2015) relating to the stationary equilibrium of the model.

achieved in the decentralised equilibrium on average. This has the effect of easing search congestion on the worker side (the job finding rate f is significantly higher) which indirectly provides insurance by significantly reducing unemployment, average unemployment duration, and therefore income risk faced by workers in equilibrium. 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, which is inefficiently high in the decentralised equilibrium.[23]

1.4 Model Simulation: A Simple Policy Experiment

In this section we use the calibrated framework outlined above to conduct a simple policy experiment. More specifically, we simulate a recession and assess the implications of 4 different policy responses:

1. No policy response, government balances budget
2. No policy response, government runs deficit (i.e. automatic stabilisers)
3. An 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:

$$\exp\{a_t\} = \begin{cases} 0.99 & \text{for } t = 1, ..., T \\ 1 & \text{for } t = T+1, ... \end{cases} \tag{1.14}$$

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).

1.4.1 Policy Alternatives in a Recession

Figure 1.1 presents the responses of key endogenous variables under the 4 different policy responses discussed above. We review each one in turn.

[23] As an aside, this is a key difference from the standard matching model with risk-neutral workers (e.g. Pissarides 2000). In that standard environment it is well-understood that separations can only be inefficiently *low*, and are maximised in the efficient equilibrium (i.e. when the Hosios (1990) condition is satisfied). In the present environment, the fact that workers are risk-averse and unable to insure means that separations can be inefficiently *high*.

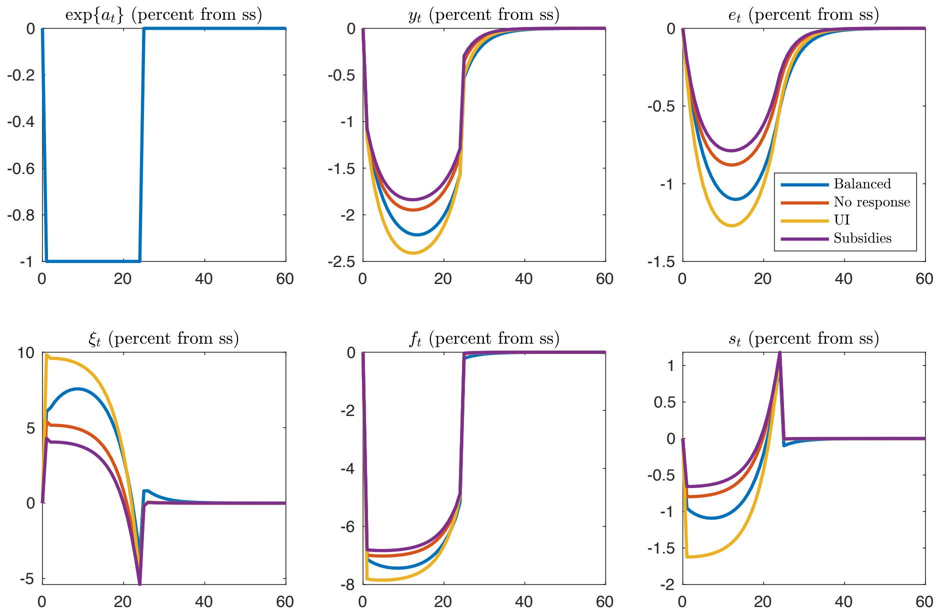

Figure 1.1. Labour market responses under different policies.

Balanced budget. We first analyse the response of the economy where the policymaker 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 1.1). 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? In the experiment we assume the level of UI increases by 1% in response to the recession. Figure 1.1 illustrates that under the baseline calibration an increase in UI *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 1.1), 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? We 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 the job value ,J_t. As a result there are fewer separations, the fall in tightness is dampened, and the increase in unemployment is not as large relative to the no response case. Quantitatively, the dampening on unemployment appears to predominantly come from the reduction in job separations, as the impact on tightness itself is quite small.

