Optimal Short-Time Work Policy in Recessions

Gero Stiepelmann*

July, 2024

Preliminary and Incomplete

Abstract

Short-time work (STW) is a subsidy program linked to hours reduction that has been widely used around Europe to combat job losses in the financial recession and the COVID-19 pandemic. Its benefits paid orientate towards the UI system, yet the interplay between STW and the unemployment insurance (UI) system is still conceptually unclear (cf. Cahuc (2024)). To close this gap in the literature, I develop a search and matching model of the labor market with risk-averse workers, flexible hours choice, endogenous separations, and generalized Nash-Bargaining. Through closed-form expressions, I demonstrate that while the UI system provides income insurance to workers, the STW system mitigates the fiscal externality of UI-induced separations. Notably, STW only exists due to the UI system. Reflecting European practices, I allow the STW system to adjust with the business cycle while keeping the UI system constant. In line with the actual policy, my findings indicate that STW benefits have to increase in recessions, while in contrast to the actual use of STW, eligibility criteria have to be tightened. Interestingly, using STW and UI together is fiscally less expensive than the UI system on its own.

JEL Classification: E24, E32, H21, J63, J64, J65

*Department of Economcis, University of Bonn, E-Mail: gero.stiepelmann@uni-bonn.de. I would like to thank my supervisors Moritz Kuhn and Keith Kuester for helpful feedback and guidance in the project. Furthermore, I want to thank participants of the IAB workshop on short-time work 2022, the Midewestern Macroeconomics Conference 2022, the EEA-ESEM summer meeting 2022 and the Yale Macro Lunch (2023) for helpful comments. I gratefully acknowledge financial support from the Bonn Graduate School of Economics and the DFG research training group 2281 ”The Macroeconomics of Inequality”.

1 Introduction

The Great Recession and the COVID-19 pandemic have reignited interest in fundamental questions of labor economics: How can we prevent unemployment, and how can we protect workers from income loss due to unemployment? To address these challenges, policymakers in Europe have primarily relied on a combination of two tools: Unemployment Insurance (UI) and Short-Time Work (STW). This raises the question how to use both instrument together. UI provides benefits to unemployed workers, while STW offers partial or full wage compensation to employees when employers temporarily reduce working hours. Europe responded to the recent crises by expanding its STW system, increasing both its generosity and accessibility, while largely leaving the UI system unchanged.

Although extensive literature exists on UI,[1] the use of STW and its interaction with UI are less well understood. Burdett and Wright (1989) analyze STW within an implicit contract model, identifying it as a tool to mitigate inefficient separations caused by the UI system. However, they emphasize that STW distorts working hours, making its overall impact on total working hours ambiguous. Building on this, Braun and Brügemann (2017) show that an optimal combination of UI and STW can enhance total working hours and welfare within an implicit contract model. Nonetheless, both studies rely exclusively on numerical simulations and do not address business cycle dynamics. As a result, Braun and Brügemann (2017) call for an extension to dynamic labor market models. Further, Cahuc (2024) argues in a recent literature review that the relationship between UI and STW remains conceptually vague, and clarifying this relationship is essential for formulating effective policy recommendations.

To address this gap in the literature, I develop a real business cycle model incorporating Mortensen and Pissarides (1994) type matching frictions in the labor market. The model accounts for risk-averse workers, flexible working hours, and endogenous separations. Contracts about income, working hours, and separations are determined within a generalized Nash-Bargaining framework, capturing the main insights of the implicit contract literature. The UI and STW systems are chosen optimally and are financed by income taxes.

The paper makes two key contributions. First, I derive closed-form expressions for the optimal policy mix between UI and STW, providing clarity on their optimal interaction. Second, I demonstrate that STW does not necessarily function as an automatic stabilizer as in Balleer et al. (2016). Instead, optimal STW policy needs to increase benefits and tighten eligibility conditions in a recession to reduce labor market fluctuations. Consistent with European prac-

[1] Several studies, including Baily (1978), Shavell and Weiss (1979), Hopenhayn and Nicolini (1997), and Chetty (2006), explore the optimal design of UI systems with a focus on job search incentives. Landais, Michaillat, and Saez (2018) extend this by incorporating vacancy posting incentives. Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008) discuss layoff taxes to reduce UI-induced separations. Jung and Kuester (2015) and Michau (2015) examine the optimal UI design, addressing these issues with vacancy subsidies and layoff taxes. This paper investigates optimal UI design where STW could target vacancy postings and separations.

tices, I assume that the UI system remains unchanged in recessions.

The analytical solutions show that while the UI system provides income insurance to workers, the STW system mitigates the fiscal externality of UI-induced separations. The expression addresses Burdett and Wright (1989)'s concern about the distortion of working hours. Notably, STW itself does not provide income insurance and would not exist without the UI system but it enables the UI system to offer more generous income insurance.

In contrast to the implicit contract literature, search and matching models account for the reallocation of workers via the labor market and job-finding rates. Job-finding rates prove to be crucial for the optimal adjustment of STW over the business cycle. I demonstrate that a decline in the job-finding rate increases the social costs of separations due to prolonged spells on the UI system. To counter these additional social costs, optimal STW benefits must become more generous during a recession. Simultaneously, prolonged unemployment spells reduce workers' outside options which causes the optimal eligibility condition for STW to become stricter. The encouraging news for policymakers is that integrating the STW system with an UI system proves to be less fiscally expensive than relying solely on the UI system.

In more detail, the model entails two potential reasons for government intervention. First, risk averse workers cannot insure themself with savings or on the financial market. Second, the Hosios (1990) condition might not be fulfilled causing inefficiencies in vacancy posting. To counter these inefficiencies, the Ramsey planner can choose the UI and STW system.

The UI system pays unemployed workers UI benefits as their sole source of income while they are unemployed. STW consists of two instruments: the eligibility condition and STW benefits. Firms and workers choose working hours freely and qualify for STW when the hours worked fall below a specific eligibility threshold. Hijzen and Martin (2013) show that most STW systems in practice use this type of hours reduction as eligibility criterion. Under STW, the government compensates workers for every hour they work less than usual. STW benefits are directed towards the temporarily least productive matches since firms with low working hours have the lowest productivity. Essentially, STW offers firms and workers a wage subsidy contingent on being temporarily low-productive.
While STW effectively reduces separations, it subsidizes hours reduction and thus leads to sub optimal low working hours on STW. Higher STW benefits and a looser eligibility threshold make the distortionary effects of STW worse.

The modeling contrasts with the recent business cycle literature on STW. Balleer et al. (2016), Gehrke, Lechthaler, and Merkl (2017), Dengler and Gehrke (2021) and Cooper, Meyer, and Schott (2017) argue that working hours outside STW are inflexible and that STW's role is to flexibilize the intensive margin. Instead, I follow the spirit of the implicit contract literature of Burdett and Wright (1989), Van Audenrode (1994), and Braun and Brügemann (2017), where working hours are flexible, STW acts as a subsidy, and STW distorts working hours.

Cahuc, Kramarz, and Nevoux (2021) emphasizes the empirical and quantitative relevance of these hours' distortions in a partial equilibrium search model. This approach has the advantage of providing a rationale for the eligibility condition and allows STW benefits to influence separations.

Using this framework, I derive the optimal policy mix between the UI system and STW system. Optimal UI benefits have to balance the classical trade-off. On the one hand, higher unemployment benefits offer workers more income insurance in case of job-loss. On the other hand, it distorts vacancy posting and separations. Offering higher UI benefits increases the outside option of workers. Consequently, workers demand higher salaries, squishing the revenue of firms. Firms react by posting less vacancies and increasing separations (cf. Pissarides (2000)), leading to inefficiently high unemployment levels.

STW can counter inefficient separations. In fact, I can show that STW could theoretically eliminate all inefficient separations. However, STW cannot combat inefficiently low vacancy rates. This might be surprising since papers like Balleer et al. (2016), Giupponi and Landais (2018) or Cahuc, Kramarz, and Nevoux (2021) argue that STW works by increasing vacancy postings. However, their models rely on lump-sum taxes or do not consider a government budget constraint at all, thereby overlooking the costs of financing the STW system. In my model, STW, like the UI system, is financed by income taxes. Any increase in the joint surplus of firms and workers by increasing the generosity of STW is offset by a corresponding increase in income taxes.
Even when ignoring the fiscal costs of financing the STW system and allowing it to directly influence vacancy posting, the Ramsey planner would still opt not to stabilize job-finding rates. This is because the distortionary effects of the STW system are too costly.

The optimal eligibility condition primarily addresses windfall effects, which refer to the hour's distortions caused by matches on STW that don't require STW support to survive. It is determined by the separation threshold firms and workers would choose if they didn't have access to STW. A looser eligibility condition would reinforce the distortionary effects of the STW system without saving additional jobs, resulting in pure windfall effects as in Cahuc, Kramarz, and Nevoux (2021). A tighter eligibility condition would risk losing firms that could have been saved with STW. Teichgraeber and Reenen (2022) show in a mechanism design model that obligatory working hours reduction can be used as an instrument to screen for jobs at risk.

Optimal STW benefits respond to two opposing forces. First, they are designed to counterbalance the distortionary effects of the UI system. When workers and firms negotiate separations, workers face a trade-off: stay employed during low productivity but accept a lower salary or opt for a higher salary with greater unemployment risk. The UI system skews this decision towards higher unemployment risk, raising overall separation rates. Optimal STW benefits help to prevent separations by reducing firms' salary costs during downturns. Essentially, STW should reduce firms' salaries by the amount the UI system would pay if the worker were unemployed. In spirit, this is the same rule as for optimal lay-off taxes derived by Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008).

However, optimal STW benefits have to take its distortionary effects stressed by Burdett and Wright (1989) into account. When benefits are increased, firms and workers will opt for even lower hours, to draw in more support from the government. Therefore, the Ramsey planner does not prevent all inefficient separations caused by the UI system. Instead, he trades-off stabilizing employment against distorting average hours worked and, thus, adjusts STW benefits downwards.

It is important to note that while STW secures jobs, it does not provide income insurance. Income insurance for unemployed workers is offered through the UI system. Firms, on the other hand, provide income protection against idiosyncratic productivity shocks as long as the worker remains employed, a finding supported by the implicit contract literature (cf. Rosen (1985) or Braun and Brügemann (2017)). In my search and matching model, firms and workers negotiate income, working hours, and separations within a generalized Nash-Bargaining framework before the idiosyncratic productivity of the match is known. They establish a contract contingent on the realization of productivity shocks. As a result, the risk-neutral firm offers the risk-averse worker income insurance in exchange for lower expected wages. This entails stock-up during times on STW as we have seen in the COVID-19 pandemic.[2]

Quantitatively in the model, firms and workers are eligible to go on STW if hours worked fall 10% below its normal value and STW benefits replace 80% of a workers wage in steady state. Further, the distortionary effects of STW reduce the optimal net-transfers by roughly 25%.

In the model, recessions are caused by a negative aggregate productivity shock. Salaries are assumed to be rigid to solve the Shimer (2005) puzzle. Reflecting European practices, I allow STW to adjust over the business cycle while the UI system stays unaltered. In response to a 1% negative productivity shock, the Ramsey planner tightens the eligibility condition by 0.4% and STW benefits rise by 7.8%.

Following a productivity shock, and exacerbated by rigid salaries, the job-finding rate declines. Optimal STW policy cannot stabilize the job-finding rate. From the expression for the optimal eligibility condition, we can infer that this decline causes the eligibility condition to tighten. The lower job-finding rate prolongs unemployment spells, making workers less willing to leave their jobs. Consequently, firms are more likely to reduce working hours rather than initiate separations. If matches survive on their own, subsidizing them becomes harmful, as it would only distort working hours. Therefore, the eligibility condition needs to be tightened.

[2] In Germany, large companies like Volkswagen, Telekom, and Deutsche Bahn, along with major unions such as IG Metall and Verdi, supplemented their employees' income on STW to 78%–95% of their regular earnings, while the STW system alone only provided 60% (cf. Münchner 2020).

Moreover, the expression for the optimal STW benefits shows that a fall in the job-finding rate also makes the Ramsey planner choose more generous STW benefits. The prolonged unemployment spell causes workers to receive UI benefits for longer raising the social costs of separations. By impeding separations from growing during recessions, larger STW benefits help to stabilize employment, save costs from hiring and firing workers and stabilize consumption, despite the decline in the job-finding rate. Quantitatively, optimal STW policy closes almost 60% of the gap to the optimal consumption level. Additionally, I find that the STW system is self-financing, as reducing the number of unemployed workers lowers the costs of the UI system. This reduction is sufficient to cover all additional costs by the STW system.

Nonetheless, the distortionary effects of the STW system are costly. Without the distortionary effects of STW the Ramsey planner could almost completely close the gap to the optimal consumption level. The problem is that during a recession, more firms and workers enter the STW system, resulting in increased fluctuations in working hours and, consequently, output. From the expression of optimal STW benefits, we know that this situation prompts the Ramsey planner to increase STW benefits less than what would be required to fully counteract all the additional inefficient separations leading to higher fluctuations in employment.

The paper contributes to two additional topics discussed in the literature. First, in a model framework without welfare costs and inflexible hours' choice, Balleer et al. (2016) argue that STW acts as an automatic stabilizer. By stabilizing separations, STW helps to stabilize employment, output, and consumption without requiring adjustments throughout the business cycle. In my model, similar results are obtained for employment but not for consumption. Since the eligibility condition is not adjusted, even firms that could survive without STW enter the program. This exacerbates the distortionary effects on hours worked, negating the positive effects of employment stabilization on consumption. The gap to the optimal consumption response can only be closed by roughly 15% instead of 60%. This experiment emphasizes the necessity of adjusting STW over the business cycle.

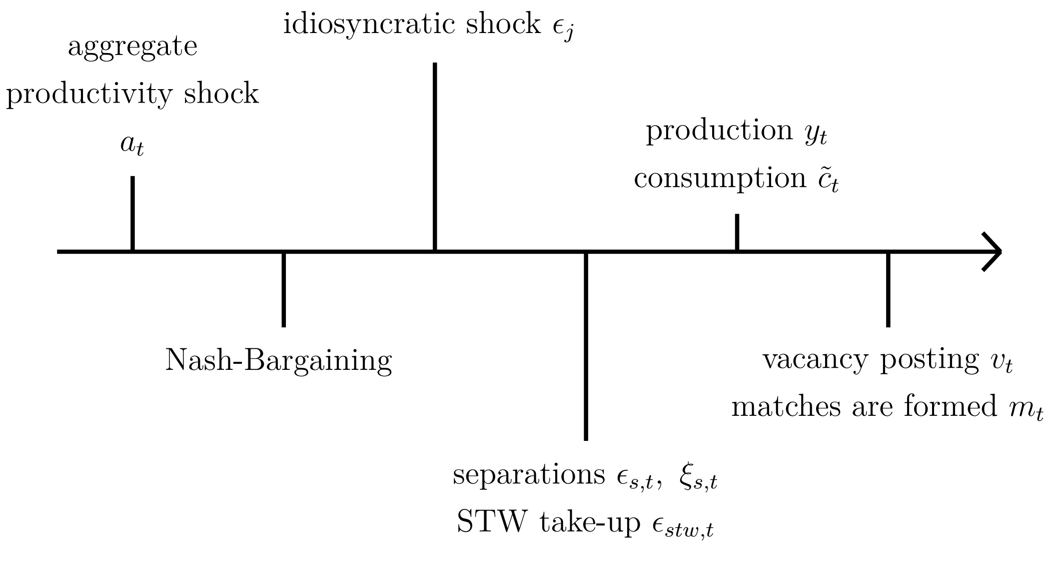
Second, a major concern of STW systems is that subsidizing low productive matches causes allocative inefficiencies. Cooper, Meyer, and Schott (2017) argue in a search and matching model that STW keeps workers in unproductive matches and hinders their reallocation to more productive firms, effectively reducing overall productivity and output. Within my model, I find that the social planner must balance the costs of reallocating a worker via the labor market against the costs of keeping a worker in an unproductive occupation. If the STW system is set too generously, the concern of Cooper, Meyer, and Schott (2017) is valid: the loss in productivity exceeds the costs of reallocating a worker via the labor market, leading to a fall in output. Conversely, if STW benefits are set too low, the opposite occurs: the costs of reallocating a worker exceeds the costs of productivity loss. By setting STW benefits optimally, it is possible to realign private and social incentives, thereby avoiding misallocation effects.

The remaining structure of the paper is as follows. Section 1 introduces the model, explores the decentralized economy, and solves for the social planner economy. Section 2 derives analytical expressions for optimal STW policy and explores its theoretical implications. Section 3 describes the calibration of the model. Section 4 applies the optimal STW policy to a supply-side recession. Section 5 analyzes the results under an alternative tax system. Finally, section 6 concludes the paper.

2 Model

The economy is populated by a continuum of workers of measure one, infinitely many one-worker firms and a continuum ν_t of firm owners. Each firm produces a homogeneous and non-storable good. The economy is closed. Each period, firms and workers are subject to aggregate and idiosyncratic shocks. The aggregate shock can be interpreted as a shock on the supply side, similar to a supply chain shock in the Covid-19 pandemic or the current energy cost shock. Nonetheless, firms are ex-ante homogeneous to their match-efficiency.

Figure 1: Period Timeline



The timeline of the period is structured as follows: At the start, firms experience an aggregate productivity shock. Before the idiosyncratic productivity shocks occur, generalized Nash-Bargaining takes place. Firms and workers write a contract specifying income, separations, hours of work, and short-time work (STW) take-up, all contingent on the realization of the idiosyncratic productivity shock. Following this the idiosyncratic productivity is drawn. Separations and STW take-up take place. Then, output is produced based on working hours and households consume. At the end of the period vacancies are posted and new matches are formed. New matches don't produce until next period.

2.1 Decentralized Economy

In the decentralized economy, separations, vacancy postings and working time are determined by firms and workers.

Firm Side Each firm that enters a match with a worker can either produce or separate from the worker. There is an aggregate component a_t that is common to all matches and an idiosyncratic component ϵ_j that is, for analytical tractability, i.i.d. across time and matches with the distribution function $G(\epsilon)$.[3]

Firm-specific output $y_t(\epsilon, h_t(\epsilon))$ depends on the firm-specific productivity $a_t \cdot \epsilon$ which is divided in an aggregate productivity part a_t and the idiosyncratic part ϵ, the number of hours worked $h_t(\epsilon)$ and the resource costs of the firm $(\mu_\epsilon - \epsilon) \cdot c_f$:[4]

$$y_t(\epsilon, h_t(\epsilon)) = a_t \cdot \epsilon \cdot h_t(\epsilon)^\alpha - (\mu_\epsilon - \epsilon) \cdot c_f \quad \text{with} \quad E[y_t(\epsilon_j)] = E\left[a_t \cdot \epsilon_j \cdot h_t(\epsilon_j)^\alpha\right]$$

In line with Krause and Lubik (2007), I assume that the idiosyncratic shock ϵ_j follows a log-normal distribution $\epsilon_j \sim \mathcal{LN}(\mu, \sigma^2)$ with $\mu_\epsilon = E[\epsilon_j] = \exp(\mu + \frac{1}{2} \cdot \sigma^2)$. Furthermore, I assume that aggregate productivity follows an AR(1) process:

$$a_t = \mu_a + \rho_a \cdot (a_{t-1} - \mu_a) + \iota_t, \quad \rho_a \in [0, 1), \quad \iota_t \sim \mathcal{N}(0, \sigma_a^2)$$

Firms are assumed to be owned by firm owners. As a result, Future cash flows are discounted using a stochastic discount factor, reflecting how firm owners weigh future marginal utility of consumption againsts todays:

$$Q^f_{t,t+1} = \beta \cdot \frac{u'(c^f_{t+1})}{u'(c^f_t)}$$

The value of a worker for a firm, that is not on STW, and whose idiosyncratic shock has realized to ϵ, is:

$$J_t(\epsilon) = y_t(\epsilon, h_t(\epsilon)) - w_t(h_t(\epsilon)) + E_t\left[Q^f_{t,t+1}\mathcal{J}_{t+1}\right]$$

[3]Having persistent idiosyncratic shocks, we would need a state vector to keep track of the productivity distribution of the firms. This would make computing Ramsey policy very difficult. c_f can also be interpreted as a measure for the persistence of the idiosyncratic productivity shocks.

