Short-Time Work and the Unemployment Scar*

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Abstract

Short-time work (STW) is a policy tool which subsidizes employment during recessions. I assess its welfare effects, who benefits most from it, and whether it is suitable as an automatic stabilizer. For this purpose, I develop a heterogeneous agents model in which the income process is generated by a job ladder search and matching model. I calibrate the model to match the German labor market around the Great Recession. Key parameters governing the value a worker generates after entering STW are estimated using German social security data in combination with a survey on the use of STW. The welfare effect of a worker entering STW instead of becoming unemployed is about one third of her yearly output. Workers at the peak of their careers benefit most as they stand to lose job- and firm-specific knowledge, as well as the high wages they negotiated in the past. I find that the effectiveness of STW depends on the type of crisis an economy undergoes. STW is less beneficial if the crisis is driven by a structural change, if financial markets are healthy such that few firms are affected by borrowing constraints, or if low wage workers with little firm and task specific human capital are affected. As a consequence, its usefulness varies from crisis to crisis, and it is ill-suited as an automatic stabilizer.

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1 Introduction

Short-Time Work (STW) is a policy tool which subsidizes employment during recessions in order to keep matches between employers and employees alive. Firms reduce the number of hours for which they employ their workers, and part of the lost wages is replaced by the government. Instead of one worker remaining employed, and one worker being laid off, two workers only work half the time.

STW is an important policy tool. Japan, France, Germany, Spain, and Italy all expanded their STW policies in response to the great financial crisis and relied heavily upon it during the COVID crisis. In the US, STW was suggested as a policy option (von Wachter, 2021), but no large-scale STW policy was introduced.[1]

This paper evaluates the welfare effects of STW. These are large and positive, high-income workers benefit the most, and STW is especially useful in temporary crisis that affect high human capital workers and are accompanied by credit frictions. To arrive at these results, I proceed in four steps. First, I combine a heterogeneous agents model with a job ladder search and matching model with human capital. Second, I estimate key model parameters using social security data and a firm-level survey on the use of STW. Third, I calibrate the model to describe Germany at the time of the great financial crisis. Fourth, I consider the counterfactual in which no STW policy was implemented in Germany, and vary parameters that are likely to differ from crisis to crisis.

My paper contributes to a small but growing literature on the consequences of STW. It is the first to allow for differences in wealth, human capital, and job-to-job transitions jointly. For this purpose, I develop a setup in which a heterogeneous agents model for which the income process is generated by a job ladder model is simple to solve. To my knowledge, the only other paper to study STW in the presence of human capital and job-to-job transitions is Tilly and Niedermayer (2016). My approach diverges both in terms of model and empirics. I am able to capture re-distributive effects and heterogeneity more accurately because I consider savings. I also utilize data for much larger population within Germany.

The welfare effects of STW are large, because it affects a large number of people. Figure

[1]Short-time compensation, which is the US version of STW, exists, but is less generous and affects a far smaller share of the working population.

1 depicts the unemployment rate in Germany (yellow), one of the countries with the most longstanding STW policies, and in the US (blue), where STW is hardly used. During the last two crises the unemployment rate in the US rose rapidly, while the one in Germany hardly moved in comparison. When adding the number of workers in STW to the number of unemployed workers in Germany (green line) we can make two observations. First, the number of people in STW reacts strongly to both crisis. During the financial crisis 3.6% of the working population were in STW, while during the COVID crisis more than 10% were short time workers. Second, the change in the share of people in STW can account for virtually the entire difference between the reaction of unemployment in the US and Germany.[2]

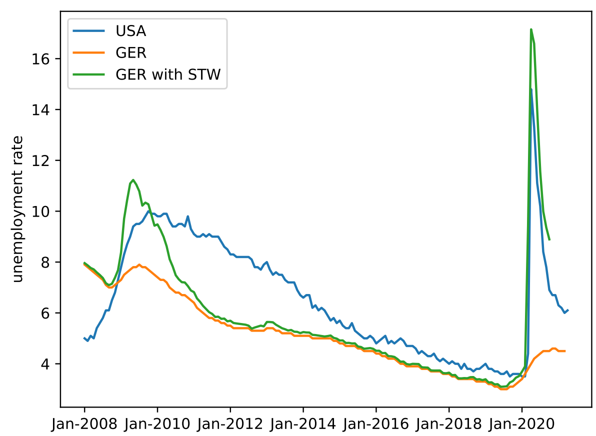

Figure 1: Unemployment and Short-Time work in Germany and the US

Notes: Unemployment rate in the US (blue), and Germany (yellow), and the number of unemployed workers plus the number of workers in STW in Germany (green). Souces: Statistik der Bundesagentur für Arbeit, Tabellen, Realisierte Kurzarbeit (hochgerechnet) (Monatszahlen), Nürnberg, Mai 2021; OECD, Short-Term Labour Market Statistics.