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

1.4.2 Welfare

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

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

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)

In general, policy alternatives will affect social welfare in different ways depending on how they influence these three channels.

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

Table 1.2. Welfare decomposition: Shares

Stationary equilibrium. Table 1.2 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. Overall we find that in the calibrated model welfare losses from congestion externalities and incomplete markets amount to around 11.4% in the stationary equilibrium. The results in Table 1.2 suggest that the social planner achieves these welfare gains primarily by reducing the share of workers

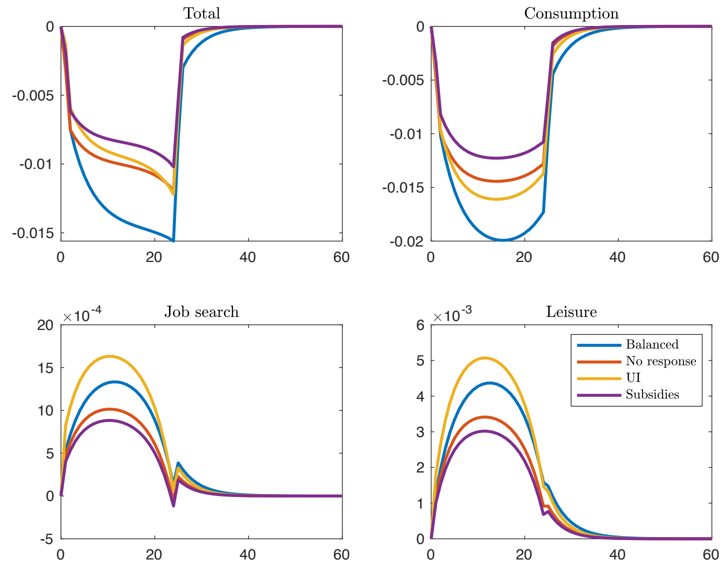

Figure 1.2. Decomposing the social welfare response

in non-employment, and thereby increasing the average worker's consumption utility.

Policy experiment. Figure 1.2 plots the responses of each component of social welfare (in deviation from steady state) for each of the policy responses studied in the previous section, whilst Table 1.3 summarises the welfare gains under different policy alternatives.[24] In all cases social welfare falls during the recession, again driven primarily by the falling level of average consumption due to the fall in employment, but is partially offset by reduced job search disutility and increased flow utility from non-employment. Relative to a balanced-budget response, no response achieves welfare gains of 1.43% mainly through higher average consumption of workers, despite this resulting in lower utility from the job search and leisure channels. This isolates welfare benefits of being able to tax smooth for the government during recessions.

Both an increase in UI and an introduction of match subsidies during the recession achieve further welfare gains on top of this, but for different reasons. Despite reducing the consumption fall upon separation, increasing UI during the recession actually delivers a *larger* peak fall in average consumption utility due to indi-

[24]Welfare gains are reported as a percentage relative to the balanced-budget scenario over the simulation period.

rect effects amplifying the fall in tightness, though this is counteracted by reduced disutility from job search and increase utility from leisure which actually dominate quantitatively. In contrast, introducing match subsidies reduces the welfare gains associated with reduced job search and increased utility from leisure, but overall provides better overall insurance of average worker consumption via the stabilisation of tightness. Under the baseline calibration, we find that the welfare gains from introducing match subsidies are quantitatively larger than those from increasing UI (+ 0.64% compared to 0.23%).

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

Table 1.3. Welfare gains under alternative policy responses.

1.5 Flexible vs. Rigid Labour Markets?

A common reason put forward for cross-country differences in the responses of labour market policies to recessions is because of differences in existing institutions and underlying structures. For instance, compared to the US 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. These differences in institution contribute to lower turnover rates (separation and job finding) as well as higher average unemployment. In other words, the German labour market is more 'rigid' compared to the relative 'flexibility' of the US. In a rigid labour market with lower turnover rates, it takes unemployed longer to find new jobs and therefore the welfare gains from preserving matches during downturns are potentially higher.