[4]Note that the cost shock of the firm is important, if we want to have a quantitatively realistic impact of the UI system on unemployment, endogenous separations, and time-independent idiosyncratic shocks in an otherwise analytically tractable model. It is a well-known problem that search and matching models overstate the importance of the UI system (see Costain and Reiter (2008)). To have a sensible impact of the UI system, we need a large surplus calibration. The bigger the surplus, the smaller the relative impact of a change of UI benefits. However, large surpluses lead to small separation incentives. Since the cost shock has an expectation value of zero it allows for a large surplus calibration. At the same time, it affects the marginal firms the most, allowing for endogenous separations.

The firm gets the production value of the match $y_t(\epsilon, h_t(\epsilon))$ but pays the wage-sum $w_t(h_t(\epsilon))$ dependent on the total working hours to the worker.

The value of a worker for a firm, who is on STW, and whose idiosyncratic productivity has the value ϵ, can be written as:

$$J_{stw,t}(\epsilon) = y_t(\epsilon, h_{stw,t}(\epsilon)) - w_t(h_{stw,t}(\epsilon)) + E_t\left[Q^f_{t,t+1}\mathcal{J}_{t+1}\right]$$

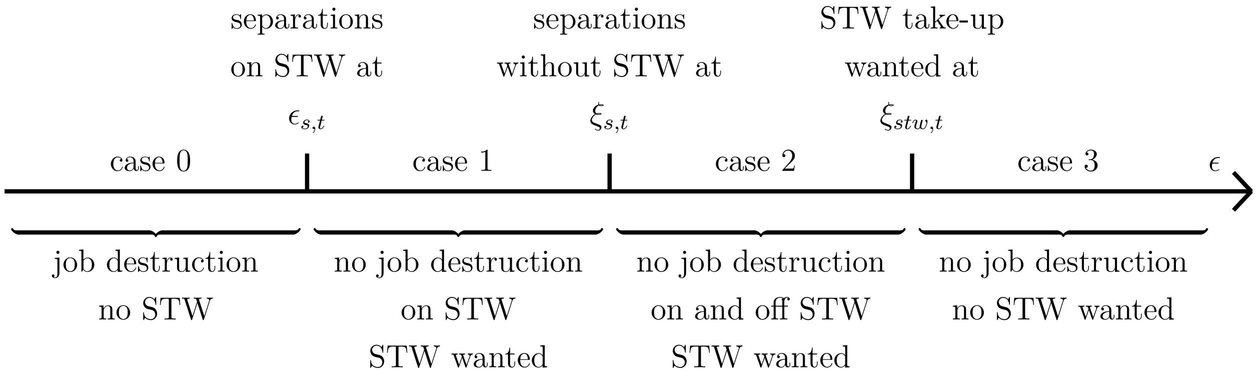
Since working hours fall on STW firms have to pay a smaller salary.

The access to the STW system is restricted by the government via the eligibility condition. Firms and workers have the option to transition to STW when the number of hours worked falls below a specific threshold set by the government, denoted as D_t. This threshold serves as a criterion for determining eligibility for STW:

$$h_t(\epsilon) \leq h_t(\epsilon_{stw,t}) = D_t$$

It essentially means that firms and workers are eligible to participate in the STW system if they reduce their hours worked by a certain percentage below their normal level, $\frac{D_t - \bar{h}}{\bar{h}} \cdot 100\%$, where $\bar{h}$ represents the mean hours worked in the steady state. This eligibility condition is consistent with findings by Hijzen and Martin (2013), who identify that 15 out of 24 OECD countries with STW programs in place employ this minimum hours' reduction as an eligibility criterion. In subsequent sections, we say that the eligibility condition becomes looser when D_t increases, indicating that it becomes easier to enter into STW. The eligibility threshold, denoted as $\epsilon_{stw,t}$, is defined based on temporary productivity ϵ and is implicitly determined by the equation $D_t = h_t(\epsilon_{stw,t})$. In the spirit of Teichgraeber and Reenen (2022), the hours reduction criterion can be used as an instrument to screen for productivity and jobs at risk. Depending on the values of D_t and $\epsilon_{stw,t}$, the eligibility threshold may or may not be binding and can have various impacts on the economy. We need to consider four distinct cases, as illustrated in Figure 2.

Figure 2: Thresholds



Case 0: $\epsilon_{stw,t} < \epsilon_{s,t}$. In case 0 the eligibility threshold is stricter than the separation threshold for firms and workers on the STW system. Under these conditions, no firm or worker will ever access the STW system, rendering it obsolete. For the sake of notational brevity, we will exclude this case from further consideration in subsequent sections, as it does not limit the planner's choice set. We require $\epsilon_{stw,t} \geq \epsilon_{s,t}$. By setting $\epsilon_{stw,t} = \epsilon_{s,t}$, the Ramsey planner can still make the STW system obsolete.

Case 1: $\epsilon_{s,t} \leq \epsilon_{stw,t} < \xi_{s,t}$. Case 1 describes a situation where matches with lower productivity $\epsilon \in [\epsilon_{s,t}, \epsilon_{stw,t}]$ are allowed on the STW system and are rescued, while matches with higher productivity $\epsilon \in (\epsilon_{stw,t}, \xi_t)$ are not allowed and dissolve. Here, $\xi_{s,t}$ denotes the separation threshold of matches without access to STW, determined within the generalized Nash-Bargaining framework.

Case 2: $\xi_{s,t} \leq \epsilon_{stw,t} < \xi_{stw,t}$. In case 2, all firms and workers that would dissolve without STW can enter the STW system. At the same time, the eligibility threshold denies matches with productivity $\epsilon \in (\epsilon_{stw,t}, \xi_{stw,t}]$ access to STW. Note that these matches want to take up STW but are not at risk of breaking up. Here, $\xi_{stw,t}$ denotes the STW take-up threshold of firms and workers. This threshold determines the idiosyncratic productivity level at which firms and workers want to enter the STW system. It is also determined within the generalized Nash-Bargaining framework.

Case 3: $\xi_{stw,t} \leq \epsilon_{stw,t}$. In case 3, the eligibility condition becomes so loose that it does not bind anymore. Firms and workers do not want to take up STW. Without loss of generality we can assume that the planner wants to set $\epsilon_{stw,t} \leq \xi_{stw,t}$ and exclude the case from further considerations. Setting $\epsilon_{stw,t} = \xi_{stw,t}$ has the same effect as setting $\xi_{stw,t} < \epsilon_{stw,t}$.

To wrap up, we have seen that only case 1 and 2 are relevant for the subsquent analysis. Without loss of generality and for notational brevity we require the eligibility threshold to be at least as larger as the separation threshold of firms and workers with access to STW but not larger than the STW take-up threshold for firms and workers:

$$\epsilon_{s,t} \leq \epsilon_{stw,t} \leq \xi_{stw,t}$$

From this, we can derive the separation rate. The separation rate depends on the probability that firms in the STW system dissolve, plus the probability that firms and workers experience a productivity shock strong enough to cause dissolution but not strong enough to warrant entry into the STW system (case 1):

$$\rho_t = G(\epsilon_{s,t}) + \max\{G(\xi_{s,t}) - G(\epsilon_{stw,t}), 0\}$$

The expected value of a worker for a firm right before the idiosyncratic shock has realized can be denoted as:

$$\mathcal{J}_t = \int_{max\{\epsilon_{stw,t},\xi_{s,t}\}}^{\infty} J_t(\epsilon)dG(\epsilon) + \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} J_{stw,t}(\epsilon)dG(\epsilon) - \rho_t \cdot (w_{eu,t} + F) \tag{1}$$

When the idiosyncratic productivity exceeds both the eligibility threshold and the separation threshold for firms without access to STW, $\epsilon \geq \max\{\epsilon_{stw,t}, \xi_{s,t}\}$, the firm continues to operate regularly. If productivity falls within the interval $\epsilon \in [\epsilon_{s,t}, \epsilon_{stw,t}]$, then firms shift to production under STW.
Finally, when firms decide to separate from a worker, they incur two types of costs. First, they must pay severance payments, denoted as $w_{eu,t}$. Severance payments compensate the worker for the loss of employment and are part of the contract that firms and workers bargain over at the beginning of the period. Second, firms face fixed costs of job destruction, represented by F. These costs include administrative and legal expenses associated with removing the worker from the payroll, as well as efficiency losses due to the need to restructure the production process.[5]

Firms post vacancies v_t until the expected costs of recruiting a worker equal the discounted expected value of a worker for the firm.

$$\frac{k_v}{q_t} = E_t\left[Q^f_{t+1}\mathcal{J}_{t+1}\right] \tag{2}$$

Here, q_t denotes the probability of filling a vacancy and k_v the costs of posting a vacancy.

Firm Owners There exists a continuum ν_t of firm owners in the economy. Firm owners consume the profits Π_t produced in the firm sector spread among all firms owners. Besides that

[5]Research by Kuhn et al. (2021) indicates that firms often operate with coordinated teams and work processes. Separation from a worker disrupts this coordination, resulting in output losses. According to the study, firms view these costs as one of the main reasons for the use of STW.

they do not make any decisions. The value of a firm owner is denoted as:

$$V_t^f = u\left(\frac{\Pi_t}{\nu_t}\right) + \beta \cdot E_t\left[V_{t+1}^f\right]$$

Profits equal total output minus the wage bill, separation and vacancy posting costs:

$$\begin{aligned}\Pi_t = n_t \cdot \Bigg(&\int_{\max\{\epsilon_{stw,t},\xi_{s,t}\}}^{\infty} \left(y_t(\epsilon, h_t(\epsilon)) - w_t(h_t(\epsilon))\right) dG(\epsilon) \\ &+ \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} \left(y_t(\epsilon, h_{stw,t}(\epsilon)) - w_t(h_{stw,t}(\epsilon))\right) dG(\epsilon)\Bigg) \\ &- \rho_t \cdot n_t \cdot (w_{eu,t} + F) - k_v \cdot v_t\end{aligned}$$

Worker Side The value of an employed worker with idiosyncratic productivity ϵ can be written as:

$$V_t^w(\epsilon) = u\Bigg(w_t(h_t(\epsilon)) - \tau_{J,t} - v(h_t(\epsilon))\Bigg) + \beta \cdot E_t\left[\mathcal{V}_{t+1}^w\right] \quad \text{with} \quad u'() > 0,\ u''() < 0,\ v(0) = 0$$

Workers derive utility from consumption and disutility from working $v(h)$. Each period, workers consume their after tax salary $w_t(h_t(\epsilon)) - \tau_{J,t}$. Further, workers are risk averse. The use of the quasi-linear utility function excludes the income effects and makes the theoretical results cleaner. Mathematically it allows to map the model flexible intensive margin into a standard search and matching model wit risk aversion. The expected value of entering next period's employment is denoted by $E_t\left[\mathcal{V}_{t+1}^W\right]$.

The value of an employed worker on STW can be denoted as:

$$V_{stw,t}^w(\epsilon) = u\Bigg(\underbrace{w_t(h_{stw,t}(\epsilon))}_{\text{Reduced income by firm}} + \underbrace{\tau_{stw,t} \cdot (\bar{h} - h_{stw,t}(\epsilon))}_{\text{net transfer STW}} - \tau_{J,t} - v(h_{stw,t}(\epsilon))\Bigg) + \beta \cdot E_t[\mathcal{V}_{t+1}^w]$$

During STW firms and workers will agree on reducing working hours. Consequently, the income of workers fall. The government now steps in an compensates the worker for every hour he works less than he would normally do. Note that only the least productive firms will reduce working hours sufficiently to enter the STW system. As a result, STW is a subsidy to the least productive matches.

The expected value of a worker at the beginning of the period is:

$$\mathcal{V}_t^w = \int_{\max\{\epsilon_{stw,t},\xi_{s,t}\}}^{\infty} V_t^w(\epsilon) dG(\epsilon) + \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} V_{stw,t}^w(\epsilon) dG(\epsilon) + \rho_t \cdot \left(u(w_{eu,t} - \tau_{J,t}) - u(b_t) + U_t\right)$$

As in the equation 1 for the expected value of the firm, households work normally if the idiosyncratic productivity is large $\epsilon > \max\{\epsilon_{stw,t}, \epsilon_{s,t}\}$, go on STW if $\epsilon \in [\epsilon_{s,t}, \epsilon_{stw,t}]$ and get unemployed for $\epsilon < \epsilon_{s,t}$, respectively $\epsilon \in (\epsilon_{stw,t}, \xi_{s,t})$. When workers get unemployed they receive severance payments $w_{eu,t}$. Workers still have to pay taxes $\tau_{J,t}$ on the severance payment. As in Jung and Kuester (2015), workers get no unemployment insurance in the period when they receive the severance payment. This reduces the elasticity of the separation rate on movements in the UI benefits, helping to solve the puzzle of Costain and Reiter (2008).

The value of an unemployed worker at the beginning of the period can be written as:

$$U_t = u(b_t) + \beta \cdot E_t \left[f_t \cdot \mathcal{V}^w_{t+1} + (1 - f_t) \cdot U_{t+1} \right]$$

Being unemployed, a worker receives unemployment benefits b_t. With probability f_t, the worker finds a job and gets the value of being employed at the beginning of the next period. Otherwise, the worker stays unemployed.

Nash-Bargaining Firms and workers bargain over the wage $w_t(h)$, severance payments $w_{eu,t}$, the hours worked on STW $h_{stw,t}(\epsilon)$ and off STW $h_t(\epsilon)$, the voluntary STW take-up threshold $\xi_{stw,t}$ and the separation decisions with STW $\epsilon_{s,t}$ and without STW ξ_t before the idiosyncratic productivity is known in a generalized Nash-Bargaining set-up. They can write a contract based on the realization of each idiosyncratic productivity state ϵ. η_{t-1} denotes the bargaining power of the worker. The bargaining solves:

$$\max_{w_t(h), w_{eu,t}, h_t(\epsilon), h_{stw,t}(\epsilon), \xi_t, \xi_{stw,t}, \epsilon_{s,t}} \mathcal{J}_t^{1-\eta_{t-1}} \cdot (\mathcal{V}^w_t - U_t)^{\eta_{t-1}}$$

The risk neutral firm decides to offer the risk averse worker a contract that insures the worker against any idiosyncratic productivity shock: [6]

$$u'\Bigg(\underbrace{w_t(h_t(\epsilon)) - \tau_{J,t} - v(h_t(\epsilon))}_{\tilde{c}_t(\epsilon)} \Bigg) = u'\Bigg(\underbrace{w_t(h_{stw,t}(\epsilon)) - \tau_{J,t} - v(h_{stw,t}(\epsilon))}_{\tilde{c}_{stw,t}(\epsilon)} \Bigg) = u'\Bigg(\underbrace{w_{eu,t} - \tau_{J,t}}_{\tilde{c}_{eu,t}} \Bigg)$$

It guaranties the same consumption equivalent and therefore utility regardless of whether workers work regulary, are on STW or get laid off:

$$\tilde{c}_t = \tilde{c}_t(\epsilon) = \tilde{c}_{stw,t}(\epsilon) = \tilde{c}_{eu,t}$$

The firm wants to offer such a contract because workers are willing to give up expected income in exchange for income insurance. To achieve the same utility on and off STW, firms must stock up part of the wage of the worker on STW, a behavior we actually have seen in the COVID-19 pandemic. Further, note that we equalize utility. If the worker works fewer hours, his income is still reduced, but the reduction is cushioned, because it does not decrease proportionally with

[6] Derivations of the optimality conditions implied by the Nash-Bargaining can be found in the appendix in section H.

the drop in production value.

Note that firms only offer income insurance against idiosyncratic shocks but not against aggregate shocks. Aggregate shocks have full pass through to the salary of the worker. This flexibility in salary causes the so-called Shimer Puzzle: search and matching models struggle to generate sufficient cyclical fluctuations. The puzzle is commonly resolved by introducing wage-rigidity (see Hall 2005) or in my case: rigid salaries. In the implementation of rigid salaries, I follow Jung and Kuester (2015) and assume procyclical bargaining power of the firms.

$$(1-\eta_t) = \exp(\gamma_w \cdot a_t), \quad \gamma_w > 0$$

We can relate the expression to rigid salaries as follows: If productivity falls in recessions, but salaries are rigid, then a larger share of the joint surplus is claimed by the workers. In a model with Nash-Bargaining, this is equivalent to reducing the firms' or respectively increasing the workers' bargaining power. Fahr and Abbritti (2011), for instance, show that the existence of wage adjustment costs lead to the procyclical bargaining power of the firm.

As in the efficient bargaining setup of Trigari (2006), hours are chosen to maximize the joint surplus. As a result, outside STW, the marginal product of hours worked needs to equal its marginal disutility. This is the solution the social planner would choose as well (see equation 5):

$$\underbrace{\frac{\partial y_t(\epsilon, h_t(\epsilon))}{\partial h_t(\epsilon)}}_{\text{Marginal Product of Labor}} = \underbrace{v'(h_t(\epsilon))}_{\text{Marginal Disutility of Work}} \tag{3}$$

Workers with low idiosyncratic productivity work less to save disutility of hours worked, while those with high idiosyncratic productivity will work more to make use of the extra productivity boost. This result can be interpreted as some kind of perfect working time account. Working time accounts let workers do overtime in good times while reducing working time in bad times. Such flexible working times gain importance, for example, in Germany (see Ellguth, Gerner, and Zapf 2018). A reduction in aggregate productivity will reduce the working hours of every worker in the economy.

Firms and workers want to access the STW system when the surplus gain from the STW subsidy exceeds the loss from working hour reduction:

$$\underbrace{\left(\bar{h} - h_{stw,t}(\xi_{stw,t})\right) \cdot \tau_{stw,t}}_{\text{Surplus Gain from STW Subsidy}}$$
$$= \underbrace{y_t(\xi_{stw,t}, h_{stw,t}(\xi_{stw,t})) - v(h_{stw,t}(\xi_{stw,t})) - y_t(\xi_{stw,t}, h_t(\xi_{stw,t})) + v(h_t(\xi_{stw,t}))}_{\text{Surplus Loss from suboptimal low Working Hours}}$$

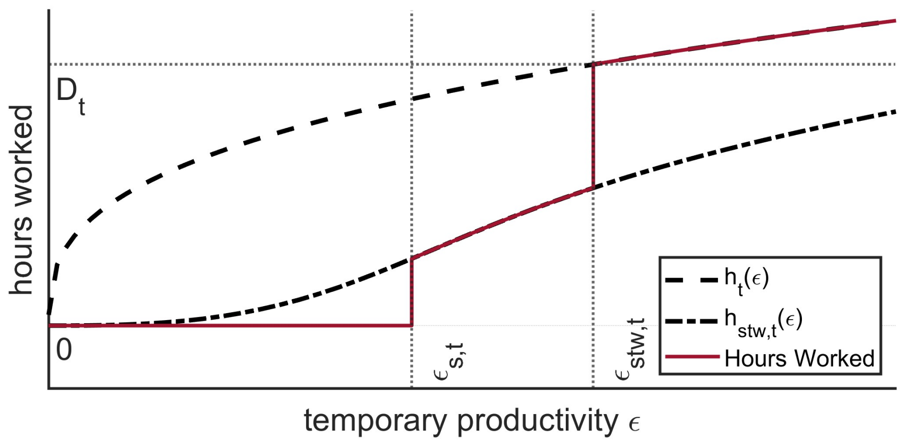
If firms and workers are highly productive, they will decide not to enter the STW system, as they can only attract benefits if they reduce the working hours below the usual level $\bar{h}$. Instead, they want to work more than usual to exploit the benefits of the extra productivity. All matches with an hours choice of $h_t(\epsilon) < \bar{h}$ will want to enter the STW system to exploit benefits. Naturally, the government would want to set a stricter eligibility condition as otherwise more than 50% of the workforce would want to enter the STW system.