This observations becomes even more striking, when we consider the large and persistent consequences of job-loss, the so-called unemployment scar. Labor earnings drop sharply and, on average, never fully recover.[3] If STW prevents this drop in earnings, it has potentially important welfare effects. In addition, a significant part of the drop in earnings is attributed to human capital losses during unemployment (Lachowska et al.,

[2]This observation is not specific to the US and Germany. Similar patterns have been recognized across countries and regions (Boeri et al., 2011; Giupponi et al., 2022).

[3]See Jarosch (2021) for the German unemployment scar

2020; Burdett et al., 2020). If STW can prevent part of those, welfare effects are even more substantial.

Model. My model consists of two components. First, to account for the heterogeneous effects of STW, the household side of the model consists of a typical heterogeneous agents model with savings and a credit constraint. In such a model, a worker's earnings history matters for her asset level. Second, to account for the effects of STW on the economy as a whole, a worker's income process is generated by a search and matching labor market model (SAM). I augment the SAM with a job ladder component and human capital to account for the severe and long-lasting income losses following unemployment.

The frictions I add to the model aim to capture the insights of recent empirical work on STW and key general equilibrium effects. First, financing STW is costly as taxation reduces firms' incentives to post vacancies. In equilibrium, this shifts the balance between congestion and thick market externalities, which determine efficiency in search and matching models in an unfavorable way. Second, STW saves potentially valuable matches which would otherwise be lost because of wage-setting frictions or credit constraints. This is in line with recent empirical evidence by Giupponi et al. (2022) that STW is most effective when these types of frictions are present.[4] Third, credit constraints on workers ensure that while workers can save to insure themselves against future job loss, this insurance is imperfect. Consequently, past income matters for how much worse off a worker is after losing their job, as they neither simply consume what they earn nor fully insure themselves against job loss.

Calibration. In my model, STW may be beneficial because the subsidy preserves matches that are productive in the future. Depending on the calibration, STW may also be detrimental because the subsidy prevents matches that produce little in the future from splitting. Which of the two is the case depends on whether a worker's output is higher after entering unemployment or after entering STW. This is governed by (a) the time it takes for an unemployed worker to find a job, (b) the human capital loss in unemployment, (c) the human capital loss during STW, and (d) whether short-time workers return to their

[4] Further, Jäger et al. (2019) are able to test whether separations between workers and firms are efficient. They find that this is not the case and identify collective bargaining as one of the causes. In addition, Giroud and Mueller (2016) point towards the relevance of credit frictions during the financial crisis and suggest employment policies targeting firms as a solution.

previous jobs, or simply become unemployed at a later point in time. Finally, (e) the time a worker spends in STW is also important.

In order to describe (a) and (b), I match the unemployment scar as identified by Jarosch (2021) and make alternative assumptions about the role of human capital to reflect different views in the literature. In order to understand (c) and (d), I utilize German social security data in conjunction with a firm-level survey on the use of STW and compare workers in firms that rely heavily on STW to workers in firms that do not. The evidence indicates that workers in STW lose little human capital and are barely more likely to become unemployed. In order to describe (e), I measure the exit rate out of STW.

Results. I consider a situation in which 1% of the labor force transition from employment in a productive match to employment in an unproductive match. With STW the 1% enter short-time work until either their job transitions to its productive state or they become unemployed. Without STW the 1% become unemployed, until they find a new job.[5][6]

I find that STW has substantial positive welfare effects. In the baseline scenario, STW generates a windfall gain of 0.72% of GDP. If one worker enters STW instead of becoming unemployed, the welfare gain from STW corresponds to about two-thirds of her yearly output. The effect remains substantial if the loss of human capital in STW is more comparable to the loss of human capital in unemployment, a smaller part of the unemployment scar is due to human capital, or some workers get recalled to their previous jobs from unemployment (Fujita and Moscarini, 2017). In my preferred scenario, credit and wage-setting frictions are less widespread. Even without STW, only one in four workers whose job is affected by the crisis would be laid off. In this setting, the welfare effect of STW is 0.37% of GDP per 1% of the working population kept in employment.