In this section we test this hypothesis by repeating the analysis above using alternative calibration for the model, where we instead target key moments of the German labour market based on comparative evidence presented in Jung and Kuhn (2014). We first outline the alternative calibration, 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 with the US calibration, before presenting welfare results.

1.5.1 Alternative Calibration

Below we outline details of the alternative calibration of the model.[25] Table 1.4 compares the implied values of the structural parameters used in the two different calibrations, whilst Table 1.5 presents the values of key endogenous variables in the stationary equilibrium for the two different calibrations.

Externally calibrated parameters. 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 $100 \cdot \sigma_f = 10.4$.[26]

Discussion. In order to generate higher unemployment and a lower 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

[25] A summary of the calibration is given in Table 1.10.

[26] Table 1.11 reports moments and correlations compared to what we see in the data.

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

Table 1.4. Structural parameters under alternative calibrations

rate consistent with this is comparable with that the data[27], and is achieved by a significantly higher cost of job separation for firms, τ_ξ. The higher level of B ensures that 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 equal to 81%, the model requires $\bar{h} = -0.349$. Finally, to achieve a 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.

1.5.2 Model Assessment

Stationary equilibria. How does the competitive stationary equilibrium compare to the efficient equilibrium for the calibration of the model to the German labour market? Table 1.5 compares the decentralised stationary equilibrium to the constrained-efficient allocation (as well as for the US calibration). Tightness is still inefficiently low in the German calibration, though not by as much as for the

[27]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.

US calibration. The social planner chooses 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 (vacancies are actually inefficiently *high* in the decentralised equilibrium). Increased tightness is achieved primarily through a much lower amount of job separations, which requires existing matches to pay higher costs of production and for workers to consume less in absolute terms (which is partly achieved by lowering the replacement rate, which is inefficiently high).

Table 1.6 presents the decomposition of social welfare into its three distinct channels in the stationary equilibria as before. Again utility from consumption is the key determinant of social welfare, though job search disutility now plays a more significant role under the German calibration compared to the US.

	US		Germany	
Variable	Decentralised	Efficient	Decentralised	Efficient
c_e	0.945	0.945	0.913	0.899
c_u	0.427	0.429	0.615	0.601
θ	0.834	2.050	0.188	0.440
v	0.053	0.054	0.016	0.009
f	0.282	0.369	0.062	0.077
s	0.843	0.846	0.810	0.832
N	0.075	0.031	0.102	0.026
ξ	0.019	0.010	0.006	0.002
$urate$	0.064	0.026	0.084	0.021

Table 1.5. Comparing stationary equilibria

Dynamic responses. Figure 1.3 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.[28] This leads to a less severe recession in terms of employment and output deviations from steady state. This is also driven by the dynamics of job 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, it takes much longer on average for the

[28]This is by construction as we target the lower observed volatility in the data when determining the degree of wage rigidity.