As already alluded to working hours are chosen suboptimally low on STW. By reducing the number of hours worked, firms and workers can not only reduce disutility from work but can also attract more STW benefits (see Cahuc, Kramarz, and Nevoux 2021):

$$\underbrace{\frac{\partial y_t(\epsilon, h_{stw,t}(\epsilon))}{\partial h_{stw,t}(\epsilon)}}_{\text{Marginal Product of Labor}} = \underbrace{v'(h_{stw,t}(\epsilon))}_{\text{Marginal Disutility of Work}} + \underbrace{\tau_{stw,t}}_{\text{STW Benefits}} \tag{4}$$

To provide a visual representation of the hours distortion effect of STW for the case $\xi_t \leq \epsilon_{stw,t}$, Figure 2 displays the relationship between hours worked and idiosyncratic productivity. When productivity is high, workers tend to work their normal hours. However, as productivity decreases, both firms and workers have the option to utilize the STW program. Under STW, working hours are reduced below the optimal level. We refer to this reduction of hours as the hours distortion effect of STW. The loss in working hours is represented as the area between the number of hours worked without STW and the actual hours worked on STW. Its impact on the optimal provision of STW will be discussed extensively in subsequent sections. If productivity declines even further, separations occur and working hours fall to zero.

Figure 3: Hours Distortion Effect of STW



Notes: The figure illustrates how STW influences the hours choice decision. $h_t(\epsilon)$ denotes the hours choice firms and workers would take if they were not on STW. $h_{stw,t}(\epsilon)$ denotes the hours choice if they were on STW. The red line shows the actual hours choice dependent on being on regular production $\epsilon > \epsilon_{stw,t}$, on STW $\epsilon \in [\epsilon_{s,t}, \epsilon_{stw,t}]$ or separated $\epsilon < \epsilon_{s,t}$. The differences between the red line and the dashed line on STW shows the hours distortion effect of STW.

Separations occur, if the joint surplus, after the idiosyncratic shock has been realized, becomes negative. The separation threshold without access to STW can thus be determined as:

$$y_t(\xi_t, h_t(\xi_t)) - v(h_t(\xi_t)) + F + \frac{1-\eta_t \cdot f_t}{1-\eta_t} \cdot \frac{k_v}{q_t} = 0$$

The separation threshold with STW can be determined as:

$$y_t(\epsilon_{s,t}, h_{stw,t}(\epsilon_{s,t})) - v(h_{stw,t}(\epsilon_{s,t})) + (\bar{h} - h_{stw,t}(\epsilon_{s,t})) \cdot \tau_{stw,t} + F + \frac{1-\eta_t \cdot f_t}{1-\eta_t} \cdot \frac{k_v}{q_t} = 0$$

Firms and workers want to separate if period output minus disutility from work becomes negative but are disincentivized by potential separation costs. Furthermore, the firm want to hoard workers to save search costs for a new worker while the worker would lose its expected value of being employed by the separation. This value is reduced by the opportunity of the worker to find a new job, which is represented $1-\eta_t \cdot f_t < 1$. Notably, STW increases the joint surplus and disincentives separations. Firms are committed to insure workers against income fluctuations, even in bad times. Higher STW reduces the wage firms have to pay to workers and thus reduce the willingness of fir s to separate from a worker.

Budget Constraint Government I assume that the government must balance its budget every period. Income taxes finance the UI system, and the STW system.

$$n_t \cdot \tau_{J,t} = (1-n_t) \cdot b_t + n_t \cdot \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} \tau_{stw,t} \cdot \left(\bar{h} - h_{stw,t}(\epsilon)\right) \cdot dG(\epsilon)$$

The government will determine the UI and the STW system endogenously. The tax is adjusted accordingly.

Labor Market Flows Based on the timing of the economy, we can formulate the law of motion of employment n_t:

$$n_t = (1-\rho_t) \cdot n_{t-1} + m_{t-1}$$

Here, n_t denotes the number of employed workers at the beginning of the period. m_t denotes the number of newly formed matches. $1-n_t+\rho_t \cdot n_t$ denotes the number of unemployed workers after separations took place. Unemployed workers are matches with vacancies v_t according to a Cobb-Douglas matching function:

$$m_t = \bar{m} \cdot v_t^{1-\gamma} \cdot (1-n_t+\rho_t \cdot n_t)^{\gamma}$$

The parameter χ determines the matching efficiency, and $\gamma \in (0,1)$ denotes the elasticity of the matching function for unemployment. The labor market tightness is defined as the ratio of vacancies to unemployed $\theta_t = \frac{v_t}{1-n_t+\rho_t \cdot n_t}$. Based on the matching function and the labor market tightness, we can derive the probability to find a job f_t and the probability to fill a vacancy q_t:

$$f_t = \chi \cdot \theta_t^{1-\gamma}, \qquad q_t = \chi \cdot \theta_t^{-\gamma}$$

The number of separations s_t can be determined by:

$$s_t = \rho_t \cdot n_t$$

Market Clearing The market clearing is defined via consumption equivalents. Due to the quasi-linear utility function of workers, disutility from work is measured in consumption units. The total production of consumption equivalents can be expressed as:

$$\begin{aligned} z_t = n_t \cdot & \int_{\max\{\epsilon_{stw,t},\xi_t\}}^{\infty} y_t(\epsilon, h_t(\epsilon)) - v_t(h_t(\epsilon)) dG(\epsilon) \\ + n_t \cdot & \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} y_t(\epsilon, h_{stw,t}(\epsilon)) - v_t(h_{stw,t}(\epsilon)) dG(\epsilon) \end{aligned}$$

These can be used to pay for aggregate vacancy posting costs $v_t \cdot k_v$, separation costs $s_t \cdot F$, and consumption equivalents of employed $\tilde{c}_t^w$ and unemployed $\tilde{c}_t^u$ workers as well as firm owners c_t^f:

$$z_t = \underbrace{v_t \cdot k_v + s_t \cdot F}_{\text{Reallocation Costs}} + n_t \cdot \tilde{c}_t^w + (1-n_t) \cdot c_t^u + \nu_t \cdot c_t^f$$

2.2 Social Planner

I assume that the social planner equally weights the utility of every household equally. The planner can freely allocate, consumption, working hours, separations and job-finding rate given the production technology of the economy (I) and the matching technology, respectively, the law of motion of employment, (II).

$$W_t^P = \max_{\theta_t, \epsilon_{s,t}, h_t(\epsilon)} n_t \cdot \int_0^{\infty} u(\tilde{c}_t^w(\epsilon)) dG(\epsilon) + (1-n_t) \cdot u(c_t^u) + \nu_t \cdot u(c_t^f) + \beta \cdot E_t[W_{t+1}^P]$$

subject to

$$\begin{aligned} (I) \quad n_t \cdot \int_0^{\infty} \tilde{c}_t^w(\epsilon) dG(\epsilon) + (1-n_t) \cdot c_t^u + \nu_t \cdot c_t^f = \\ \int_{\epsilon_{s,t}}^{\infty} y(\epsilon, h_t(\epsilon)) - v_t(h_t(\epsilon)) dG(\epsilon) - \theta \cdot (1 - n_t + G(\epsilon_{s,t}) \cdot n_t) \cdot k_v - s_t \cdot F \end{aligned}$$

$$(II) \quad n_{t+1} = (1 - G(\epsilon_{s,t})) \cdot n_t + f(\theta_t) \cdot (1 - n_t + G(\epsilon_{s,t}) \cdot n_t)$$

Since workers and firm owners are risk averse, the social planner wants to offer the same consumption equivalents and thus utility regardless of whether a worker is employed or unemployed.

$$\tilde{c}_t = \tilde{c}_t^w(\epsilon) = c_t^u = c_t^f$$

Note that in the decentralized economy firms can insure employed workers against idiosyncratic productivity shocks but cannot insure unemployed workers. Unemployed workers need to resort to the UI system. As in the decentralized economy the social planner cannot insure households against aggregate shocks.

Since the planner can allocate ressources freely he tries to maximize output minus disutility from work and reallocation costs of a worker via the labor market. Just like firms and workers outside STW, the planner selects working hours such that the marginal productivity of hours worked is equal to the marginal disutility derived from work:[7]

$$\underbrace{\frac{\partial y_t(\epsilon, h_t(\epsilon))}{\partial h_t(\epsilon)}}_{\text{Marginal Product of Labor}} = \underbrace{v'(h_t(\epsilon))}_{\text{Marginal Disutility of Work}} \tag{5}$$

As a result, working hours are optimally determined in the absence of STW intervention. The social planner discounts future welfare using a stochastic discount reflecting how households weigh future marginal utility of consumption againsts todays:

$$Q_{t,t+1} = \beta \cdot \frac{u'(\tilde{c}_{t+1})}{u'(\tilde{c}_t)}$$

The optimal hiring condition can be written as:

$$\begin{aligned}\underbrace{\frac{k_v}{q_t}}_{\text{Recruitment Costs}} &= \\ &+ \underbrace{(1-\gamma)}_{\substack{\text{Static}\\ \text{Congestion Externality}}} \cdot \underbrace{E_t\left[Q_{t,t+1}\left(\int_{\epsilon_{s,t+1}}^{\infty}\left[y_{t+1}(\epsilon, h_{t+1}(\epsilon)) - v\left(h_{t+1}(\epsilon)\right)\right]dG(\epsilon) - G(\epsilon_{s,t+1})\cdot F\right)\right]}_{\text{Expected Increase in Welfare}} \\ &+ E_t\left[Q_{t,t+1} \underbrace{(1-\gamma\cdot f_{t+1})}_{\substack{\text{Dynamic}\\ \text{Congestion Externality}}} \cdot \underbrace{(1-G(\epsilon_{s,t+1}))\cdot\frac{k_v}{q_{t+1}}}_{\text{Saved Recruitment Costs}}\right]\end{aligned}$$

By creating and filling a new vacancy, the planner increases output and saves recruitment costs in the subsequent period. However, an increase in hiring also leads to a congestion externality, as firms compete for the available pool of unemployed workers. This externality has both a static and intertemporal component.

[7] The derivations of the optimality conditions of the planner can be found in the appendix in section **??**.

First, when firms post vacancies, they reduce the probability of other firms to fill their vacancies, leading to higher recruitment costs. This relationship is reflected in the term $(1-\gamma) < 1$. Second, keeping workers employed reduces unemployment and thus increases the labor market tightness. A larger labor market tightness reduces the probability of filling a vacancy and increases recruitment costs for other firms. The effect is captured in the term $(1-\gamma \cdot f_{t+1}) < 1$, which discounts the potential future recruitment cost savings.
The optimal labor market density is determined such that the expected costs of filling a vacancy equals its social benefits.

From the perspective of a social planner, separations should occur if the costs of keeping an unproductive match alive surpass the social costs of reallocating a worker via the labor market:

$$\underbrace{a_t \cdot \epsilon_{s,t} \cdot h_t(\epsilon_{s,t})^\alpha - (\mu_\epsilon - \epsilon_{s,t}) \cdot c_f - v\left(h_t(\epsilon_{s,t})\right)}_{\text{Social costs from keeping unproductive matches alive}} = \underbrace{-F - \frac{1-\gamma \cdot f_t}{1-\gamma} \cdot \frac{k_v}{q_t}}_{\text{Social costs from reallocating a worker via the labor market}}$$

The costs of reallocating a worker via the labor market entail the costs of employee turnover for the firm, that is, the costs of separating from an old and recruiting a new worker, and the opportunity costs of leaving a worker outside production. The opportunity costs rise with a fall in the job-finding rate, as the worker stays longer unemployed.

$$F + \frac{1-\gamma \cdot f_t}{1-\gamma} \cdot \frac{k_v}{q_t} = \underbrace{F + \frac{k_v}{q_t}}_{\text{Expected Costs of Employee Turnover}} + \underbrace{(1-f_t) \cdot \frac{\gamma}{1-\gamma} \cdot \frac{k_v}{q_t}}_{\text{Opportunity Costs of having a Worker Outside Production}}$$

Note that having a worker outside production also entails a positive search externality as unemployment rises which increases the probability for all firms to recruit a worker. This is represented by $\gamma \in (0,1)$ which reduces the costs of lost production.

3 Optimal STW Policy

3.1 Ramsey Problem

The Ramsey planner weights the utility of every worker equally. In order to bring the decentralized economy as close as possible to the Social planner economy, the Ramsey planner can choose the UI system b_t and the STW system. The STW system consists of the eligibility condition D_t and its benefits $\tau_{stw,t}$. The Ramsey planner's decisions are subject to the decentralized labor market equilibrium. With UI benefits, the planner can adjust the income insurance provided to unemployed workers. With STW, the Ramsey planner can influence the separation rate. However, the use of STW also introduces a distortion in the choice of working hours, which is summarized in the welfare cost term $n_t \cdot \Omega_t$. The Ramsey problem can be denoted as:

$$
\begin{aligned}
W_t^G = & \max_{D_t, \tau_{stw,t}, b_t} (1 - n_t) \cdot u(b_t) + n_t \cdot u(\tilde{c}_t^w) \\
& + \nu_t \cdot u\left(\left[n_t \cdot \int_{E_t} y_t(\epsilon, h_t(\epsilon)) - v(h_t(\epsilon)) dG(\epsilon) - n_t \cdot \Omega_t - n_t \cdot \tilde{c}_t^w - (1 - n_t) \cdot b_t - n_t \cdot \rho_t \cdot F - v_t \cdot k_v \right] / \nu_t \right) \\
& + \beta \cdot E_t W_{t+1}^G
\end{aligned}
$$

$$\text{s.t.} \quad \text{decentralized Equilibrium}$$

Since the primary focus of the paper is not on distributional conflicts between firm owners and employed workers, I set the number of firm owners ν_t such that firms and workers have the same amount of consumption units $c_t^f = \tilde{c}_t^w$. Inclusion of distributional conflicts between firm owners and workers would not fundamentally change the subsequent analysis but would increase the complexity of the expressions.

The welfare costs of STW are defined as the difference between output minus disutility of work with and without the hours distortion effect of the STW system.

Definition 2, Welfare Costs of STW
The aggregate difference between output minus disutility of work with and without hours distortions of STW is defined as the welfare costs of STW $n_t \cdot \Omega_t$. Here, Ω_t can be denoted as:

$$
\Omega_t = \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} \Big[\underbrace{y_t(\epsilon, h_t(\epsilon)) - v\left(h_t(\epsilon)\right)}_{\text{No Hours Distortion}} - \underbrace{y_t(\epsilon, h_{stw,t}(\epsilon)) + v\left(h_{stw,t}(\epsilon)\right)}_{\text{With Hours Distortion}} \Big] dG(\epsilon)
$$

The optimal implementation of STW is significantly influenced by how the STW threshold and benefits impact the hours distortion problem associated with STW. The results are summarized in lemma 1.

Lemma 1, Welfare Costs of STW
The welfare costs of STW $n_t \cdot \Omega_t$ are positive, and increase, if the eligibility condition gets looser or the STW benefits get more generous or both as:

$$\Omega_t \geq 0, \qquad \frac{\partial \Omega_t}{\partial \tau_{stw,t}} > 0, \qquad \frac{\partial \Omega_t}{\partial \epsilon_{stw,t}} > 0, \qquad \frac{\partial^2 \Omega_t}{\partial \tau_{stw,t} \partial \epsilon_{stw,t}} > 0$$

PROOF: *Appendix E*

First, the welfare costs must be positive. In the absence of STW, firms and workers would naturally choose the optimal number of hours worked. However, under STW, working hours are distorted downward, resulting in inefficiently low production levels.
Second, more generous STW benefits create stronger incentives for workers on STW to reduce their hours, thus severing the hours distortion effect.
Third, the welfare costs increase as the STW threshold becomes looser. A looser eligibility condition allows more firms and workers to enter STW. Consequently, a greater number of them will choose sub-optimal low working hours, leading to a larger loss in output.
Finally, if both eligibility condition and STW threshold get looser, respectively more generous, the hours distortion effects are further exacerbated.

3.2 Optimal UI

Before examining the joint determination of optimal UI and STW, it's helpful to first explore the optimal UI system given a STW system that may not be optimally set, as described in Proposition 1. This analysis provides insight into the role of the STW system.

Similar to the Social Planner, the Ramsey Planner seeks to insure workers against income losses due to job loss. Ideally, as envisioned by the Social Planner, the Ramsey planner would set $\tilde{c}^w = b$. However, it's well known that UI systems create fiscal externalities, leading to a wedge between $\tilde{c}^w$ and b, such that $\tilde{c}^w > b$.
The issue arises because UI systems enhance workers' outside options, driving up wages. This reduces firms' revenues and their incentive to hire new workers. In Proposition 1, the welfare loss due to fewer vacancies is captured in the term LV, which explains the first part of the wedge. Additionally, firms and workers do not internalize the costs they impose on the UI system when separating. Supported by UI, workers demand higher wages and accept a higher probability of separation, leading to more separations than the Ramsey Planner would deem optimal. The welfare costs of these additional separations are summarized in the term LS. The combination of increased separations and reduced vacancy postings results in inefficiently high unemployment levels. Thus, optimal UI benefits must strike a balance between income insurance and efficiency.

Proposition 1: Optimal UI given STW
Suppose the economy is in its non-stochastic steady state and a non-optimized STW system exists where its STW threshold is set so that $\epsilon_{stw} > \xi$*. Then the optimal UI benefits can be determined by*

$$\underbrace{(1-n)\cdot(u'(b)-u'(\tilde{c}^w))}_{\text{Provide additional Income Insurance}} = \underbrace{(LV+LS)\cdot\beta\cdot\frac{\partial J}{\partial b}}_{\text{Additional Distortions through UI}}$$

where LV determines the additional welfare costs from reduced vacancy posting and LS the additional welfare costs from inflated separations and M the inverse multiplier:[8]

$$LV = \frac{1}{M}\cdot\underbrace{\frac{\eta-\gamma}{(1-\eta)\cdot(1-\gamma)}}_{\text{Deviation from Hosios Condition}} + \frac{1}{M}\cdot\underbrace{\frac{\beta\cdot(1-G(\epsilon_s))}{1-\beta\cdot(1-f(\theta))\cdot(1-G(\epsilon_s))}\cdot\frac{b}{n}/\frac{k_v}{q(\theta)}}_{\text{Fiscal Externality}}$$

$$LS = \frac{1}{M}\cdot\frac{n\cdot(\gamma-\eta\cdot f(\theta))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)}\cdot\left(\underbrace{\frac{\beta\cdot(1-G(\epsilon_s))}{1-\beta\cdot(1-f(\theta))\cdot(1-G(\epsilon_s))}\cdot\frac{b}{n}}_{\text{Fiscal Externality}} - \underbrace{\tau_{stw}\cdot(\bar{h}-h_{stw}(\epsilon_s))}_{\text{STW subsidy}}\right)$$

PROOF: *Appendix E*

The welfare cost terms from posting too few vacancies (LV) and having too many separations (LS) provide detailed insights into the cost structure and the effectiveness of STW programs in addressing these issues.