The biggest winners of STW are workers with high human capital at the peak of their career. STW prevents them from losing their human capital, and the high wages they were able to negotiate in the past. This result highlights that STW cannot be thought of as a

[5] I add a robustness test in which firms that are not constraint utilize STW as well. This is, however, consistent with the observation that STW is strongly correlated with a lower increase in unemployment, empirical findings that the moral hazard costs of STW is low (Kopp and Siegenthaler, 2021; Giupponi and Landais, 2018; Giupponi et al., 2022), and the idea that the number of workers laid off because of the recession is large relative to the number of workers that would be laid of in a stable economic environment.

[6] I choose not to compare STW to an expansion of unemployment benefits since Germany experienced a strong decline in the unemployment rate after it reduced the generosity of its unemployment benefits in the early 2000s. As a consequence such a policy would likely not be welfare enhancing.

close substitute to unemployment insurance, as it targets wealthy workers at the peak of their careers instead of low wage workers with less stable jobs.

I find that STW is not well suited as an automatic stabilizer. This is because the effectiveness of STW varies with factors that are likely different from crisis to crisis. First, STW is less beneficial if a shock is structural such that it delays rather than prevents unemployment. Second, STW is less beneficial if a crisis is not accompanied by a credit crunch such that few firms face credit frictions, and productive matches would survive even without STW. Third, STW is less beneficial if the crisis affects workers who do not stand to lose human capital or high wages. Government policy can accomodate these insights by introducing a less generous STW scheme and expanding it in crisis in which STW is likely beneficial. This is the approach German policy makers took in recent crises.

2 Literature

I contribute to several strands of literature. First, there is a large literature on heterogeneous agents (HA) going back to Aiyagari (1994) and Krusell and Smith (1998). More recent incarnations include Boppart et al. (2018), Auclert et al. (2021a,b), and Bardóczy (2020) to all of which this paper owes a great deal.

Several papers have combined heterogeneous agents models with search and matching models. One of the earlier contributions is Krusell et al. (2010). Further, Lise (2013) is an excellent read which summarizes the key forces governing wealth dynamics in these types of models. More recently, Ravn and Sterk (2021) provide insights in how New Keynesian frictions and labor search interact in HA models. Alves (2022) moves further and develops a HA labor search model with new Keynesian frictions and on the job search. Birinci et al. (2022) studies the consequences of monetary policy in this type of setting. Especially relevant to this paper is Kekre (2021) who investigates the role of unemployment insurance in a HA model with a job ladder. My contribution here is to suggest a tractable setup incorporating an unemployment scar which is driven by human capital accumulation and job to job transitions in which wage negotiation is not done by unions. The key feature that adds simplicity is that wages do not depend on workers assets.

Second, I contribute to the literature on STW, which is still in an earlier stage. Together with Cahuc and Carcillo (2011), and Hijzen and Venn (2011), Giupponi et al. (2022) provide a crystal clear overview of relevant frictions, and open questions concerning STW. Giupponi et al. (2022) highlights that in the presence of credit constraints and wage rigidity STW is especially useful. This finding motivates my model, in which credit constraints and downward wage rigidity may cause inefficient separations.

Cooper et al. (2017) is closely related. The paper documents the trade-off between between a less severe crisis and a slower recovery with a less dynamic labor market. This trade-off is also identified here. In addition, I highlight another mechanisms through which this channel is amplified. STW does not only reduce the effective number of workers searching, but also reduces the surplus firms receive when finding workers.

Tilly and Niedermayer (2016) also study the impact of STW on human capital during the great financial crisis. Important differences between my approach and theirs are that I am able capture re-distributive effects more accurately by capturing savings. In addition, I explicitly target income losses at different horizons and thereby obtain scarring effects of unemployment similar to those in Jarosch (2021). Another quantitative model of STW is Albertini et al. (2022) who study its effect of STW during an pandemic in France.

Birinci et al. (2022) study a related policy, payroll subsidies, in the US. They describe how high productivity workers benefit most from those subsidies. This is in line with my finding that wealthy workers benefit most from STW, and indicates that part of my results may generalize to the US.