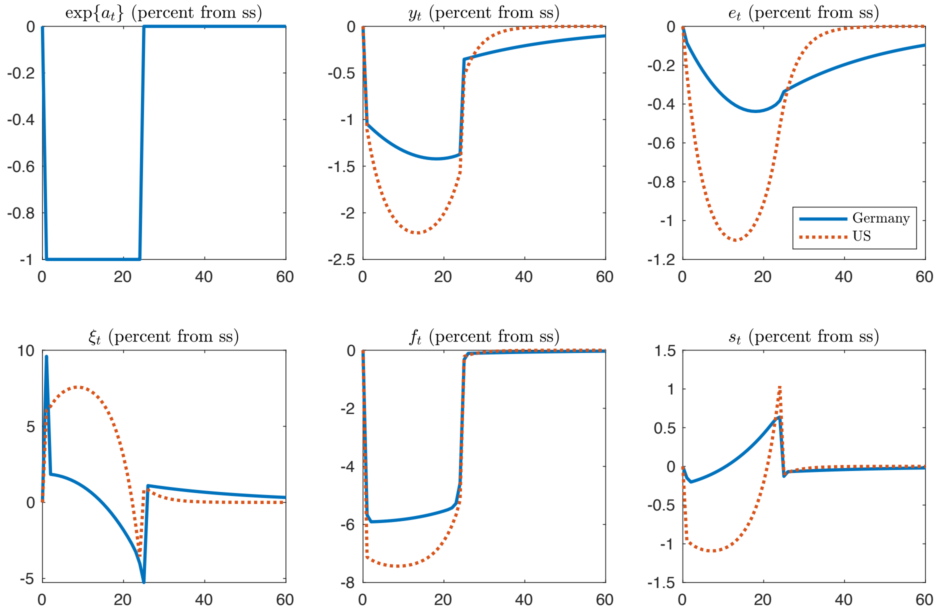

Figure 1.3. Comparing the response of the labour market under different calibrations.

non-employed to find jobs and therefore for the stock of non-employed workers to reduce back to its equilibrium level.

1.5.3 Policy experiment

We present results from same policy experiment as above under the alternative rigid labour market calibration.[29]

Labour market responses. Figure 1.4 plots the labour market responses under alternative policies. In general we see a fairly similar picture to the US calibration in Figure 1.1. Allowing the government to run a deficit dampens the recession, 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. Increasing the existing employment subsidies directly counteracts the effects of the negative shock, whilst the increase in UI again amplifies the shock through its effect on the worker's employment surplus (though this

[29]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.

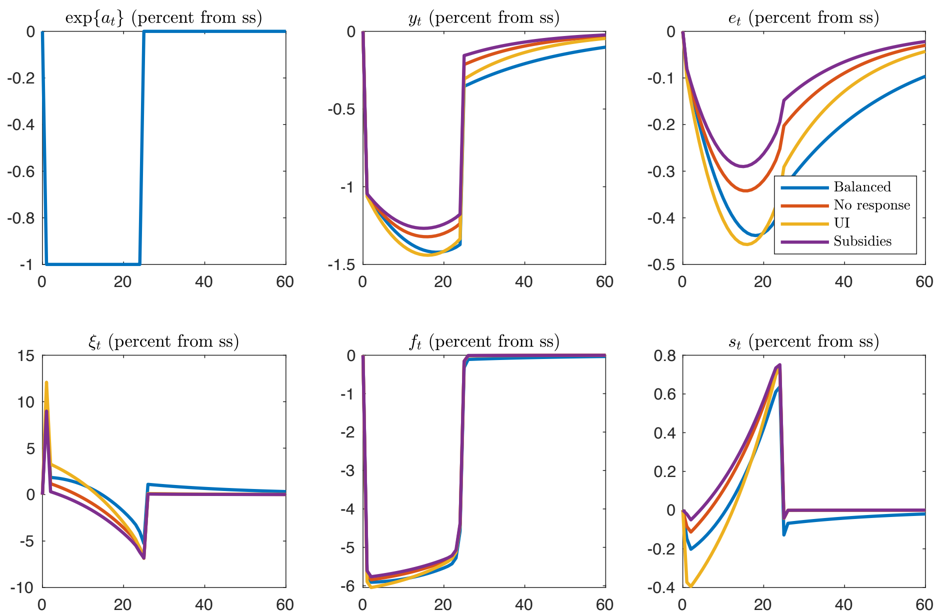

Figure 1.4. German calibration: Policy responses

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

Table 1.6. Welfare decomposition: Shares

channel is less strong relative to the US calibration for a comparable increase in UI in percentage terms).

Welfare. The dynamic response of social welfare - as well as each distinct channel - are plotted in Figure 1.5. We find in all cases that aggregate social welfare is driven by the dynamics of average consumption, whilst contributions of leisure and job search appear to be quantitatively irrelevant.[30] 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, which increases wages for

[30]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.