First of all, STW cannot directly address inefficient vacancy postings. Inefficiencies in vacancy postings in the model stem either from a deviation from the Hosios Condition[9] or from the fiscal externality of the UI system. If the bargaining power of workers is high ($\eta > \gamma$), then too few vacancies are posted. Higher UI benefits exacerbate the problem. STW is of no help here. To increase vacancy postings, STW would need to boost the joint surplus of firms and workers. However, any increase in STW benefits is offset by an increase in the income tax, nullifying any direct influence of STW on vacancy postings.
Second, STW can theoretically eliminate all inefficient separations. The welfare costs of additional inefficient separations are driven solely by the fiscal externality of the UI system. If UI benefits are high, more productive matches are destroyed, increasing the marginal welfare loss of a destroyed match. STW reduces separations by reducing the the cost of firms to insure

[8]A detailed discussion of the Multiplier can be found in the Appendix A.
[9]When posting vacancies, firms don't consider that they reduce the probability of other firms finding a worker (congestion externality) and increase the probability for workers to find a job (thick market externality). As a result, firms may post too many vacancies, inflating vacancy posting costs, or too few vacancies, leading to excessive unemployment.

workers against idiosyncratic productivity shocks.

Note that STW helps to enhance the income insurance provided by the UI system. A major drawback of STW is that it cannot stabilize the job-finding rate.

3.3 Optimal Eligibility Condition, STW Benefits and UI benefits

Now we are well prepared to analyze the joint determination of the STW system and UI system. We start by analyzing the optimal provision of STW benefits described in in proposition 2:

Proposition 2, Optimal STW benefits in steady state
Consider the economy as previously descried. Assume that it has converged to its non-stochastic steady state. Then, the optimal STW benefit τ_{stw} are determined by:

$$\underbrace{\left(\bar{h} - h_{stw}(\epsilon_s)\right) \cdot \tau_{stw}}_{\text{Net-Transfer STW}} = \underbrace{\frac{\beta \cdot (1-f)}{1 - \beta \cdot (1 - G(\epsilon_s)) \cdot (1-f)} \cdot \left[b + \frac{1-n}{n} \cdot b\right]}_{\text{A: Fiscal Externality UI } > 0}$$
$$- \underbrace{\frac{1}{g(\epsilon_s)} \cdot \left[\frac{\partial \Omega}{\partial \tau_{stw}}\right] \cdot \left[-\frac{1}{\frac{\partial \epsilon_s}{\partial \tau_{stw}}}\right]}_{\text{B: Welfare Costs of larger STW benefits } > 0} - \underbrace{\tilde{BE}}_{C\text{: Bargaining Effect}}$$

PROOF: *Appendix E*

The determination of optimal STW benefits, denoted as τ_{stw}, follows a two-step procedure, as outlined in Proposition 2. First, the Ramsey planner calculates the optimal net-transfer to the least productive matches. This reflects the amount of resources the planner intends to transfer to the marginal match.
Second, the planner must consider how the STW system influences the reduction in working hours by firms and workers, represented by $\bar{h} - h_{stw}(\epsilon_s)$. This reduction determines the amount of resources allocated to the match for given STW benefits τ_{stw}. Higher STW benefits result in a greater reduction in working hours, which in turn leads to a larger transfer of resources to the match. Using this information, the Ramsey planner adjusts the STW benefits to achieve the optimal net transfer of resources.

The optimal net transfer to the least productive matches comprises three components. Part A explains the rationale for STW's existence. As previously discussed, the UI system inefficiently increases separation incentives, and the planner counters this by offering positive STW benefits. The optimal level of STW benefits is directly influenced by the generosity of the UI system—the more generous the UI benefits, the higher the optimal STW benefits.
When workers and firms negotiate separations, workers face a trade-off. Either stay employed during periods of low productivity, accepting an overall lower salary to compensate firms for the larger losses in downturns, or they can opt for a higher salary, accepting a greater risk of unemployment. The UI system distorts this decision, pushing workers towards contracts with higher unemployment risk, thereby increasing aggregate separation rates. Optimal STW benefits aim to reduce the likelihood of separations by insuring firms against wage costs during downturns. Essentially, STW lowers the wage the firm must pay the worker by an amount equivalent to what the UI system would otherwise pay if the worker became unemployed. This approach removes the additional separation risk that workers accept due to the UI system, thereby eliminating unnecessary separations.
Additionally, the firm receives a rebate for the tax costs imposed by the UI system. This rebate further reduces the firm's financial burden, ensuring that the UI-induced fiscal costs do not discourage them from retaining workers during downturns. In spirit, this is the rule Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008) found in their analysis of optimal lay-off taxes.

Part B addresses Burdett and Wright (1989) concern that STW distorts working hours. The planner recognizes that the use of STW is costly as it downward distorts the hours choice in the economy. Consequently, the planner faces a trade-off between preventing socially undesirable separations and minimizing the distortions introduced by the STW system. To keep distortions low, STW benefits are adjusted downward, referred to as the welfare cost penalty of STW (Γ_Ω). More generous benefits directly increase the welfare costs associated with STW $\frac{\partial \Omega}{\partial \tau_{stw}} > 0$. In the calibrated model, the welfare costs of STW reduce the net-transfers by approximately 25%. Interestingly, the welfare cost penalty of STW does not dependent on the absolute value of welfare costs of STW but on their additional effects. In case of zero-STW (no work on STW), for example, additional distortions caused by STW benefits would be minimal ($\frac{\partial \Omega}{\partial \tau_{stw}} \rightarrow 0$). Consequently, the net-transfer would closely resemble the benefits provided without hours distortion effects ($\frac{\partial \Omega}{\partial \tau_{stw}} = 0$).

Part C describes the bargaining effect, an effect not previously discussed in the literature to STW. A detailed expression can be found in Appendix A. It takes the effect of STW on wage changes and thus job-postings and separations into account: Workers' risk aversion makes it more difficult for firms to reduce income. A decrease in salary increases the marginal utility of consumption, meaning that workers dislike salary cuts more than they would in a model with risk-neutrality. In essence, workers resist income cuts more strongly than they would advocate

for income increases.
In the model, this is reflected by the fact that workers secure a larger share of the joint surplus $\mathcal{S} = \mathcal{J} + \mathcal{V} - U$ when their salary falls. The following equations describe the worker's surplus from being employed at the firm and the value of the worker to the firm, both of which depend on the joint surplus:

$$\mathcal{V} - U = \tilde{\eta}(c^w) \cdot \mathcal{S} \qquad \text{and} \qquad \mathcal{J} = (1 - \tilde{\eta}(c^w)) \cdot \mathcal{S} \qquad \text{with} \qquad \tilde{\eta}(c^w) = \frac{u'(\tilde{c}^w) \cdot \eta}{u'(\tilde{c}^w) \cdot \eta + 1 - \eta}$$

The term $\tilde{\eta}(c)$ represents the effective bargaining weights, which are influenced by the marginal utility of consumption. Specifically, if a worker's salary decreases, the marginal utility of consumption increases, thereby enhancing the worker's effective bargaining power and allowing them to secure a larger portion of the joint surplus. Conversely, firms secure a smaller share of the surplus. When firms secure less of the joint surplus, firms reduce vacancy postings and increase separations.
STW encourages firms to reduce separations, meaning that during downturns, firms may opt to keep workers on STW rather than laying them off. However, STW remains costly for firms, as they still bear fixed production costs and continue to partially compensate workers. As a result, overall salaries must be reduced. Due to workers' resistance to salary cuts, this reduction is implemented imperfectly, leading to fewer vacancy postings and more separations. To mitigate STW's impact on vacancy postings and separations, the Ramsey planner chooses smaller STW benefits.

Corollary 1: STW has no Insurance Role
Suppose that $b = 0$ and the Hosios condition is met $\eta = \gamma$, then STW benefits are zero. This implies that STW itself is not used to provide income insurance.

PROOF: *Appendix E*

One surprising effect of the analysis is that STW itself does not provide any income insurance. The sole reason for STW to exist is to counter the fiscal externality of the UI system. Thereby, STW takes the role of an optimal lay-off tax in the sense of Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008). We can see this more clearly by setting unemployment benefits to zero and imposing the Hosios condition. In this case, optimal STW benefits are equal to zero. STW itself provides no income insurance as firms write a contract that insures workers against any idiosyncratic productivity shocks on the firm. Appendix C derives the optimal layoff tax within my model and shows its similarity to the STW system.

Optimal Eligibility Condition Proposition 2 displays the major draw back of STW: it distorts working hours. We will now try to set the eligibility condition in a way that the distortionary effects are as small as possible. Proposition 3 outlines the optimal eligibility condition for STW. It states that the optimal condition is achieved when the STW threshold equals the separation threshold of firms and workers without STW ($\epsilon_{stw} = \xi$, equation 6).

Proposition 3, Optimal Eligibility Condition

Consider the economy described in section 2.1 and assume that it has converged to its non-stochastic steady state. Then, the optimal eligibility condition $D = h_{stw}(\epsilon_{stw})$ is implicitly defined by the separation threshold of a firm without STW ($\epsilon_{stw} = \xi$).

$$\underbrace{S(\epsilon_{stw}) = y(\epsilon_{stw}, h(\epsilon_{stw})) - v\left(h(\epsilon_{stw})\right) + F + \frac{1-\eta \cdot f}{1-\eta} \cdot \frac{k_v}{q} = 0}_{\text{Joint Surplus without STW is zero}} \tag{6}$$

as long as the welfare costs of a looser eligibility condition are positive:

$$\underbrace{n \cdot u'(\tilde{c}^w) \cdot \frac{\partial \Omega}{\partial \epsilon_{stw}}}_{\text{More hours distortion}} + (1 + \eta \cdot BE) \cdot \left(\underbrace{LV}_{\text{Reduction vacancies}} + \underbrace{LS}_{\text{Increase separations}} \right) \cdot \frac{\partial \Omega}{\partial \epsilon_{stw}} \geq 0 \tag{7}$$

PROOF: *Appendix E*

To better understand why we should set the eligibility condition equal to the separation threshold of firms and workers without access to STW ($\epsilon_{stw} = \xi$), we must examine the consequences of choosing a too loose ($\epsilon_{stw} > \xi$) or too strict ($\epsilon_{stw} < \xi$) STW threshold.

Let us begin with the case of a too strict eligibility condition ($\epsilon_{stw} < \xi$). In this case, there exist unproductive matches that are allowed onto the STW system while more productive matches are not, causing the latter to dissolve. Rescuing less productive matches while allowing more productive matches to dissolve would clearly be inefficient. To avoid such inefficiencies, the STW threshold needs to be set at least as loose as the separation threshold without STW ($\epsilon_{stw} \geq \xi$).

The costs of choosing the eligbility condition too lose $\epsilon_{stw} > \xi$ are described in equation 7. The main cost to consider are the additional welfare costs associated with the STW system ($\frac{\partial \Omega}{\partial \epsilon_{stw,t}} > 0$). The hours distortion effect spreads among more firms without saving additional workers. Furthermore, a looser eligibility condition reduces vacancy postings (LV) and increases separations (LS). At first sight, an easier access to the STW system should increase the surplus of firms and workers. However, the effect is nullified by an equivalent increase in the income tax. Even worse, the spread of the hours distortion effect reduces the expected output of firms, leading to a fall in the joint surplus. Hence, it must be optimal to set the eligibility condition at least as strict as the separation threshold of firms and workers without STW ($\epsilon_{stw} \leq \xi$). This property is later referred to as the "no-windfall effect condition. Equation 7 describes also the sufficient condition for the eligibility condition. For $\eta \geq \gamma$, the condition is unambiguously positive and fulfilled. However, even if $\eta < \gamma$, it is hard to imagine that the condition would not be fulfilled. It would mean that firms post so many vacancies that it would be optimal to sacrifice output to reduce the profits of firms and thus decrease vacancy postings. Using STW in that case seems unreasonable.

Combining both statements, we can conclude that if the eligibility condition is too strict, the planner will be unable to save some firms worth saving. If it is too loose, it will exacerbate the distortionary effects of STW. Therefore, it is optimal to set the separation threshold of firms and workers without access to STW equal to the STW threshold, denoted as $\epsilon_{stw} = \xi$. In the end, only matches that would dissolve otherwise, should be allowed on the STW system.

In contrasts to the optimal STW benefits, it is not directly obvious from the expression of the optimal eligibility condition how the eligibility condition interacts with the unemployment insurance system. Its connection is highlighted in corollary 2:

Corollary 2, Optimal STW Policy can save Fiscal Costs
Suppose that the sufficient condition for the eligibility condition holds and that $S'(\epsilon_{stw}) > 0$, then ceteris paribus, the optimal eligibility condition becomes looser when UI benefits increase.

$$\frac{\partial D}{\partial b} > 0$$

PROOF: *Appendix E*

When UI benefits increase the optimal eligibility condition has to be loosened. Any increase in UI benefits raises the worker's outside option, leading to higher separation rates in firms without access to STW. If the eligibility condition isn't adjusted, these matches are destroyed even though they could have been saved with STW. To prevent unnecessary separations, the eligibility condition must be loosened. The expression becomes important when considering the interaction of optimal UI benefits with the STW system.[10]

[10] As necessary condition, $S'(\epsilon_{stw}) > 0$ states that the joint surplus of a match at the eligibility condition must increase. Theoretically, a loosening of the eligibility condition can increase the distortionary effects of the STW system and decrease the continuation value of the match. However, quantitatively this is very unlikely to exceed the direct effect of higher productivity on the joint surplus.

Furthermore, combining proposition 2 and 3 has interesting implications for the fiscal costs of the STW system discussed in cororally 3:

Corollary 3, Optimal STW Policy can save Fiscal Costs
Suppose that STW benefits are set optimally and equation 7 holds. If

$$\underbrace{\frac{\beta \cdot (1-f)}{1-\beta \cdot (1-G(\epsilon_s)) \cdot (1-f)} \cdot \left[\frac{1-n}{n} \cdot b\right]}_{\text{Distortionary Production Tax } > 0} < \underbrace{\frac{1}{g(\epsilon_s)} \cdot \left[\frac{\partial \Omega}{\partial \tau_{stw}}\right] \cdot \left[-\frac{1}{\frac{\partial \epsilon_s}{\partial \tau_{stw}}}\right]}_{\text{B: Welfare Costs of larger STW benefits } > 0} + \underbrace{\tilde{BE}}_{C\text{: Bargaining Effect}}$$

then keeping workers employed with STW is fiscally less expensive than letting them become unemployed and enter the UI system.

PROOF: *Appendix E*

Corollary 2 states that an optimal STW policy may not be more expensive than relying solely on the UI system. By setting the eligibility criteria optimally, only workers who would have been laid off enter the STW system, reducing the overall number of unemployed workers and thereby cutting UI costs. Workers in the STW system receive the same expected discounted benefits they would have under the UI system, so there are no additional costs. While these transfers might be slightly higher to address the distortionary effects of income tax, the Ramsey planner chooses to replace less than the expected UI costs to minimize STW's distortionary impact on working hours. Further, STW's impact on working hours lets the planner choose even smaller STW benefits.

Optimal UI benefits Finally, we need to characterize optimal UI benefits, taking into account its impact on the optimal STW benefits. Proposition 4 offers an expression.

Unaltered, The Ramsey planner faces a trade-off between providing additional income insurance for workers and the economic distortions introduced by higher UI benefits. The negative impact of UI benefits on vacancy posting has not changed. However, the new expression for the additional welfare costs associated with increased separations is noteworthy (LS). The planner must account for the fact that raising UI benefits will increase separations inefficiently. To counter these inefficient separations, STW benefits must become more generous. However, these additional STW benefits are not without cost; they exacerbate the distortions in working hours caused by STW. Consequently, the planner does not achieve the efficient number of separations (LS = 0) but allows some efficient matches to dissolve to keep the welfare costs of STW low. Additionally, the planner must consider the impact of STW on the eligibility condition

(LSTW). Higher UI benefits increase the likelihood of separations among firms without access to STW. To mitigate this effect and support these firms, STW needs to relax its eligibility criteria, which in turn affects the welfare costs associated with STW.

Proposition 4: Optimal UI given STW
Suppose the economy is in its non-stochastic steady state and a non-optimized STW system exists where its STW threshold is set so that $\epsilon_{stw} > \xi$. Then the optimal UI benefits can be determined by

$$\underbrace{(1-n)\cdot(u'(b)-u'(\tilde{c}^w))}_{\text{Provide additional Income Insurance}} = \underbrace{(LV+LS+LSTW)\cdot\beta\cdot\frac{\partial J}{\partial b}}_{\text{Additional Distortions through UI}}$$

where LV determines the additional welfare costs from reduced vacancy posting and LS the additional welfare costs from inflated separations and M' the joint multiplier:[11]

$$LV = \frac{1}{M'}\cdot\underbrace{\frac{\eta-\gamma}{(1-\eta)\cdot(1-\gamma)}}_{\text{Deviation from Hosios Condition}} + \frac{1}{M'}\cdot\underbrace{\frac{\beta\cdot(1-G(\epsilon_s))}{1-\beta\cdot(1-f(\theta))\cdot(1-G(\epsilon_s))}\cdot\frac{b}{n}/\frac{k_v}{q(\theta)}}_{\text{Fiscal Externality}}$$

$$LS = \frac{1}{M'}\cdot\frac{n\cdot(\gamma-\eta\cdot f(\theta))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)}\cdot\frac{\partial\Omega}{\partial\tau_{stw}}/\left(\bar{h}-h_{stw}(\epsilon_s)\right)$$

$$LSTW = \frac{1}{M'}\cdot\frac{n\cdot(\gamma-\eta\cdot f(\theta))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)}\cdot\frac{\partial\Omega}{\partial\epsilon_{stw}}/\left(a\cdot h(\epsilon_{stw})+c_f\right)$$

PROOF: *Appendix E*

3.4 Implications for the Business Cycle

In Section 5, we examine how the STW system should be optimally adjusted throughout the business cycle in a calibrated version of the model. Utilizing the closed-form expressions derived in Section 3, we will explore the main channels through which business cycle fluctuations can impact both optimal STW benefits and eligibility conditions.

[11] A detailed discussion of the Multiplier can be found in the Appendix

Corollary 4, Higher job-finding rates decrease optimal STW benefits
Assume that the STW benefits are set optimally according to proposition 2. Then, the welfare costs of the UI system and, thus, the STW benefits increase if the job-finding rate decreases:

$$\frac{\partial \tau_{stw}}{\partial f} < 0$$

PROOF: *Appendix E*

First, we examine the decline in job-finding rates. A well-documented stylized fact of the business cycle is that job-finding rates tend to fall during recessions (see Section 4). In response to this decline, optimal STW benefits should increase. A lower job-finding rate prolongs unemployment for workers, which is especially costly without unemployment benefits. In the absence of these benefits, workers would select contracts with significantly lower unemployment risk to reduce the chance of layoffs. However, when workers receive benefits, the negative impact of a decreased job-finding rate is partially mitigated by the extended receipt of UI benefits. This adjustment allows workers to keep contracts with higher unemployment risk, placing the burden of job-loss on the UI system. To counteract the extra social costs of separations and address these inefficiencies, STW benefits must be increased.