There are several strands of literature discussing issues that are central to this paper. First I turn to the literature on wage rigidities and their relevance. As pointed out by Hall (2005) the empirical observation that most wages do not change most of the time is perfectly consistent with a friction-less labor market. What is necessary for substantial wage setting frictions is that wages are rigid, when for some reason the net surplus of the match between worker and firm is positive, but the current wage leaves one of the two with a negative surplus. Elsby and Solon (2019) conclude that wage rigidity is unlikely to be important.

There are, however, a number of papers pointing to wage setting frictions being relevant in specific situations. Examples include Jäger et al. (2019) who provide a first piece of evidence on the efficiency of separations. They find that separations between workers and firms are not efficient and point to collective bargaining as a likely reason for this. Further, Hazell and Taska (2020) provide evidence of downward rigid wages for new hires.

Giupponi et al. (2022) conclude that when wage setting frictions are present, STW seems most effective.

Work on the unemployment scar and its causes also informs this paper. Early contributions include Jacobson et al. (1993) who describe the unemployment scar, and Davis and Von Wachter (2011) who observe that labor search models are unable to explain the large losses due to unemployment.

Jarosch (2021) argues that a significant part of the unemployment scar is caused by workers transitioning to ever saver and better paid jobs. Lachowska et al. (2020), and Burdett et al. (2020) emphasize the role of human capital and learning by doing. Schmieder et al. (2022) consider the cost of job loss in Germany. They highlight that workers switch to lower paying employers after they become unemployed, and that this drives a significant part of of the unemployment scar. They also highlight that the unemployment scar increases during downturns.

The classic work of Mortensen and Pissarides (1994) and Pissarides (1994) provides the foundation for my job search model. Burdett and Coles (2003) and Stevens (2004) are especially relevant here as they develop models of job search with wage tenure contracts. With their bargaining protocol and estimation method Postel-Vinay and Robin (2002) and Cahuc et al. (2006) lay the foundations for many modern job ladder models. More recently Bagger et al. (2014) use such a job ladder model and identify that over the course of their working life workers first shop around for jobs before they settle in fairly secure and highly paid jobs. Moscarini and Postel-Vinay (2018) is a highly useful description of how job ladder models can be used to describe the business cycle more accurately.

3 Short-Time Work in Germany 2009

Here I describe the details of the German STW system in 2009. Several changes to the STW system have been made since then, and the reader should be careful not extrapolate to STW during the COVID crisis.

How to obtain STW benefits. The firm needs to first indicate to the *Bundesagentur für Arbeit* (Federal Employment Agency, or BA) that it intends to use STW. The worker can object to being put on STW unless there are prior agreements in the worker's contract, made by the union a worker is part of, or the council that represents worker's interests within the firm. The firm pays wages and STW benefits to the worker, and requests reimbursement from the state retrospectively. The state my still refuse to pay if firm and worker are not eligible for STW.

Eligibility. Any company with at least one employee is eligible to use STW if there is a substantial loss of work[7] which is temporary, and due to the general economic situation or an inevitable event. The firm only has to provide an explanation of why there is a temporary loss of work, so the burden of proof is not high. Any worker who is currently employed, or in training, and is expected to continue to be employed at the company after STW ends is eligible to receive STW benefits. Workers have to use the BA services to look for new jobs, and accept them if they are offered. Workers are not eligible if they receive certain other benefits.

Duration and generosity. STW benefits are paid for 1 year in normal times. During the crisis in 2009 the duration was extended to 2 years. The duration of STW benefits is determined on the company level. This means that if the first worker in a company enters STW in January 2009, no worker employed by that company can be in STW in January 2011. Employees on STW receive 60% of their lost wage, and 67% if they have children.

Cost of STW to the firm. The firm initially pays STW benefits to the employee with the wage, and is reimbursed later on by the state. The firm further pays social security contribution as usual. During the crisis in 2009 firms only paid half of the usual social security contributions. This amounted to 24% of the entire cost of labor in a standard case. If the worker participated in on the job training, or other educational programs the firm did not pay any social security contributions.

Prior agreements. In some cases workers and firms made prior agreements regarding STW. These may be negotiated between firms and worker representations or unions, and include provisions in which workers preemptively agree to go on STW, or provisions which require the firm to make additional payments to workers in STW.