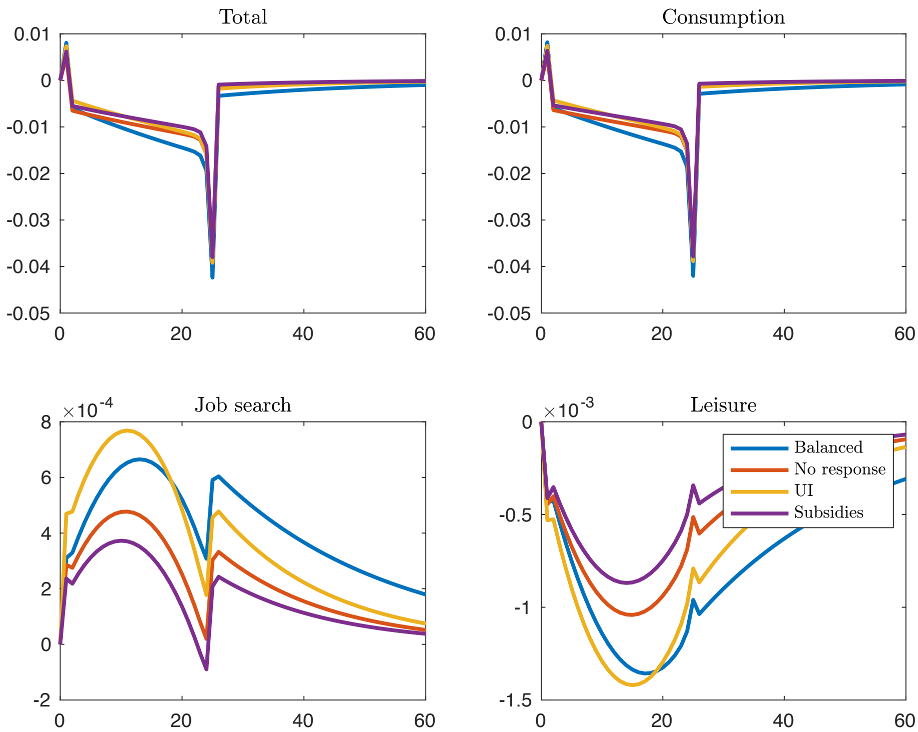

Figure 1.5. German calibration: Welfare decomposition

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

Table 1.7. Welfare gains under alternative policy responses.

one period before they subsequently decline in line with the present discounted value of the joint surplus.[31]

As with the flexible US calibration, we find that the fall in average consumption is mitigated more significantly when policy acts to stabilise labour market tightness, rather than seeking to provide direct insurance. However as the increase in UI has a less destabilising effect under this alternative calibration (e.g. see the top right panel of Figure 1.5), welfare losses from consumption are actually mitigated by the increase in direct insurance provision to workers.[32]

Finally, Table 1.7 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 we find they are more effective at insuring average consumption via the stabilisation tightness relative to reducing the consumption cost of separation via increasing UI. However in this calibration we find that a cost-equivalent expansion in UI *does* 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.[33] 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. If anything, this result goes in the opposite direction to the hypothesis that employment subsidies in recession are more desirable in the context of more rigid labour markets.

[31] 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 ($\gamma_w = 14.81$).

[32] This contrasts with the US calibration, where providing greater direct insurance via increasing UI actually worsened the outcome for average consumption.

[33] 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 a lower elasticity of unemployment duration to changes in UI, as well as lower average worker flow rates.

1.6 Relationship to the Literature

In this section we discuss in detail the relationship between the results presented above and those presented in Birinci et al (2021) and Garcia-Cabo et al. (2023), who perform a very similar policy experiment comparing the relative benefits of an expansion in UI during a downturn versus employment protection.