Corollary 5, Looser eligibility increases moral hazard cost penalty on net-transfers
Assume risk neutrality and that the STW condition D is exogenous such that $\epsilon_{stw} \geq \xi$. Otherwise STW benefits are chosen according to proposition 2. A looser STW condition then increases the welfare cost penalty of STW on the optimal net-transfer and, ceteris paribus, reduces the optimal STW benefits.

$$\frac{\partial \tau_{stw}}{\partial D} = -\frac{1}{\bar{h} - h_{stw}(\epsilon_s)} \left[\underbrace{\frac{\partial^2 \Omega}{\partial \tau_{stw} \partial \epsilon_{stw}}}_{>\,0} \cdot \underbrace{\left(-\frac{\xi_1}{\frac{\partial \epsilon_s}{\partial \tau_{stw}}} \right)}_{>\,0} + \underbrace{\frac{\partial \Omega}{\partial \tau_{stw}}}_{>\,0} \cdot \underbrace{\left[\frac{1}{\frac{\partial \epsilon_s}{\partial \tau_{stw} \partial \epsilon_{stw}}} \right]}_{>\,0} \right] \cdot \underbrace{\frac{\partial \epsilon_{stw}}{\partial D}}_{>0} < 0$$

PROOF: *Appendix E*

Second, if the eligibility condition is loosened then the moral hazard cost penalty on optimal net-transfers increases. A looser eligibility condition implies that more firms and workers can enter STW. Therefore, large STW benefits become more expensive as the hours choice of a larger number of firms and workers becomes distorted $\frac{\partial^2 \Omega}{\partial \tau_{stw} \partial \epsilon_{stw}} > 0$. To attenuate the welfare costs of STW, the Ramsey planner chooses smaller STW benefits.

In recessions, the effect will become important again as the fraction of firms and workers on STW rises. Section 5.3. discusses how growing welfare cost penalties in recessions influence STW's ability to stabilize the business cycle.

Corollary 6, Influence on eligibility condition

Suppose that the sufficient condition for the eligibility condition holds and that $S'(\epsilon_{stw}) > 0$*, then ceteris paribus, a decrease in productivity will loosen while a fall in the job-finding rate will tighten the optimal eligibility condition:*

$$\frac{\partial D}{\partial a} < 0, \qquad \frac{\partial D}{\partial f} > 0$$

PROOF: *Appendix E*

The eligibility condition aims to ensure that only job matches unable to survive without STW are included in the system. However, how this eligibility should adjust during a recession is not straightforward. Two key factors are at play. First, a drop in aggregate productivity reduces the chances of a full recovery for a match, lowering its continuation value. This causes matches to separate after a smaller decline in firm-specific productivity, making them less willing to reduce working hours before dismissal. To save these matches, the eligibility condition should be loosened.

Second, recessions usually lead to a sharp decline in the job-finding rate, extending expected unemployment spells and weakening workers' outside options. As a result, workers may accept wage cuts and reduced hours to stay with the firm. If workers voluntarily stay attached, STW support isn't needed. If this effect is stronger, the eligibility condition should be tightened.

4 Calibration and Solution Procedure

This section calibrates the model to the US economy, using a period length of one month. For the business cycle analysis, I allow only the STW system to adjust, while keeping the unemployment insurance (UI) system exogenously set. Given that Section 2 demonstrates that STW primarily responds to the UI system without offering direct income insurance, I assume risk neutrality in this calibration. Importantly, all results hold even if risk aversion were included. The baseline model used here incorporates wage rigidity and an exogenously determined UI system but excludes any STW mechanism. The choice of US data is particularly advantageous because, historically, the US has not implemented a nationwide STW system, thereby ensuring that the data is unaffected by such a system's influence. This allows for a clearer analysis of the model's implications.

Data used for Calibration I calibrate the model to data from 1952:I to 2020:I. The unemployment rate is taken from the U.S. Bureau of Labor Statistics. Following Shimer (2005), the job-finding rate and separation rate are calculated using data on the absolute number of unemployed u^a, newly unemployed [12] u^s and employed e^a workers from the U.S. Bureau of Labor Statistics: $f_t = 1 - \frac{u^a_{t+1} - u^s_{t+1}}{u^a_t}$, $s_t = \frac{u^s_{t+1}}{e_t \cdot (1 - \frac{1}{2} \cdot f_t)}$. For vacancies I use the composite help-wanted index from Barnichon (2010). Average weekly hours $\bar{h}_t/4 = E_t[h_t(\epsilon)|\epsilon \geq \epsilon_{s,t}]/4$ and average labor productivity $p_t = E[y_t(\epsilon)|\epsilon \geq \epsilon_{s,t}]$ are retrieved for the non-farm business sector from the U.S. Bureau of Labor Statistics.

The business cycle properties are reported in table 1. Following Shimer (2005), the table reports log-deviations from an HP-trend with smoothing parameter 10^5. The properties of the business cycle data are well known. Vacancies, unemployment and labor market tightness are very volatile. The job-finding rate and the average hours worked are pro-cyclical while separations are counter-cyclical. Separations are less volatile than the job-finding rate.

[12] Unemployed for less than 5 weeks

Table 1: Business Cycle Properties US Data

		v	f	ρ	u	θ	$\bar{h}$	p
Standard Deviation		20.13	14.31	8.2	20.49	39.67	0.81	1.91
Autocorrelation		0.95	0.95	0.77	0.95	0.96	0.92	0.9
	v	1	0.85	-0.55	-0.92	0.98	0.55	0.19
	f	-	1	-0.29	-0.93	0.91	0.38	0.09
	ρ	-	-	1	0.6	-0.59	-0.63	-0.4
Correlation	u	-	-	-	1	-0.98	-0.55	-0.23
	θ	-	-	-	-	1	0.57	0.22
	$\bar{h}$	-	-	-	-	-	1	0.46
	p	-	-	-	-	-	-	1

Notes: The table lists the second moments of the data reported by Shimer (2005). u, v, f, and G(ϵ_s) are expressed as quarterly averages of monthly series. p is the seasonally adjusted average labor productivity in the non-farm business sector. All variables are reported as log-deviations from a HP trend with smoothing parameter 10^5.

Calibrated Parameters Table 2 summarizes the chosen parameter values and table 3 the respective business cycle properties of the model. Following Jung and Kuester (2015), I set the discount factor to $\beta = 0.996$. As target steady states I choose the monthly steady state job-finding rate of $f = 0.41$ and separation rate $\rho = 0.03$ from the Data. To implement the job-finding rate, I set vacancy posting costs to $k_v = 0.139$. To implement the separation rate, the strength of the resource cost shock is set to $c_f = 10.441$. The matching efficiency parameter $\bar{m} = 0.383$ is determined by targeting a monthly vacancy filling rate of $q = 0.338$. This is the monthly equivalent of the quarterly job-filling rate of 0.71 reported in Haan, Ramey, and Watson (2000). I set the bargaining power of the worker to $\eta = 0.65$, which is, according to Petrongolo and Pissarides (2001), within the reasonable set of parameter estimates. In order to ensure that inefficiencies in the steady state are only driven by the UI system, the Hosios-Condition (see Hosios 1990) is implemented by setting the elasticity of the matching function with respect to unemployment equal to the bargaining power of the firm: $\gamma = \eta$. The unemployment benefits are set to $b = 0.4$ which ensures a replacement rate of 40% of the wage. This is a value commonly used in the literature, for instance by Shimer (2005), and is close to the empirical value reported by Engen and Gruber (2001).

The parameter $\bar{h}$ represents the mean hours worked in a firm and is set to its steady state value in the baseline economy: $\bar{h} = 0.834$. Similar to Christoffel and Linzert (2010), I set the labor elasticity of the production function to $\alpha = 0.65$. The disutility of work has the common functional form of v(h) = $\frac{h^{1+\psi}}{1+\psi}$, $\psi > 0$. Following Domeij and Floden (2006), I set the Frish-elasticity to 0.66 which implies $\psi = 1.5$. As Krause and Lubik (2007), I set the parameter for the variance of log-normal distribution of the the idiosyncratic shock to $\sigma = 0.12$. In order to

Table 2: Parameters

Parameter	Description	Value	Reason
ρ	Target ss separation rate	0.03	Data
f	Target ss job-finding rate	0.41	Data
q	Target ss vacancy filling rate	0.338	Haan, Ramey, and Watson (2000)
β	Discount rate	0.996	Jung and Kuester (2015)
ψ	Inverse Frisch-elasticity	1.5	Domeij and Floden (2006)
γ	Elasticity matching function with respect to unemployment	0.65	Shimer (2005).
η	Bargaining power worker	0.65	Implements Hosios-Condition
γ_w	Coefficient reaction bargaining power to productivity shock	15.5	s.d. job-finding rate 14.31 in data
F	Separation costs	1.01	s.d. separation rate of 8.2 in data
b	UI benefits	0.4	40% replacement rate of wage
α	Labor elasticity production function	0.65	Christoffel and Linzert (2010)
$\bar{h}$	"Normal" hours worked	0.834	Mean hours worked in baseline
ρ_a	Autocorr. productivity shock	0.985	Jung and Kuester (2015)
μ_a	Mean aggregate productivity	1.0	Normalization
$\sigma_a \cdot 100$	s.d. aggregate productivity	0.259	s.d. labor prod. of 1.91 in data
μ	Parameter steering mean of lognormal distribution	0.082	Normalize wage to 1
σ	Parameter steering variance of lognormal distribution	0.12	Krause and Lubik (2007)
$\bar{m}$	Matching parameter	0.383	Calculated by target ss
k_v	Vacancy posting costs	0.139	Calculated by target ss
c_f	Strength resource cost shock	10.441	Calculated by target ss

normalize the wage to 1, the parameter that stears the mean of the log-normal distribution is set to $\mu = 0.082$.

In order to reach a standard deviation (s.d.) of 0.02 of labor productivity over the business cycle, I set the standard deviation of the aggregate productivity shock to $\sigma_a = 0.003$ and follow Jung and Kuester (2015) in setting the autocorrelation to $\rho_a = 0.985$. Similar to Jung and Kuester (2015), I set the coefficient for the procyclical bargaining power of the firm to $\gamma_w = 15.5$. This ensures reasonable fluctuations in the job-finding rate over the business cycle (compare table 1 and 3). To ensure a standard deviation of the separation rate of 0.075, I set the separation costs to F = 0.95.[13]

[13] This is consistent with the value used in Silva and Toledo (2009) for the US economy as severance payments plus the wasteful separation costs account for roughly 8 weeks of the annual salary of a worker. Silva and Toledo (2009), respectivley Ahr and Ahr (2000) report that turnover costs vary between 25% and 200% of the monthly salary. In this model turnover costs would be at the lower end with roughly 20% accounting for recruitment and wasteful separation costs as well as severance payments.

Compare the business cycle facts from the baseline economy from table 3 to the US business cycle facts in table 1. With the calibration chosen above, we can closely replicate the business cycle properties from the data. Note that a large chunk of the fluctuations is driven by our assumption of the procyclical bargaining power of the firms. Therefore, a lot of these fluctuations must be inefficient, which gives room for the policymaker to intervene.

Table 3: Business Cycle Properties Baseline Model

		v	f	ρ	u	θ	$\bar{h}$	p
Standard Deviation		19.8	14.31	8.2	21.26	40.88	0.76	1.91
Autocorrelation		0.95	0.97	0.97	0.98	0.97	0.97	0.97
	v	1	1	-0.99	-0.98	1	1	1
	f	-	1	-1	-1	1	1	1
	ρ	-	-	1	1	-1	-1	-1
Correlation	u	-	-	-	1	-1	-1	-1
	θ	-	-	-	-	1	1	1
	$\bar{h}$	-	-	-	-	-	1	1
	p	-	-	-	-	-	-	1

Notes: The table reports the second moments of the model. As in the data of Shimer (2005), all variables are quarterly averages of monthly series and reported as log-deviations. p denotes the average output per person, that is $p = E[y_t(\epsilon)|\epsilon \geq \epsilon_{s,t}]$.

Another problem of search and matching models typically is that they cannot simultaneously produce realistic business cycle fluctuations and a realistic elasticity of unemployment with respect to changes of the unemployment insurance (see Costain and Reiter 2008). In order to match the business cycle facts of the data, we would need a small surplus calibration as in Hagedorn and Manovskii (2008). Small movements in productivity result in relatively large movements of the joint surplus leading to an amplification of the job-finding rate. However, this is also true for unemployment benefits resulting in an inflated elasticity. The workaround is wage-rigidity, as in our model, which allows for a large surplus calibration while still matching the business cycle facts. As a result, the model generates a realistic unemployment reaction to the UI system. Costain and Reiter (2008) report that the semi-elasticity of unemployment with respect to the replacement ratio is between 2 and 3.5. The model generates a semi-elasticity of 3.54 in the steady state of the baseline economy, which is still in a reasonable range.

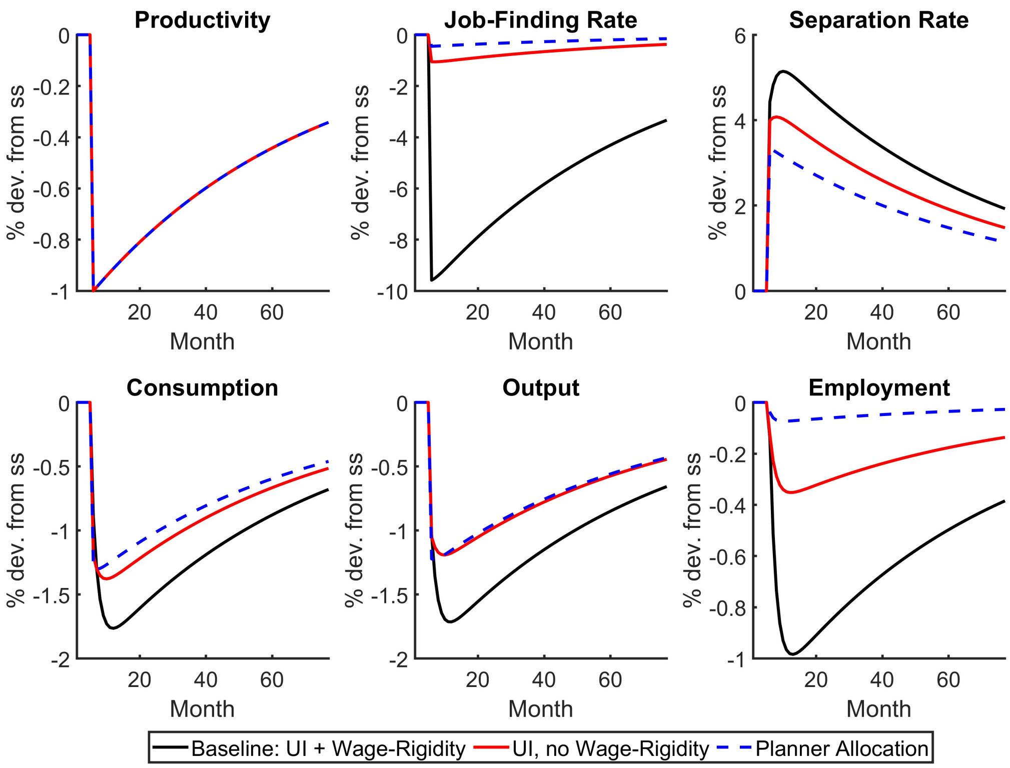
To solve the model, I rely on first-order perturbation using the code of Schmitt-Grohe and Uribe (2004) based on the symbolic toolbox of Matlab.

5 STW Policy in Recessions

5.1 Inefficiencies in the Business Cycle

The business cycle is driven by real productivity shocks. Figure 4 shows the response of the planner economy, an economy with UI system and an economy with both UI system and rigid salaries to a 1% negative aggregate productivity shock. We refer to the economy with UI system and rigid salaries as the baseline economy. Comparing the baseline economy and the economy with the UI system only to the planner allocation will give us a sense of the business cycle's inefficiencies.

Figure 4: Inefficiencies in the Business Cycle



Notes: The figure shows impulse response functions for a 1% negative productivity shock. The black line shows the response of the baseline economy, that is the economy with the moral hazard problems of the UI system and wage-rigidity as inefficiencies but without STW system. The red line shows the reaction of an economy without wage-rigidity but with the moral hazard problems of the UI system. The blue dashed line shows the response of the planner economy.

Generally speaking a reduction in aggregate productivity due to a negative productivity shock reduces the joint surplus of firm-worker matches. As a result, firms will be less willing to pay the vacancy posting costs. The number of vacancies and the job-finding rate fall. Furthermore, the reduced productivity implies that a larger fraction of firms and workers generate a negative surplus, leading to a larger separation rate. A reduction in the job-finding rate combined with

an increase in the separation rate drives down employment. Output and consumption fall mainly due to the reduction of aggregate productivity.
Note that these fluctuations can be efficient to some extent (see Figure 4, blue line). The social planner would also increase separations to get rid of unproductive matches (cleansing effect) or reduce vacancy posting efforts if new workers add less to the output.
However, these fluctuations are inefficiently amplified by the existence of the UI system and rigid salaries.

The fall in the job-finding rate increases the distortionary effects of the UI system (see corollary 4) . Workers need more time to find a new job which drives down the worker's outside option. The UI system can partially offset the effect since increasing the worker's unemployment spell also increases the expected payments from the UI system. This keeps the outside option of the workers and thus wages up, shrinks job postings and inflates separations (see Figure 4, red vs. blue line). Furthermore, increased unemployment drives up the fiscal costs of the UI, forcing the government to increase taxes, amplifying the effect.

Rigid salaries further exacerbate inefficiencies in the business cycle. In a recession, rigid salaries lead to a deviation from the Hosios-condition. Firms secure less form the joint surplus and cut vacancies to save on vacancy posting costs. As a result, the job-finding rate plummets, leading to a large increase in undesirable unemployment and an aggravation of the distortionary effects of the UI system (see Figure 4, black vs. red line).

5.2 Optimal STW Policy

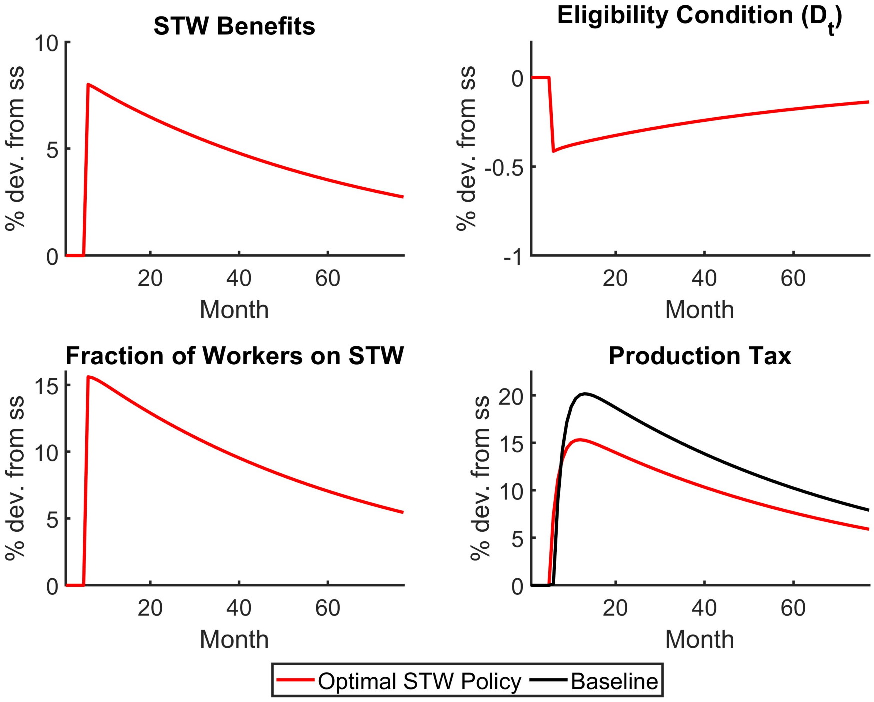
Figure 5 shows the optimal response of the STW system to a 1% negative productivity shock. Figure 6 depicts the reaction of the economy with optimal STW policy and compares it to the reaction of the planner and the baseline economy, already known from Figure 5.