[7]more than 10% for at least one worker in 2009, usually more than 10% for at least one third of the workers within the company

Main differences to STW during COVID. During the COVID crisis STW benefits became more generous. If workers are in STW for a longer period of time, STW benefits increase from 60/67% of the wage to 80/87% in two steps with the extra 7% for employees being paid with children. The duration of STW benefits has been increased multiple times. Social security contributions made by the firm were fully covered by the state until 2022. Afterwards social security contributions made by the firm were increased in two steps to their original level.[8]

STW and Moral Hazard. Given the specific regulations for STW in Germany it is unlikely that many productive workers went into STW. The reason is that firms decide to introduce STW, but workers receive the transfer. Effectively, the firm can forgo labor to save the wage by introducing STW, or pay the wage to receive labor. If a worker is productive the firm will always choose the latter. If the worker is not productive the firm will choose STW. The decision is effectively the same as hiring a worker.[9]

4 Model

Here I describe the model. First, I summarize the heterogeneous agents component of the model, treating household's income and income process as fixed. Then I outline the job ladder model determining the income process. For the sake of readability I suppress dependence on the distribution of workers, as well as the level of government debt in my notation. A key difference to standard heterogeneous agents models is that the Markov process for workers, and the income they receive in different states depends on the overall state of the economy. This is the cause because both are determined by the job ladder component of the model.

4.1 Heterogeneous Agents Component

I first focus on the heterogeneous agents component of the model, which is based on the work of Bardóczy (2020), Krusell et al. (2010), and Auclert et al. (2021a,b).

[8] The parliamentary debate about the initial expansion of STW benefits is an entertaining read. Even though the policy was approved in less than one week, and all parties in parliament supported it, the debate was adversarial and not as dignified as one might expect.

[9] Technically the firm may still have some labor costs when utilizing STW, as it may have to pay social security contributions, such that it is even less attractive to put productive workers on STW as the firm only saves part of the labor cost.

In this section a worker is described by its state s_t and its assets a. For now I will not elaborate on the worker's income $I_h(s_t)$ the Markov process with which workers transition between states, the dividends paid by firms (DIV_t) and what the payoff relevant states ($\mathcal{S}$) are. All three are explained in detail in the next section, which focuses on the job ladder part of the model. The same is true for firms, output, and the production side of the economy.

Workers. Workers have to hold positive assets, and optimize lifetime utility

$$U(a_t, s_t) = \max_{a_{t+1} \geq 0} u\left((1 + r_t)a_t + I_h(s_t) - a_{t+1}\right) + \beta E[U(a_{t+1}, s_{t+1})|s_t]. \tag{1}$$

Here t is time, which is discrete, and a_t are the worker's assets. r_t is the interest rate, and β the discount factor. $I_h(s_t)$ refers to the worker's income, which is composed of wages, short time work benefits, and unemployment insurance. My setup guarantees that $I_h(s_t)$ is only a function of s_t and not of a_t. I elaborate on this further below.

Government. The government fulfills the following functions. It issues long term debt to provide assets for workers, pays STW and unemployment benefits, and finances itself through a proportional labor tax. The price of a government bond at time t is q_t and can be written as

$$q_t = \frac{1 + \delta q_{t+1}}{1 + r_{t+1}} \tag{2}$$

where δ describes the share of bonds not retired in the next period. Each government bond pays 1 unit as dividends each period such that their price is the value of the remaining bonds tomorrow plus the dividend divided by the interest rate.

The government budget constraint takes the form

$$\tau_t \sum_{s\mathcal{S}_{pay}} w_t(s)d_t(s) + q_t b_t = G + b_{t-1} + \delta q_t b_{t-1} + \sum_{s \in \mathcal{S}_{rec}} benefits_t(s)d(s) \tag{3}$$

where G are other government expenditures and revenues, τ_t is the tax rate and equal to τ^{st} in equilibrium, and b_t is the amount of government debt. $w_t(s)$ describes the wage workers in state s earn, $benefits_t(s)$ the amount of unemployment or short time work benefits the worker receives and $d(s)$ the share of workers in state s. The states in which the worker pays taxes on labor are summarized in $\mathcal{S}_{pay}$, while the states in which the worker receives a transfer from the government are in $\mathcal{S}_{rec}$.