Birinci et al. (2021). Whilst also allowing for risk-averse workers and endogenous separations, the framework in Birinci et al. (2021) deviates in two important ways. Firstly, matches become more productive over time, capturing the idea that employment subsidies deliver benefits by protecting matches that have accumulated more 'match-specific capital' which would otherwise be lost upon separation.[34] Secondly, wages are downwardly rigid and assumed to be an exogenous function of productivity, rather than endogenously determined as 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) and therefore dampens the adverse effects from UI expansions.[35] In both environments increasing UI amplifies the effect of the downturn on unemployment and aggregate output, whilst employment subsidies act in the opposite direction. In Birinci et al. (2021) this is because increasing UI reduces the worker's surplus, generating an increase in worker-initiated separations which amplifies the increase in unemployment, whilst increasing payroll subsidies reduces the number of layoffs such that more higher productivity matches are saved and the fall in aggregate output is less severe.[36]

Birinci et al. (2021) similarly find that in isolation a cost-equivalent increase in employment subsidies delivers better welfare outcomes than an expansion in UI. However they emphasise that this is because payroll subsidies protect higher productivity matches, whilst increasing UI leads to losses in match capital despite providing consumption insurance for those workers who lose their jobs. Moreover, they emphasise that in this environment the two policies are *complements* as

[34]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.

[35]Both environments also do not feature an endogenous search decision, which means the adverse effects from expanding UI are dampened even further relative to the baseline framework we use in this paper.

[36]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.

they benefit different types of workers: employment subsidies benefit workers in matches with high match-capital, whilst more generous UI benefits the rest. Solving for the optimal allocation of a fixed budget between the two policies, they actually find that only 20% should be allocated to payroll subsidies and the rest to greater UI.[37] In contrast, in the Jung-Kuester environment with homogeneous matches, we find that UI and employment subsidies are *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.

Garcia-Cabo et al. (2023). Using a multi-sector model, the focus of this paper is purely on how different policy alternatives can improve the reallocation of workers during a downturn precipitated by a negative productivity shock to one sector. Again in contrast to our approach, matches are characterised by persistent job-specific productivity shocks whilst workers are assumed to be risk-neutral so insurance concerns play no role in evaluating the desirability of the policy alternatives from a welfare perspective. Although each policy alternative has similar effects on aggregates as in Birinci et al. (2021) and our framework, their effect on the overall allocation of workers across sectors and jobs is crucial for the desirability of each policy alternative. Expanding UI generates more job separations and a higher initial fall in output (due to higher unemployment), but potentially speeds up the process of reallocating workers away from low productivity matches towards new, higher productivity jobs in the unaffected sector. Increased employment protection (in this case wage subsidies) dampens the initial fall in output by protecting employment matches, but hinders the reallocation of workers away from the affected sector.

The key takeaway from Garcia-Cabo et al. (2023) is that when the labour market is 'flexible' (i.e. the job finding rate is higher) UI policies are preferred, as the benefits from speeding up worker reallocation are larger than the costs of amplifying the initial effect of the recession. Otherwise, employment protection policies are preferred in environments where worker reallocation is slower. In contrast, in our single-sector environment with homogeneous productivity across matches there are no gains from reallocation, whilst instead there are additional welfare gains

[37] 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 separate but provide workers with greater insurance.

from reducing income risk faced by workers. In this case, employment subsidies are always preferred as they are more effective at mitigating the increase in risk.

1.7 Conclusion

In this chapter, we have sought to address a question that has gained recent salience: Should we insure workers or employment matches during a recession? Through the lens of a relatively standard equilibrium matching model with risk-averse workers, an endogenous job search decision and endogenous job separations, we find that subsidising matches is preferred in welfare terms. This is because increasing worker insurance through expanding UI, although reducing the cost of job separation for an individual worker, has adverse effects on tightness through its effects on search effort and job creation which exacerbates income risk faced by workers. In contrast, increasing employment protection during a recession directly offsets some of the increase in income risk. Moreover, this finding is robust to whether we calibrate the model to match a 'flexible' labour market (such as the US) or a more 'rigid' labour market (such as Germany) characterised by more generous policy support and lower turnover.