Since STW has minimal influence on the job-finding rate (see proposition 1), the job-finding rate still plummets. To address the growing moral hazard issues of the unemployment insurance (UI) system, the Ramsey planner increases STW benefits[14] (see Figure 5 and corollary 4). This action reduces separations and encourages labor hoarding, stabilizing employment. Notably, the separation rate in this scenario is significantly lower than in the planner economy (see Figure 6, blue vs. red lines) and can even become negative. To offset the negative impact of the job-finding rate's decline on employment, the government needs to oversteer the reduction in separations[15].

[14] In steady state the STW benefits replace roughly 80% of a worker's wage.

[15] These results correspond surprisingly well to what actually happened in the Covid-19 crisis in Germany. Germany significantly increased the generosity of its STW system during the pandemic. Weber and Röttger (2022) find that the separation rate fell even below the level before the crisis. Furthermore, new hires decreased.

Figure 5: Optimal STW Policy - Instruments



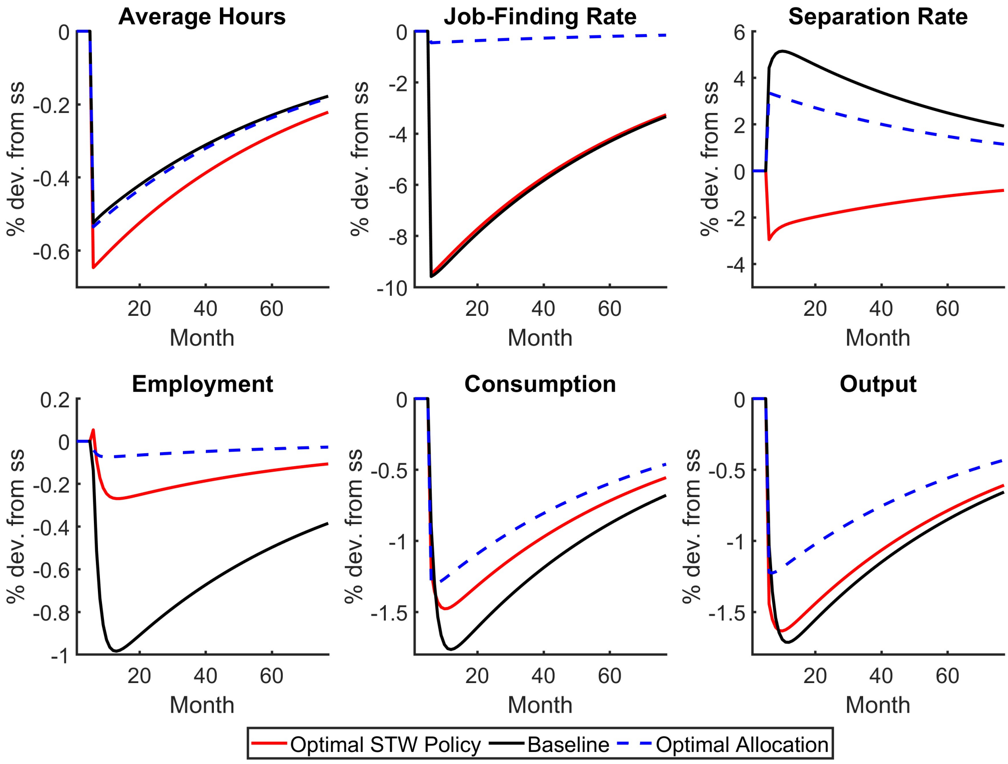
Notes: The figure shows the response of the economy with optimal STW system (red line) to a 1% negative productivity shock, and compares it to the baseline economy (black line) and planner allocation (blue dashed line)

In contrast to commonly applied STW policies, the eligibility condition does not need to be loosened during a recession; in fact, it may need to be tightened [16] (see Figure 5). After a negative productivity shock, the job-finding rate decreases, and workers' unemployment prospects worsen, making it more challenging to find new employment. Consequently, workers are more inclined to stay with their current employer, working fewer hours for a reduced salary This effect dominates the positive effect of a fall in productivity on the eligibility condition Optimal STW policy does not subsidize these marginal matches, as doing so would only increase the distortionary effects of the STW system without reducing the separation rate. Thus, the eligibility condition falls to exclude windfall profits (see corollary 6).

Stabilizing the economy through oversteering the separation rate, increasing STW benefits, and expanding the fraction of workers on STW comes with two costs. First, by keeping unproductive workers employed, STW hinders the cleansing effect of recessions and leads to a further decline in average firm productivity. Second, larger STW benefits and a higher fraction of workers on STW amplify the distortionary effects of the system, destabilizing average hours worked. These factors explain why optimal STW policy has limited effectiveness in stabilizing output.

[16] In steady state workers are eligible to go on STW if hours worked fall more than 10%. Appendix B.1 shows that setting the STW threshold on the separation threshold of firms and workers without access to STW remains optimal.

Figure 6: Optimal STW Policy - Allocation



Notes: The figure shows the optimal response of the STW system (red line) to a 1% negative productivity shock and compares it to the baseline economy (black line).

Fortunately, the impact on consumption is closer to the planner economy. By hoarding labor, STW reduces the need for reallocation of workers via the labor market, resulting in lower costs associated with firing and recruiting workers. Almost 60% of inefficient fluctuations in consumption can be eliminated by STW despite distorting working hours.

One important note for policy makers is that using STW optimally over the business cycle is fiscally not more expensive than a system without STW (see figure 5). Since STW keeps employment stable, it prevents workers from entering the UI system keeping its costs down in recessions (see corollary 3). After the recession, the STW system should revert to its baseline values.

We can conclude that STW can be used to stabilize employment and consumption but not output in recessions. However, its inability to influence the job-finding rate and its distortionary effects prevent it from reaching the planner allocation.

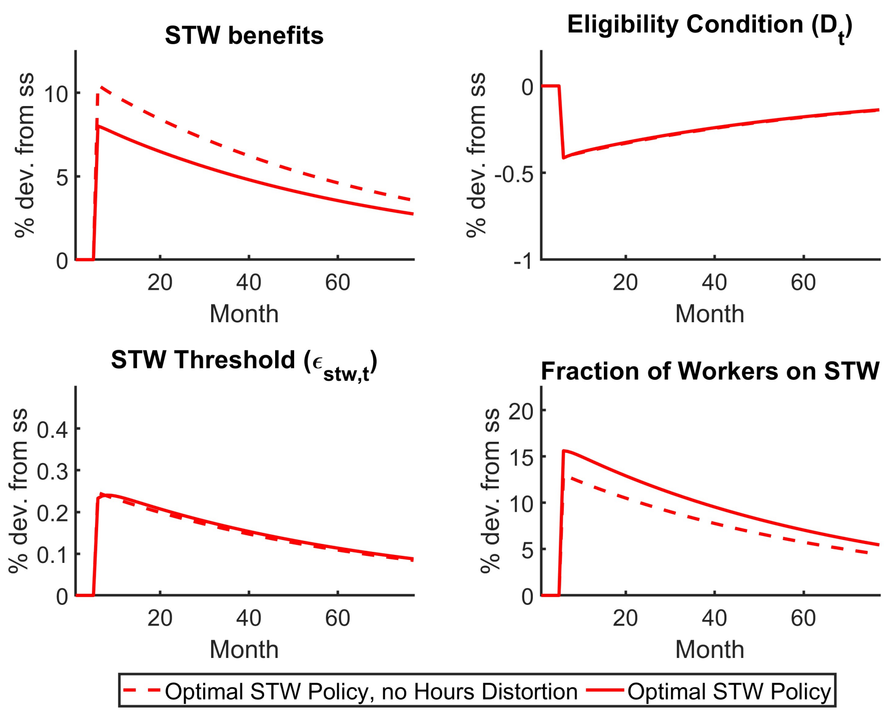
The inability to stabilize the job-finding rate in recessions might seem surprising, particularly given that studies like Balleer et al. (2016) view STW as a tool that could potentially stabilize the job-finding rate. In the model presented here, STW is unable to influence the job-finding rate due to the assumption of budget balance. However, if STW were financed through deficits during recessions, it could potentially influence the value of firms and thus encourage vacancy creation. Despite this possibility, Appendix B shows that even if the Ramsey planner had the option to use STW to affect the job-finding rate, he would choose not to. The reason is that the additional distortionary effects of STW—particularly its impact on working hours and production—would be too costly. These costs would outweigh any potential benefits of stabilizing the job-finding rate, making it an undesirable approach.

5.3 Welfare Costs of STW and Optimal STW Policy Adjustment

Proposition 2 states that the optimal STW benefits depend on two main effects. First, the reason for STW to exist is to offset the distortionary effects of the UI system on separations. The last section discussed its implication for the business cycle extensively. The second part of the formula looks at how the distortionary effects of the STW system influence the optimal provision of benefits. This section investigates its impact on the business cycle.

Figure 7 compares the response of the optimal STW system to a hypothetical STW system that does not distort the hours choice of firms and workers in the economy. I assume that hours on STW are set according to: $h_{stw,t}(\epsilon) = h_t(\epsilon)$. Figure 8 applies it to the core variables in the economy.

Figure 7: Optimal STW Policy, Hours Distortion - Instruments



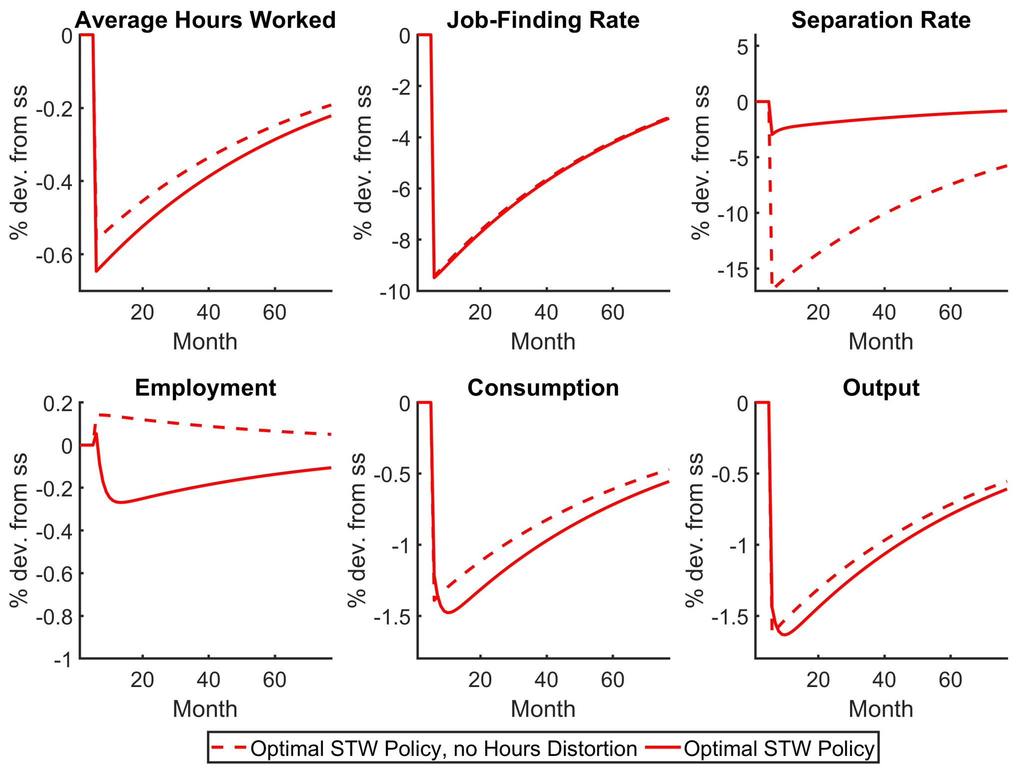
Notes: The figure compares the optimal adjustment of the STW system (solid line) to a hypothetical system without hours distortion (dashed line) to a 1% negative productivity shock.

From corollary 5, we can infer that the distortion of working hours and thus the welfare cost

penalty of STW needs to rise in a recession as the fraction of workers on STW (and the STW threshold [17]) expand. The planner reacts to the growing welfare costs by increasing transfers and thus STW benefits less in recession. This can be seen in figure 7.
The optimal STW benefits represent a trade-off between the distortionary effects of the STW system and the prevention of socially undesirable separations. Without the welfare costs, the planner would reduce separations by more than 15%. However, the welfare costs of STW reduces the optimal response of separations to less than 5% (see figure 8).

We can conclude that the distortionary effects of STW do not only destabilize average hours worked but also reduce the ability of the Ramsey planner to reduce separations. Both effects pull the economy with optimal STW policy away from an economy that can implement the optimal separation rate. Such an economy would bring the consumption response close to the one of the planner, so that the 40% gab in the consumption response between the optimal STW system and the planner economy can be almost entirely attributed to the distortionary effects of STW (see also Figure 11, in the appendix D).

Figure 8: Optimal STW Policy, Influence of Hours Distortion - Allocation



Notes: The figure shows the impulse response function of an economy with optimal STW system (solid line) to a hypothetical system without hours distortion (dashed line) for a 1% negative productivity shock.

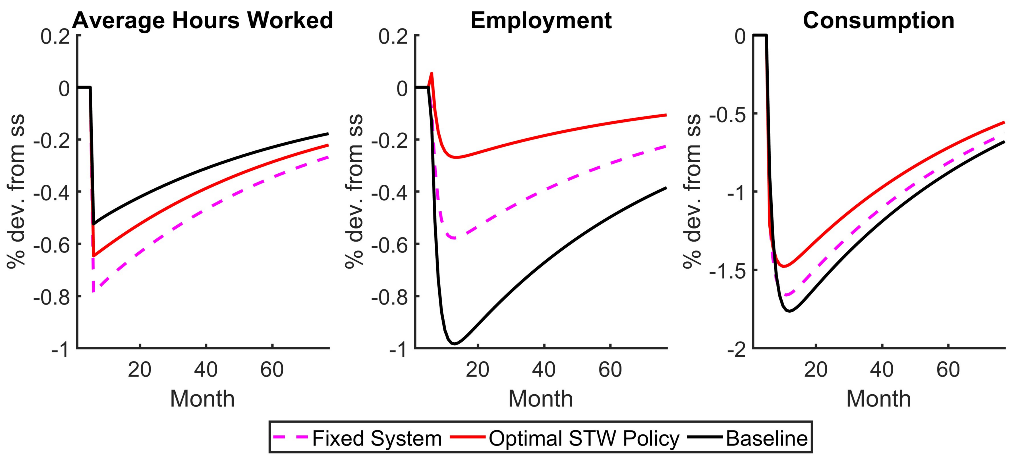
[17]Note that the STW threshold is defined on the idiosyncratic productivity. The eligibility condition is defined on the hours choice. While the eligibility condition falls in a recession, the STW threshold rises. Workers need to reduce their hours more to become eligible for STW but their idiosyncratic productivity part can be higher.

5.4 Fixed STW System

The last sections have shown that optimal STW policy requires the eligibility condition and STW benefits to be adjusted in the business cycle. However, Balleer et al. (2016) argue that STW acts as an automatic stabilizer. Without adjusting the system over the business cycle it can stabilize employment, output and thus consumption. Therefore, the question can be raised, how important a dynamic STW system is for business cycle stabilization.

To answer the question, I implement the optimal STW system in steady state but keep the eligibility condition and STW benefits constant in a recession. Figure 9 shows the results.

Figure 9: Fixed STW System



Notes: The figure shows the impulse response function of an economy with fixed STW system (dashed line, magenta) to the optimal STW system (red line) and the baseline economy for a 1% negative productivity shock. The fixed STW system sets STW optimally in steady state but does not let the system adjust over the business cycle.

Employment is still stabilized compared to the baseline economy. During recessions, firms and workers choose to reduce working hours, enabling them to receive additional STW benefits, which increases the net-transfer to the least productive matches. This mechanism attenuates the decline in the joint surplus of matches, leading to fewer separations.[18] While employment can be stabilized, it is less effectively stabilized than in the optimal case, as benefits cannot be increased to reduce separations during recessions. Interestingly, despite maintaining constant STW benefits, average hours worked decline more in the fixed STW system. Since the government does not tighten the eligibility condition, firms and workers enter STW who could continue working without it. These windfall effects, as mentioned in Cahuc, Kramarz, and Nevoux (2021), exacerbate the distortionary effects of the STW system. Consequently, average hours worked decline even further compared to the economy with an optimal STW system.

[18]Note that the mechanism is different than in Balleer et al. (2016). Their model contains an inflexible intensive margin. STW allows to reduce hours and thus the wage bill. In recessions, firms can therefore reduce hours worked in response to a negative productivity shock. Due to the STW system, they consolidate their wage expenditures and thus stabilize separations.

The combination of less stabilized employment and a destabilization of average hours worked significantly diminishes the STW program's ability to stabilize consumption during recessions. It can close the gab to the optimal STW policy response by only 25%. Thus, compared to the planner economy, only 15% of inefficient volatility in consumption can be prevented compared to the 60% of the optimal STW system. This outcome underscores the importance of a dynamic STW system that can adapt to changing economic conditions.

6 Discussion and Conclusion

In conclusion, the model presented in this paper demonstrates that STW can be a valuable complement to the UI system. While the UI system offers income insurance to workers, the STW system helps mitigate its distortionary effects. STW itself does not provide income insurance. To reduce the distortionary impacts of the UI system during recessions, STW is adjusted by offering more generous benefits and tightening the eligibility condition. This adjustment helps stabilize separations, employment, working hours, and consumption.

Despite its benefits, STW has two main shortcomings that prevent it from fully implementing the planner's solution. First, STW distorts working hours. When setting optimal STW benefits, the planner faces a trade-off between implementing the optimal separation rate and minimizing the distortion of working hours. This makes it crucial to adjust STW over the business cycle. If STW is not adjusted, the distortion of working hours can exacerbate fluctuations, undermining STW's ability to stabilize total working hours.

Second, unlike alluded to in papers like Balleer et al. (2016), Giupponi and Landais (2018) or Cahuc, Kramarz, and Nevoux (2021), STW cannot stabilize the job-finding rate. If STW benefits are financed through a tax on salaries, any increase in STW benefits will be offset by a corresponding increase in the tax rate, nullifying the impact on the joint surplus of firms and workers. Even when considering lump-sum taxes, allowing STW to influence vacancy creation directly, the planner would refrain from stabilizing the job-finding rate, as the additional distortions to working hours would be too costly.