The government conducts counter cyclical fiscal policy. As in Bardóczy (2020) and Auclert et al. (2021a) the tax rate τ_t increases linearly with the debt to GDP ratio (with debt price and GDP at their steady state value), and is equal to τ^{st} in steady state. The equation which results in this exact behavior is

$$\tau_t = \tau^{st} + \kappa q^{st} \frac{b_{t-1} - b^{st}}{Y^{st}}, \tag{4}$$

where κ measures the sensitivity of the tax to the deficit, q_{st} is the steady state price of debt, and Y_{st} steady state GDP.

Asset market clearing. For markets to clear the amount of assets held by households has to be equal to the amount of assets available. This can be summarized as

$$A_t = \sum_{i=t+1}^{\infty} \left(\prod_{t<k\leq i} \frac{1}{1+r_k} \right) DIV_i + q_t b_t, \tag{5}$$

where A_t are the assets held by all workers, and DIV_i are the dividends at time i. The first term on the right hand side summarizes the value of all firms in the economy, while the second term summarizes the value of government debt.

4.2 Labor Market Component

In this section I outline a stylized search and matching model with a job ladder and human capital. The model generates dividends, household income, and the Markov process missing from the previous section. Further I elaborate on the possible states $\mathcal{S}$ for workers.

Search Technology. The search technology is standard, and analog to Pissarides (1994). There is a measure 1 of workers. The number of matches is determined as

$$m_t = (u_t + \lambda(1 - u_t))^{\psi} v_t^{1-\psi} \tag{6}$$

where v_t describes the measure of vacancies, and u_t the share of unemployed workers. $(1 - u_t)$ is the share of workers searching on the job. The equation incorporates the idea that $1/\lambda$ employed workers find matches with the same intensity as 1 unemployed worker.

Market tightness θ is defined as the number of of vacancies v_t divided by the "effective" number of workers searching

$$\theta_t = \frac{v_t}{u_t + \lambda(1 - u_t)}. \tag{7}$$

The resulting arrival rate of job offers for unemployed workers is

$$\alpha_w(\theta_t) = \mu\theta_t^{1-\psi} \tag{8}$$

where μ describes matching efficiency. The equivalent for employed workers is simply multiplied by λ. For firms the arrival rate of workers is

$$\alpha_f(\theta_t) = \mu\theta_t^{-\psi}. \tag{9}$$

Human Capital. The human capital of the worker is either high (h) or low (l). It evolves according to a Makrov process. During employment human capital can only improve, while during unemployment it can only decay.

Match quality. The quality of a match is either good (g) or (b). This affects output, and the probability with which a worker transitions to unemployment. In a match with good quality the probability of separation is ϵ, while in a match with bad quality it is ζ.

Output. Output depends on match quality and the human capital of the worker. If human capital is high and the state of the match is good output is y_h. If the state of the match is good and human capital is low the output is y_l. Otherwise the output is $y_b = 0$.

Wage setting. I assume that firms can condition the wage on the worker's human capital, the worker's outside option during the last wage negotiation, and whether the firm was credit constraint during the last wage negotiation. As a consequence wages may depend on the human capital of the worker, and whoever the firm competed with during the last wage negotiation. This assumption ensures that wages are independent of the point in time at which a worker enters a certain state, workers get compensated by the firm when their human capital improves, and firms cannot compensate workers for lower wages when the match transitions into the bad state in the good state.

Unemployment benefits. Unemployment insurance is modeled to capture key aspects of the German social security system. Workers receive generous unemployment benefits amounting to the maximum of 60% of their last wage and the minimum transfer k for an average duration of 6 month. They transition to long term unemployment at a constant rate, where they receive k.

STW benefits. If there is STW in the model, workers who are currently in a bad match receive short time work benefits. These amount to 60% of the wage lost or the minimum transfer k, whichever is larger.

Payoff relevant information for the worker. The state s_t captures all payoff relevant information for a worker. For the employed it thus indicates human capital, the outside option during the last wage negotiation, which is either no outside option (n), a firm with a good current output (g), or a firm with a bad current output (b).[10][11] Since some workers may receive short time work benefits when their match enters the bad state, the state for the worker also describes the current quality of the match $\{b, g\}$. In short the relevant states for employed workers are

$$\mathcal{S}_e = \{e\} \times \{n, b, g\} \times \{b, g\} \times \{l, h\}. \tag{10}$$

For unemployed workers s includes information about the workers human capital at the moment (h or l) since this affects future earnings prospects. For those who only recently became unemployed and still receive generous unemployment insurance the state also includes the last relevant outside option when negotiating wages and the human capital during the last employment as these determine the wage and generous unemployment benefits are proportional to the wage. Further, the state of an unemployed worker describes whether the worker receives the minimum transfer k. As a consequence the relevant states

[10] The outside option does not depend on the human capital of the worker, since firms offer a wage schedule.