Chapter 1: Appendices

1.A Model Appendix

1.A.1 Value functions

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:

$$V_{e,t} = (1-\xi_t)\left[u(w_t+\Pi_t)+\beta\mathbb{E}_t V_{e,t+1}\right] + \xi_t\left[V_{u,t}+u(w_t+\Pi_t)-u(B_t+\Pi_t)\right] \tag{1.15}$$

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:

$$\begin{aligned} V_{u,t} \quad = \quad & u(B_t+\Pi_t)+\bar{h}+\int_{-\infty}^{\iota_t^s}[-\iota_i+f_t\beta\mathbb{E}_t V_{e,t+1}+(1-f_t)\beta\mathbb{E}_t V_{u,t+1}]dF_\iota(\iota_i) \\ & +\int_{\iota_t^s}^{\infty}\beta\mathbb{E}_t V_{u,t+1}dF_\iota(\iota_i) \qquad (1.16) \\ & \qquad (1.17) \end{aligned}$$

Job value. At the beginning of the period upon realization of idiosyncratic production costs ϵ_j the worker-firm pair decide whether or not to continue the match. If $\epsilon_j > \epsilon_t^\xi$ then the match is terminated and the firm has to pay layoff tax τ_ξ as well as a severance payment to the worker. Otherwise, the match produces output $\exp\{a_t\}$ and receives employment subsidy τ_s. The firm pays the worker wages w_t, the production cost ϵ_j, and a production tax $\tau_{J,t}$. The value of a filled job can therefore be written as:

$$\begin{aligned} J_t &= -\int_{\varepsilon_t^{\xi}}^{\infty} [\tau_{\xi} + w_t] dF_{\varepsilon}(\varepsilon_j) \\ &\quad + \int_{-\infty}^{\varepsilon_t^{\xi}} [\exp\{a_t\} + \tau_s - \varepsilon_j - w_t + \tau_{J,t} + \mathbb{E}_t Q_{t,t+1} J_{t+1}] dF\varepsilon(\varepsilon_j) \end{aligned} \tag{1.18}$$

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

$$Q_{t,t+s} = \beta \frac{\lambda_{t+s}}{\lambda_t} \tag{1.19}$$

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

$$\lambda_t = \left(\frac{e_t(1-\xi_t)}{u'(w_t + \Pi_t)} + \frac{u_t}{u'(B_t + \Pi_t)} \right) \tag{1.20}$$

1.B Additional Tables & Figures

1.B.1 US Calibration

Table 1.8 provides a summary of the parameterization of the model to match US labour market data, as outlined in Section 1.3. Table 1.9 compares the second moments from simulating the baseline model to those in the data.

1.B.2 German Calibration

Table 1.10 provides a summary of the parameterization of the model to match US labour market data, as outlined in Section 1.3. Table 1.11 compares the second moments from simulating the baseline model to those in the data.

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% unemp. 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 1.8. Calibration: US Labour market

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

Notes: The table reports second moments in both the model and the data. Data moments are taken directly from those reported in Jung and Kuester (2015). Simulated series from the model are monthly averages, in logs, and multiplied by 100 to express them in percent deviation from steady state. The top panel compares unconditional standard deviations, whilst the bottom panel compare correlation with GDP.

Table 1.9. Model evaluation: Theoretical vs. Empirical Moments

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% unemp. 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 1.10. Calibration: German Labour market

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

Notes: The table reports second moments in both the model and the data. Data moments are taken directly from those reported in Jung and Kuhn (2014). Simulated series from the model are monthly averages, in logs, and multiplied by 100 to express them in percent deviation from steady state. The top panel compares unconditional standard deviations, whilst the bottom panel compare correlation with GDP.

Table 1.11. German calibration: Model evaluation