The paper suggests three avenues for further research. First, an intriguing result from the theoretical section is that STW functions similarly to a layoff tax, in the sense of Blanchard and Tirole (2008) and Cahuc and Zylberberg (2008). The key difference, however, is that STW distorts working hours, making it less effective than layoff taxes. Despite this, layoff taxes and STW are fundamentally different instruments: STW is a subsidy, while layoff taxes are a penalty. In the model, their similarity arises because firms are assumed to be never financially constrained, enabling them to offer insurance to workers and pay layoff costs regardless of circumstances. But what if firms do face financial constraints? In such a scenario, STW might provide an insurance component for workers that layoff taxes cannot. Additionally, paying penalties could become unfeasible for financially constrained firms. A comparison of STW and layoff taxes under financial constraints would be a valuable area of exploration.[19]

Second, Cooper, Meyer, and Schott (2017) argue that a major drawback of STW is its potential to reduce allocative efficiency by incentivizing workers to remain in less productive occupations, thereby hindering their reallocation to more productive firms. However, I find that STW can strike a balance between reducing allocative inefficiency and minimizing the costs of reallocating workers through the labor market, effectively leaving no room for allocative inefficiencies. This outcome is based on the assumption that the shock duration is uniform for all workers. But what happens if firms and workers experience shocks of varying durations? Investigating how optimal STW policy would respond to such differences in shock duration could provide new insights in how STW should deal with allocative inefficiencies.[20]

Finally, it remains the question of whether the performance of STW could be enhanced by combining it with other labor market instruments. One significant limitation of STW is its inability to stabilize job-finding rates. It may be advantageous to explore the potential benefits of combining STW with a vacancy subsidy.

[19] Work in progress!

[20] Work in Progress!

References

Ahr, Paul R and Thomas B Ahr (2000). *Overturn Turnover: Why some employees leave, why some employees stay, and ways to keep the ones who you want to stay*. Causeway Publishing Company.

Baily, Martin Neil (1978). "Some aspects of optimal unemployment insurance". In: *Journal of Public Economics* 10.3, pp. 379–402. URL: https://EconPapers.repec.org/RePEc:eee:pubeco:v:10:y:1978:i:3:p:379-402.

Balleer, Almut et al. (2016). "Does short-time work save jobs? A business cycle analysis". In: *European Economic Review* 84.C, pp. 99–122. DOI: 10.1016/j.euroecorev.2015. URL: https://ideas.repec.org/a/eee/eecrev/v84y2016icp99-122.html.

Barnichon, Regis (2010). "Building a composite Help-Wanted Index". In: *Economics Letters* 109.3, pp. 175–178. URL: https://ideas.repec.org/a/eee/ecolet/v109y2010i3p175-178.html.

Blanchard, Olivier J. and Jean Tirole (2008). "The Joint Design of Unemployment Insurance and Employment Protection: A First Pass". In: *Journal of the European Economic Association* 6.1, pp. 45–77. URL: https://ideas.repec.org/a/tpr/jeurec/v6y2008i1p45-77.html.

Braun, Helge and Björn Brügemann (Jan. 2017). *Welfare Effects of Short-Time Compensation*. Tinbergen Institute Discussion Papers 17-010/VI. Tinbergen Institute. URL: https://ideas.repec.org/p/tin/wpaper/20170010.html.

Burdett, Kenneth and Randall Wright (1989). "Unemployment Insurance and Short-Time Compensation: The Effects on Layoffs, Hours per Worker, and Wages". In: *Journal of Political Economy* 97.6, pp. 1479–1496. ISSN: 00223808, 1537534X. URL: http://www.jstor.org/stable/1833249.

Cahuc, Pierre (July 2024). *The Micro and Macro Economics of Short-Time Work*. IZA Discussion Papers 17111. Institute of Labor Economics (IZA). URL: https://ideas.repec.org/p/iza/izadps/dp17111.html.

Cahuc, Pierre, Francis Kramarz, and Sandra Nevoux (May 2021). *The Heterogeneous Impact of Short-Time Work: From Saved Jobs to Windfall Effects*. IZA Discussion Papers 14381. Institute of Labor Economics (IZA). URL: https://ideas.repec.org/p/iza/izadps/dp14381.html.

Cahuc, Pierre and André Zylberberg (2008). "Optimum income taxation and layoff taxes". In: *Journal of Public Economics* 92.10-11, pp. 2003–2019. URL: https://ideas.repec.org/a/eee/pubeco/v92y2008i10-11p2003-2019.html.

Chetty, Raj (2006). "A general formula for the optimal level of social insurance". In: *Journal of Public Economics* 90.10-11, pp. 1879–1901. URL: https://EconPapers.repec.org/RePEc:eee:pubeco:v:90:y:2006:i:10-11:p:1879-1901.

Christoffel, Kai and Tobias Linzert (2010). “The Role of Real Wage Rigidity and Labor Market Frictions for Inflation Persistence”. In: *Journal of Money, Credit and Banking* 42.7, pp. 1435–1446. URL: https://ideas.repec.org/a/mcb/jmoncb/v42y2010i7p1435-1446.html.

Cooper, Russell, Moritz Meyer, and Immo Schott (Aug. 2017). *The Employment and Output Effects of Short-Time Work in Germany*. NBER Working Papers 23688. National Bureau of Economic Research, Inc. URL: https://ideas.repec.org/p/nbr/nberwo/23688.html.

Costain, James S. and Michael Reiter (2008). “Business cycles, unemployment insurance, and the calibration of matching models”. In: *Journal of Economic Dynamics and Control* 32.4, pp. 1120–1155. URL: https://ideas.repec.org/a/eee/dyncon/v32y2008i4p1120-1155.html.

Dengler, Thomas and Britta Gehrke (Apr. 2021). *Short-Time Work and Precautionary Savings*. IZA Discussion Papers 14329. Institute of Labor Economics (IZA). URL: https://ideas.repec.org/p/iza/izadps/dp14329.html.

Domeij, David and Martin Floden (2006). “The Labor-Supply Elasticity and Borrowing Constraints: Why Estimates are Biased”. In: *Review of Economic Dynamics* 9.2, pp. 242–262. DOI: 10.1016/j.red.2005.11.001. URL: https://ideas.repec.org/a/red/issued/v9y2006i2p242-262.html.

Ellguth, Peter, Hans-Dieter Gerner, and Ines Zapf (2018). “Flexible working times become more and more important”. In: *IAB Kurzbericht* 15, p. 8.

Engen, Eric M. and Jonathan Gruber (2001). “Unemployment insurance and precautionary saving”. In: *Journal of Monetary Economics* 47.3, pp. 545–579. URL: https://ideas.repec.org/a/eee/moneco/v47y2001i3p545-579.html.

Fahr, Stephan and Mirko Abbritti (Apr. 2011). *Macroeconomic implications of downward wage rigidities*. Working Paper Series 1321. European Central Bank. URL: https://ideas.repec.org/p/ecb/ecbwps/20111321.html.

Gehrke, Britta, Wolfgang Lechthaler, and Christian Merkl (Apr. 2017). *The German labor market in the Great Recession: Shocks and institutions*. IAB Discussion Paper 201714. Institut für Arbeitsmarkt- und Berufsforschung (IAB), Nürnberg [Institute for Employment Research, Nuremberg, Germany]. URL: https://ideas.repec.org/p/iab/iabdpa/201714.html.

Giupponi, Giulia and Camille Landais (Dec. 2018). *Subsidizing labor hoarding in recessions: the employment and welfare effects of short time work*. CEP Discussion Papers dp1585. Centre for Economic Performance, LSE. URL: https://ideas.repec.org/p/cep/cepdps/dp1585.html.

Haan, Wouter J. den, Garey Ramey, and Joel Watson (2000). “Job Destruction and Propagation of Shocks”. In: *American Economic Review* 90.3, pp. 482–498. DOI: 10.1257/aer.90.3.482. URL: https://www.aeaweb.org/articles?id=10.1257/aer.90.3.482.

Hagedorn, Marcus and Iourii Manovskii (2008). “The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited”. In: *American Economic Review* 98.4, pp. 1692–1706.

DOI: 10.1257/aer.98.4.1692. URL: https://www.aeaweb.org/articles?id=10.1257/aer.98.4.1692.

Hall, Robert E. (2005). "Employment Fluctuations with Equilibrium Wage Stickiness". In: *American Economic Review* 95.1, pp. 50–65. DOI: 10.1257/0002828053828482. URL: https://www.aeaweb.org/articles?id=10.1257/0002828053828482.

Hijzen, Alexander and Sébastien Martin (Mar. 2013). *The Role of Short-Time Work Schemes during the Global Financial Crisis and Early Recovery: A Cross-Country Analysis*. IZA Discussion Papers 7291. Institute of Labor Economics (IZA). URL: https://ideas.repec.org/p/iza/izadps/dp7291.html.

Hopenhayn, Hugo and Juan Pablo Nicolini (1997). "Optimal Unemployment Insurance". In: *Journal of Political Economy* 105.2, pp. 412–38. URL: https://EconPapers.repec.org/RePEc:ucp:jpolec:v:105:y:1997:i:2:p:412-38.

Hosios, Arthur J. (1990). "On the Efficiency of Matching and Related Models of Search and Unemployment". In: *The Review of Economic Studies* 57.2, pp. 279–298. ISSN: 00346527, 1467937X. URL: http://www.jstor.org/stable/2297382.

Jung, Philip and Keith Kuester (2015). "Optimal Labor-Market Policy in Recessions". In: *American Economic Journal: Macroeconomics* 7.2, pp. 124–56. DOI: 10.1257/mac.20130028. URL: https://www.aeaweb.org/articles?id=10.1257/mac.20130028.

Krause, Michael U. and Thomas A. Lubik (2007). "The (ir)relevance of real wage rigidity in the New Keynesian model with search frictions". In: *Journal of Monetary Economics* 54.3, pp. 706–727. URL: https://ideas.repec.org/a/eee/moneco/v54y2007i3p706-727.html.

Kuhn, Moritz et al. (2021). *Warum nutzen Arbeitgeber Kurzarbeit?* URL: https://www.econtribute.de/RePEc/ajk/ajkpbs/ECONtribute_PB_025_2021.pdf.

Landais, Camille, Pascal Michaillat, and Emmanuel Saez (2018). "A Macroeconomic Approach to Optimal Unemployment Insurance: Theory". In: *American Economic Journal: Economic Policy* 10.2, 152–81. DOI: 10.1257/pol.20150088. URL: https://www.aeaweb.org/articles?id=10.1257/pol.20150088.

Michau, Jean-Baptiste (2015). "Optimal labor market policy with search frictions and risk-averse workers". In: *Labour Economics* 35.C, pp. 93–107. DOI: 10.1016/j.labeco.2015.04.. URL: https://ideas.repec.org/a/eee/labeco/v35y2015icp93-107.html.

Mortensen, Dale T. and Christopher A. Pissarides (1994). "Job Creation and Job Destruction in the Theory of Unemployment". In: *Review of Economic Studies* 61.3, pp. 397–415. URL: https://ideas.repec.org/a/oup/restud/v61y1994i3p397-415..html.

Münchner, Thomas (2020). *Kurzarbeitergeld aufstocken: 7 Wege, wie Sie wieder auf 100 Prozent Nettolohn kommen.* [Online; accessed 21-August-2024]. URL: https://www.focus.de/finanzen/steuern/firmenzuschuss-tarifvertrag-nebenjob-kindergeldzuschlag-hartz-iv-kurzarbeitergeld-aufstocken-so-kommen-sie-auf-100-prozent-vom-nettolohn_id_11847867.html.

Petrongolo, Barbara and Christopher A. Pissarides (2001). "Looking into the Black Box: A Survey of the Matching Function". In: *Journal of Economic Literature* 39.2, pp. 390–431. DOI: 10.1257/jel.39.2.390. URL: https://www.aeaweb.org/articles?id=10.1257/jel.39.2.390.

Pissarides, Christopher A. (2000). *Equilibrium Unemployment Theory, 2nd Edition*. Vol. 1. MIT Press Books 0262161877. The MIT Press. ISBN: ARRAY(0x4c025178). URL: https://ideas.repec.org/b/mtp/titles/0262161877.html.

Rosen, Sherwin (June 1985). *Implicit Contracts: A Survey*. NBER Working Papers 1635. National Bureau of Economic Research, Inc. URL: https://ideas.repec.org/p/nbr/nberwo/1635.html.

Schmitt-Grohe, Stephanie and Martin Uribe (2004). "Solving dynamic general equilibrium models using a second-order approximation to the policy function". In: *Journal of Economic Dynamics and Control* 28.4, pp. 755–775. URL: https://ideas.repec.org/a/eee/dyncon/v28y2004i4p755-775.html.

Shavell, Steven and Laurence Weiss (1979). "The Optimal Payment of Unemployment Insurance Benefits over Time". In: *Journal of Political Economy* 87.6, pp. 1347–62. URL: https://EconPapers.repec.org/RePEc:ucp:jpolec:v:87:y:1979:i:6:p:1347-62.

Shimer, Robert (2005). "The Cyclical Behavior of Equilibrium Unemployment and Vacancies". In: *American Economic Review* 95.1, pp. 25–49. URL: https://ideas.repec.org/a/aea/aecrev/v95y2005i1p25-49.html.

Silva, José Ignacio and Manuel Toledo (2009). "Labor Turnover Costs And The Cyclical Behavior Of Vacancies And Unemployment". In: *Macroeconomic Dynamics* 13.S1, pp. 76–96. URL: https://ideas.repec.org/a/cup/macdyn/v13y2009is1p76-96_08.html.

Teichgraeber, Andreas and John Van Reenen (Feb. 2022). *A policy toolkit to increase research and innovation in the European Union*. CEP Discussion Papers dp1832. Centre for Economic Performance, LSE. URL: https://ideas.repec.org/p/cep/cepdps/dp1832.html.

Trigari, Antonella (2006). *The Role of Search Frictions and Bargaining for Inflation Dynamics*. Tech. rep.

Van Audenrode, Marc A (1994). "Short-Time Compensation: Job Security, and Employment Contracts: Evidence from Selected OECD Countries". In: *Journal of Political Economy* 102.1, pp. 76–102. URL: https://EconPapers.repec.org/RePEc:ucp:jpolec:v:102:y:1994:i:1:p:76-102.

Weber, Enzo and Christof Röttger (2022). *Es gab keinen Big Quit in Deutschland*. URL: https://www.oekonomenstimme.org/artikel/2022/06/es-gab-keinen-big-quit-in-deutschland/.

A In greater Detail

Inverse Multiplier M - optimal UI given STW When we alter the surplus for firms and workers, such as by changing UI benefits, we have to consider the feedback effects that these changes induce. The additional welfare costs from posting fewer vacancies (LS) and increased separations (LV) capture the feedback effect in the inverse multiplier M.

$$M = \underbrace{\frac{\gamma - \beta \cdot (\gamma - (1 - (1-\eta) \cdot BE) \cdot \eta \cdot f(\theta)) \cdot (1 - G(\epsilon_s)) + (\gamma - \eta \cdot f(\theta)) \cdot BE \cdot \frac{1-f(\theta)}{1-\eta} \cdot \frac{k_v}{q(\theta)} \cdot \frac{g(\epsilon_s)}{a \cdot h_{stw}(\epsilon_s)^{\alpha} + c_f}}{(1-\eta) \cdot (1-\gamma) \cdot m(\theta) \cdot u'(\tilde{c}^w)}}_{\text{regular multiplier effect}}$$
$$- \underbrace{\frac{\beta \cdot (1 - G(\epsilon_s))}{1 - \beta \cdot (1 - f(\theta)) \cdot (1 - G(\epsilon_s))} \cdot \frac{\beta \cdot (1 + \eta \cdot BE) \cdot \lambda_\theta}{n \cdot u'(\tilde{c}^w)} \cdot \frac{b}{n} / \frac{k_v}{q(\theta)}}_{\text{tax effect via vacancy posting}}$$
$$- \underbrace{\frac{n \cdot (\gamma - \eta \cdot f(\theta))}{(1-\eta) \cdot (1-\gamma) \cdot m(\theta)} \cdot \frac{\beta \cdot (1 - G(\epsilon_s))}{1 - \beta \cdot (1 - f(\theta)) \cdot (1 - G(\epsilon_s))} \cdot \frac{\beta \cdot (1 + \eta \cdot BE)}{n \cdot u'(\tilde{c}^w)} \cdot \left(\frac{b}{n} - \tau_{stw} \cdot (\bar{h} - h_{stw}(\epsilon_s))\right)}_{\text{tax effect via separations}}$$

The feedback effects can be divided into three channels, which can be illustrated by considering an increase in UI benefits. The first channel is the regular channel, where an increase in UI benefits depresses the joint surplus of firms and workers, not only in the present but also in the future.

The second channel emerges through the free entry condition. As the joint surplus declines, firms reduce vacancy postings. This reduction leads to higher unemployment, which, in turn, increases the fiscal burden of the UI system. To cover these additional costs, higher income taxes are required, which further depresses the joint surplus, thereby amplifying the initial impact.

Finally, the third channel arises through the separation condition. A decrease in the joint surplus increases the separation rate, as the continuation value of the match between firms and workers diminishes. More separations result in higher unemployment, which once again raises the costs of the UI system, leading to the need for higher taxes. This creates a reinforcing loop that further reduces the joint surplus of firms and workers.

It's important to note that the last effect is mitigated by the STW system. Larger STW benefits reduce separation incentives, thereby lowering the number of workers entering the UI system. As a result, the increase in unemployment is smaller, which in turn lessens the distortionary tax effect caused by the UI system. STW itself has a neutral impact on the joint surplus of firms and workers. On one hand, an increase in STW benefits raises the joint surplus through the subsidy effect. On the other hand, this increase is offset by the need to raise taxes to finance the system, which decreases the joint surplus. Ultimately, these two effects cancel each other out.

In the following, I require the inverse multiplier to be positive $M > 0$. Otherwise, the model would not converge to its steady state.

The bargaining effect As described in the main text, the bargaining effect illustrates how STW influences vacancy posting and separation behavior of firms via the wage channel. Diminishing returns to consumption, makes it harder for firms to reduce wages. However, the introduction of STW necessitates wage reductions to offset firms' losses during downturns. These adjustments are imperfect, resulting in relatively high wages, which, in turn, leads to fewer vacancies being posted and an increase in separations. Mathematically, this effect can be expressed as:

$$\tilde{BE} = \frac{\frac{BE \cdot \lambda_\theta}{n \cdot u'(\tilde{c}^w)}}{1 + \frac{\beta \cdot (1+\eta \cdot BE) \cdot \lambda_\theta}{n \cdot u'(\tilde{c}^w)}} \cdot \frac{1 - f(\theta)}{1-\eta} \cdot \frac{k_v}{q(\theta)}$$

with

$$\lambda_\theta = LV + LS + LSTW$$

and

$$BE = \frac{\left(-\frac{u''(\tilde{c}^w)}{u'(\tilde{c}^w)}\right) \cdot \frac{u(\tilde{c}^w) - u(b)}{u'(\tilde{c}^w)}}{1 + (1-\eta) \cdot \left(-\frac{u''(\tilde{c}^w)}{u'(\tilde{c}^w)}\right) \cdot \frac{u(\tilde{c}^w) - u(b)}{u'(\tilde{c}^w)}} < \frac{1}{1-\eta}$$

Note that λ_θ captures the effect of the wage channel on vacancy posting (LV) and separations (LS). Additionally, the wage channel also impacts the eligibility condition for STW ($LSTW$). The imperfect reduction in wages leads to more separations not only in firms utilizing STW but also in those without access to STW. To mitigate the additional loss of these matches, a looser eligibility condition must be implemented, increasing the hours distortion effects of STW.

BE captures the effect of risk aversion. Under risk-aversion BE must be positive as:

$$\text{risk-aversion} \quad \Rightarrow \quad -u''(\tilde{c}_t^w) > 0$$

Note that the bargaining effect is zero under risk-neutrality:

$$\text{risk-neutrality} \quad \Rightarrow \quad u''(\tilde{c}_t^w) = 0 \quad \Rightarrow \quad BE = 0 \quad \Rightarrow \quad \tilde{BE} = 0$$

Inverse Multiplier M - optimal combination of STW and UI The inverse multiplier changes with an optimally set STW system.

$$
\begin{aligned}
M' = & \underbrace{\frac{\gamma - \beta \cdot (\gamma - (1-(1-\eta)\cdot BE)\cdot \eta \cdot f(\theta)) \cdot (1-G(\epsilon_s))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)\cdot u'(\tilde{c}^w)}}_{\text{regular multiplier effect}} \\
& - \underbrace{\frac{\beta \cdot (1-G(\epsilon_s))}{1-\beta\cdot(1-f(\theta))\cdot(1-G(\epsilon_s))} \cdot \frac{\beta\cdot(1+\eta\cdot BE)}{n\cdot u'(\tilde{c}^w)} \cdot \frac{b}{n} / \frac{k_v}{q(\theta)}}_{\text{tax effect via vacancy posting}} \\
& - \underbrace{\frac{n\cdot(\gamma-\eta\cdot f(\theta))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)} \cdot \frac{\beta\cdot(1+\eta\cdot BE)}{n\cdot u'(\tilde{c}^w)} \cdot \frac{\partial \Omega}{\partial \tau_{stw}} / \left(\bar{h} - h_{stw}(\epsilon_s)\right)}_{\text{amplification over reaction of STW beneftis}} \\
& - \underbrace{\frac{n\cdot(\gamma-\eta\cdot f(\theta))}{(1-\eta)\cdot(1-\gamma)\cdot m(\theta)} \cdot \frac{\beta\cdot(1+\eta\cdot BE)}{n\cdot u'(\tilde{c}^w)} \cdot \frac{\partial \Omega}{\partial \epsilon_{stw}} / \left(a \cdot h(\epsilon_{stw})^{\alpha} + c_f\right)}_{\text{amplification over reaction of eligibility condition}}
\end{aligned}
$$

The regular channel and the influence of vacancy posting on the cost of the UI system remain largely unchanged. However, the separation channel now accounts for the reaction of the STW system. When UI benefits increase, the joint surplus of firms and workers decreases, leading to a higher separation rate. In response, the STW system offers more generous benefits, but these benefits distort working hours, thereby reducing production. The subsidy effect of STW is effectively nullified by the corresponding increase in taxes, further decreasing the joint surplus of firms and workers.

Not only does the separation rate rise for firms with access to STW, but it also increases for firms without access to STW. As a result, the eligibility conditions must be loosened, spreading the distortionary effects of reduced working hours across more firms. This, similar to an increase in STW benefits, leads to a decline in production, which in turn reduces the joint surplus of firms and workers.

Again the paper assumes the inverse multiplier to be positive to guarantee convergence of the steady state.

B Optimal STW Policy with Lump Sum Tax

The paper has highlighted one of the core problems of STW programs, namely its inability to stabilize the job-finding rate, next to its distortionary effects. In contrast, other authors such as Balleer (2016), Giupponi and Landais (2018) or Cahuc, Kramarz, and Nevoux (2021) suggest that STW plays a role in creating vacancies and increasing the job-finding rate. They argue that STW increases the expected value of firms, thereby providing an incentive to post more vacancies. However, in this model, any increase in the joint surplus of firms and workers resulting from higher expected STW benefits is offset by an increase in the production tax. Consequently, there is no direct impact on vacancy posting.

While this assumption holds in the long run, governments may choose to borrow in the short run to avoid raising taxes during recessions. Therefore, an expansion of the STW system financed by a deficit might help stabilize the job-finding rate.

To explore this conjecture, I replace the production tax with a lump-sum tax on all households, assume risk neutrality, and allow the UI system to be set exogenously. The advantage of using a lump-sum tax, particularly in combination with risk neutrality, is that it does not distort the behavior of firms and workers. Consequently, adjusting taxes over the business cycle does not distort decisions in the economy. By increasing the subsidy value, the government can now stimulate the expected joint surplus, thus encouraging vacancy creation.

Proposition 5 shows the optimal eligibility condition in an economy with lump sum tax. When determining the eligibility condition, the government faces a new trade-off, as outlined in equation B.2. On the one hand, a looser eligibility condition increases the probability that a firm can take up the STW program. As a result, its expected benefit from the STW system rises, increasing the firm's value. This increases vacancy posting incentives and potentially depressed job-finding rates and decreases inflated separation rates. On the other hand, loosening the eligibility condition extends the distortionary effect on working hours to a larger number of firms and exacerbates the welfare costs of the STW system.

Quantitatively, the analysis reveals that the additional distortion in working hours associated with STW outweigh the additional utility of posting more vacancies and reducing separations from a looser eligibility condition in all relevant states of the model (see Appendix B.2). As in the economy without a lump sum tax (as stated in Proposition 2), the planner chooses not to stabilize the job-finding rate through the eligibility condition and implements the no-windfall profit condition. The optimal STW threshold is determined by the optimal separation threshold of firms and workers without access to STW.

If the distortionary effects of STW did not dominate the additional welfare from posting more vacancies, the optimal STW threshold would be determined by carefully weighing the additional welfare costs of a looser eligibility condition against the extra welfare gained from increased vacancy posting and reduced separations.

Proposition 5, Optimal Eligibility Condition in Steady-State - Lump Sum Tax
Consider the economy described in section 2.1. and replace the production tax by a lump sum tax. Further, assume that the economy has converged to its non-stastic steady state. Then, the optimal eligibility condition $D = h(\epsilon_{stw})$ is implicitly defined by the separation threshold of a firm without STW

$$\underbrace{S(\epsilon_{stw}) = y(\epsilon_{stw}) - v\left(h(\epsilon_{stw})\right) + F + \frac{1-\eta \cdot f}{1-\eta} \cdot \frac{k_v}{q} = 0}_{\text{Joint Surplus without STW is zero}} \tag{B.1}$$

as long as the welfare costs of a looser eligibility outweighs its welfare gains:

$$\underbrace{n \cdot \frac{\partial \Omega}{\partial \epsilon_{stw}}}_{\text{Welfare Costs}} \geq \underbrace{(LV' + LS') \cdot \Big[z_{stw,t}(\epsilon_{stw,t}) + \Big(\bar{h} - h_{stw}(\epsilon_{stw})\Big) \cdot \tau_{stw} - z_t(\epsilon_{stw,t})\Big] \cdot g(\epsilon_{stw})}_{\text{Welfare Gains}} \tag{B.2}$$

The additional welfare costs of posting less vacancy (LV) and creating more separations (LS) can be denotes as

$$LV' = \underbrace{\frac{1}{M} \cdot \frac{\eta - \gamma}{(1-\eta)}}_{\text{Congestion Externality}} + \underbrace{\frac{1}{M} \cdot \frac{b - \int_{\epsilon_s}^{\epsilon_{stw}} (\bar{h} - h_{stw}(\epsilon)) \cdot \tau_{stw} dG(\epsilon)}{1 - \beta \cdot (1 - G(\epsilon_s)) \cdot (1-f)} \Big/ \frac{1}{1-\gamma} \frac{k_v}{q}}_{\text{Fiscal Externality UI}}$$

$$LS' = \underbrace{\frac{\beta}{M} \cdot \frac{1-\eta}{\psi} \cdot (\gamma - f \cdot \eta) \cdot \left(\frac{\partial \Omega}{\partial \tau_{stw,t}} + \frac{\partial \Omega}{\partial \epsilon_{stw,t}}\right)}_{\text{STW cannot combat all inefficient separations due to hours distortions}}$$

with inverse multiplier M:

$$M = \frac{1}{(1-\eta) \cdot f \cdot u} \cdot [\gamma - \beta \cdot (\gamma - \eta \cdot f) \cdot (1 - G(\epsilon_s))] - \frac{1}{u} \cdot \left(\frac{\partial \Omega}{\partial \tau_{stw}} \cdot \frac{\partial \tau_{stw}}{\partial \theta} + \frac{\partial \Omega}{\partial \epsilon_{stw}} \cdot \frac{\partial \epsilon_{stw}}{\partial \theta}\right)$$

otherwise equation B.2 holds with equality.

PROOF: *Appendix E*

Proposition 6 establishes the optimal STW benefits under lump-sum taxes. In contrast to the previous section, the Ramsey planner's objective is to implement the optimal expected net-transfer of the STW system, as indicated by equation B.3. This means that the full transfer does not necessarily need to occur within the same period. In the absence of a production tax, the STW system does not only operate by increasing the period surplus but also by raising the expected surplus of firms and workers.
The optimal expected net-transfer depends on three factors (see equation B.4). Similar to proposition 2, the expected net-tansfer should pay workers the unemployment benefits they would forgo when staying employed (A) minus a penalty for the welfare costs of using the STW

system (B). Different to proposition 2, larger STW benefits can now increase the expected value of firms, stimulating vacancy posting and lessening separations even more. Therefore, the planner adjusts the STW benefits upwards (C). The Ramsey planner weighs the benefits of reducing inefficient separations and increasing suboptimal low vacancy posting efforts against the additional distortions introduced by STW into the economy.

Proposition 6, Optimal STW Subsidy in Steady State - Lump Sum Tax

Consider the economy described in section 2.1 and replace the production tax by a lump sum tax. Further, assume that the economy has converged to its non-stochastic steady state and the eligibility condition is set according to proposition 1B. Then, the optimal STW subsidy τ_{stw} *is implicitly determined by the optimal expected net-transfer* τ_{stw}^{net}*:*

$$\tau_{stw}^{net} = (\bar{h} - h_{stw}(\epsilon_s)) \cdot \tau_{stw} + \frac{\beta \cdot (1-f)}{1 - \beta \cdot (1 - G(\epsilon_s)) \cdot (1-f)} \cdot \int_{\epsilon_s}^{\epsilon_{stw}} (\bar{h} - h_{stw}(\epsilon)) \cdot \tau_{stw} dG(\epsilon) \quad \text{(B.3)}$$

The optimal expected net-transfer τ_{stw}^{net} is determined by:

$$\tau_{stw}^{net} = \underbrace{\frac{\beta \cdot (1-f)}{1 - \beta \cdot (1 - G(\epsilon_s)) \cdot (1-f)} \cdot b}_{\text{A: Influence Distortionary Effect UI on Separations} > 0} - \underbrace{\frac{1}{g(\epsilon_s)} \cdot \frac{\partial \Omega}{\partial \tau_{stw}} / \frac{\partial \epsilon_s}{\partial \tau_{stw}}}_{\text{B: welfare costs Penalty STW } \Gamma_\Omega > 0}$$

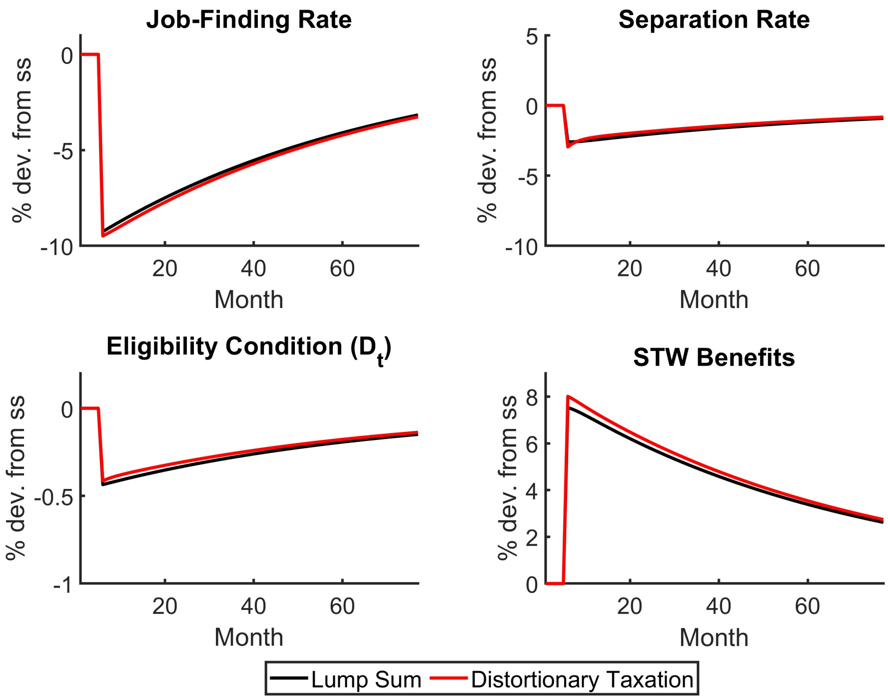
$$+ \underbrace{\frac{1}{g(\epsilon_s)} \cdot (LV' + LS') \cdot \int_{\epsilon_s}^{\epsilon_{stw}} \left(\bar{h} - h_{stw}(\epsilon)\right) dG(\epsilon) / \frac{\partial \epsilon_s}{\partial \tau_{stw}}}_{\text{C: STW increases depressed Vacancy Posting}} \quad \text{(B.4)}$$

PROOF: *Appendix E*

Since the eligibility condition implements the no-windfall effect condition and costs from the distortionary effects of the STW system rise fast compared to the ability of the government to stimulate vacancy posting with STW, we will see that the government makes quantitatively no use of its ability to stimulate vacancy postings by STW.

Using the same parameters as for the economy with distortionary taxation, I find that the planner decides against stabilizing the job-finding rate with STW (Figure 10). Responses are very similar to the economy with distortionary taxation. As a result, we can conclude that the distortionary effects of STW prevent STW from stabilizing the job-finding rate. It should only be used as an instrument to stabilize the separation rate.

Figure 10: Optimal STW Policy, Lump Sum vs Distortionary Taxation



Notes: The Figure shows the impulse response functions of a 1% negative productivity shock. It compares the response of the economy with optimal STW policy financed by a production tax (red line) against its replacement with a lump sum tax on households (black line).

C Optimal Lay-Off tax

The paper examines the optimal design of STW policy. In Proposition 7, the same model from Section 2 is employed, but with one modification: the STW system is replaced by a lay-off tax. Under this system, firms are required to pay a fee to the government when they lay off a worker. The revenue from the tax can be used to finance the UI system. Proposition 7 derives the optimal layoff tax, showing that it is used to mitigate the fiscal externality of the UI system. From the expression for the optimal layoff tax, we can deduce that STW functions similarly to a layoff tax within the model.

Proposition 7, Optimal STW benefits in steady state
Consider the economy as previously descried. Assume that it has converged to its non-stochastic steady state. Then, the optimal lay-off tax p is determined by:

$$p = \underbrace{\frac{\beta \cdot (1-f)}{1-\beta \cdot (1-G(\epsilon_s)) \cdot (1-f)} \cdot \left[b + \frac{1-n}{n} \cdot b \right]}_{\text{A: Fiscal Externality UI } > \ 0} - \underbrace{\tilde{BE}}_{C\text{: Bargaining Effect}}$$

PROOF?

The key distinction between STW and layoff taxes in the model is that layoff taxes do not distort working hours. This difference is reflected in the comparison between the optimal layoff tax and the optimal net transfer of STW benefits (as discussed in Proposition 2 versus Proposition 7). The planner reduces the optimal STW benefits to minimize the distortionary effects associated with the STW system. As a result, we can conclude that, within the model, layoff taxes are superior to STW benefits due to their ability to avoid these distortions.

However, STW and layoff taxes are fundamentally different instruments—STW functions as a subsidy, while layoff taxes operate as a penalty. Given this, one might wonder how they can lead to similar outcomes within the model. There are two main reasons for this.

First, both STW and layoff taxes do not directly influence the job-finding rate. The budget constraint for the economy with STW system is:

$$n_t \cdot \tau_{J,t} = (1-n_t) \cdot b_t + n_t \cdot \int_{\epsilon_{s,t}}^{\epsilon_{stw,t}} \tau_{stw,t} \cdot \left(\bar{h} - h_{stw,t}(\epsilon)\right) \cdot dG(\epsilon)$$

The budget constraint for the economy with layoff tax is:

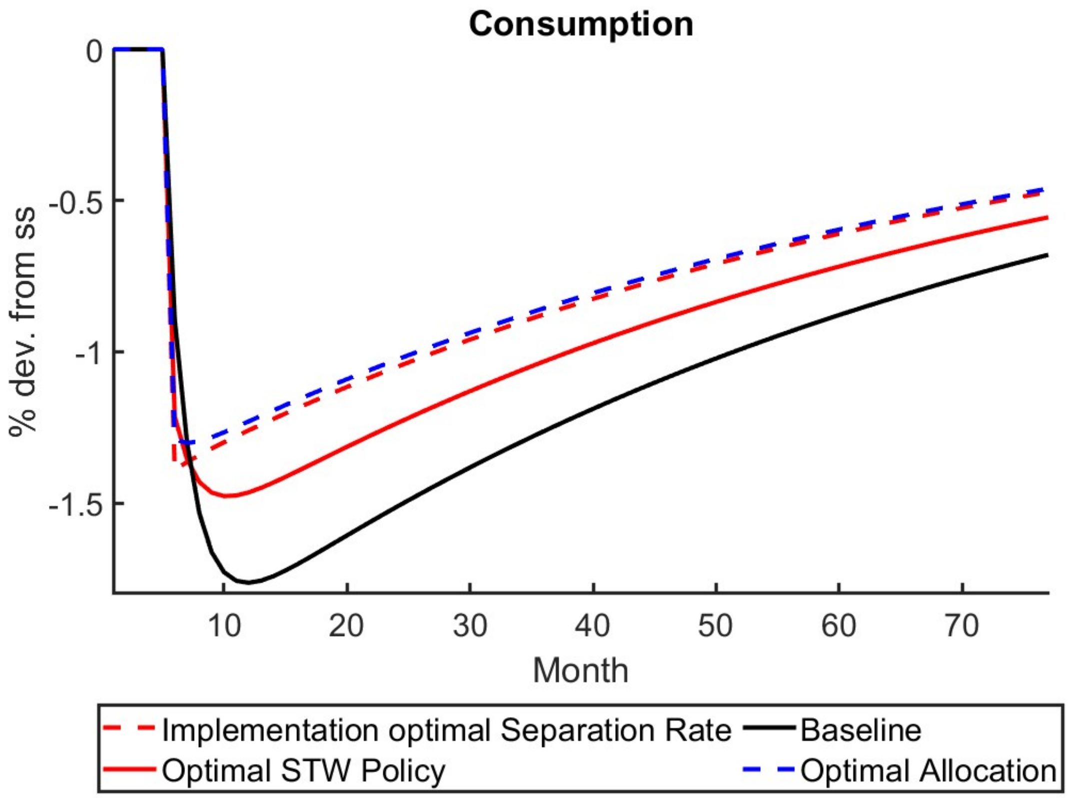
$$n_t \cdot \tau_{J,t} = (1-n_t) \cdot b_t - n_t \cdot \rho_t \cdot p_t$$

Increasing the generosity of STW can enhance the joint surplus of firms and workers; however, the subsequent rise in income taxes required to finance the STW system counteracts this benefit. Conversely, raising the layoff tax reduces the joint surplus of firms and workers. Nevertheless, this increase in the layoff tax also lowers the amount of income taxes needed to fund the UI system, which offsets the negative impact of the layoff tax on the joint surplus. If the surplus is not altered, job-finding rates do not alter.

Second, firms in the model are assumed to be never financially constrained, which allows them to offer insurance to workers and pay layoff costs regardless of their financial situation. This is a key reason why STW is seen as a tool to mitigate the fiscal externality of the UI system rather than as a means of providing direct income insurance. However, if we consider a scenario where firms are financially constrained, the dynamics could change significantly. In this case, STW can provide income insurance also on the firm. At the same time, firms might not be able to cover layoff taxes. A comparison of STW and layoff taxes in such circumstances would be interesting.

D Additional Figures

Figure 11: Closing Gap to Optimal Consumption Response



E Derivations

Derivations are very lengthy and therefore not included in this version. If you are interested, feel free to contact me!