[11] Since all new matches are good, and firms are only credit constraint if they are in a bad match, there never are workers who are employed at a firm that was credit constraint during the last wage negotiation, and it is unnecessary to keep track of this information.

for the unemployed worker are

$$\mathcal{S}_u = \{u\} \times \{l, h\} \times \{(\{h, l\} \times \{n, b, g\}) \cup \{k\}\}. \tag{11}$$

Naturally all payoff relevant states for the workers $\mathcal{S}$ are composed of all states for employed and unemployed workers $\mathcal{S}_u \cup \mathcal{S}_e$.

In terms of notation I denote the state in which a worker is employed (e), had no outside option during the last wage negotiation (n), is in a good match (g), with low human capital (l) as *engl*. Similarly an unemployed worker with low human capital, whose last wage was that of a worker with high human capital, and who only recently became unemployed is *ulhg*.

Firms. The value function of a firm depends on the state s_t the firms worker is currently in. It can be written as

$$J(s_t) = y(s_t) - (1 + \tau_t)w(s_t) + \frac{1}{1 + r_t} E[J(s_{t+1})|s_t] \tag{12}$$

where $y(s_t)$ is the output of the match.

The value function of a firm which posts a vacancy is

$$V = -\eta + \alpha_f(\theta_t) E[J_{t+1}(s_{t+1})] = 0 \tag{13}$$

The firm pays a fixed cost η to search for a worker each period. In equilibrium free entry ensures $V = 0$.

Wage negotiation. When a firm and a worker meet they negotiate wages in the following way. If a worker is currently not employed they receive a take it or leave it offer from the firm. The firm extracts all the surplus. If the wage floor is binding this results in a wage of w_0. In my setup this is usually the case, because workers would primarily be compensated with the prospect of future income growth.

If the worker is currently employed the two firms engage in Bertrand competition until one of them drops out. For a worker with low human capital and offers from two firms with which he has a good match this results in the condition

$$w_{gl} = y_{gl} + \frac{1}{1+r} E[J_t(s')|eggl]. \tag{14}$$

Similarly the condition for a worker with offers form two firms with whom they have a good match is

$$w_{gh} = y_{gh} + \frac{1}{1+r} E[J_t(s')|eggh]. \tag{15}$$

For workers who are currently in a bad match with firms that are not credit constraint the wage is

$$w_{bl} = y_b + \frac{1}{1+r} E[J_t(s')|ebgh], \tag{16}$$

$$w_{bh} = y_b + \frac{1}{1+r} E[J_t(s')|ebgl]. \tag{17}$$

For workers who are in a bad match with firms who are credit constraint the situation is some more intricate. On the one hand these workers are employed, and have income, so their bargaining position is fairly good. On the other hand their employer might not be able to bid up their wage because of credit constraints, and they technically have to accept comparable employment, as they otherwise could lose STW benefits. I pick a compromise, and set the wage equal to that of workers who are affected by no frictions, or wage setting frictions.

Inefficient Separations. Since the output in the bad match is zero, and firms cannot pay workers less than zero in employment, inefficient separations will occur if workers prefer to become unemployed rather than to receive a zero wage for an extended period of time. An alternative motivation for inefficient separations are downward rigid wages. These are plausible since unions and worker representations are relatively strong in Germany.

Dividends. There is a single investment firm which finances vacancies, and owns all individual firms. It pays firms surplus as dividends to workers each period such that

$$DIV_t = \sum_{s \in \mathcal{S}_e} (y(s_t) - w(s))d(s_t) - \theta_t(u_t + \lambda(1 - u_t))\eta \tag{18}$$

where $y(s)$ describes the output of the match a worker in state s produces (if any). The first term describes the profits of all firms matched with workers. The second term describes the cost of vacancy creation.

Equilibrium definition and solution algorithms. The equilibrium definition and solution algorithms are relegated to Appendix B.

5 Calibration

In this section I outline how I calibrate my model in order to capture welfare effects.

5.1 Short-Time Work and the Efficiency of Separations

The main mechanism which allows STW to have positive welfare effects are wage setting frictions due to credit constraints on firms or rigid wages. These may result in workers entering unemployment, even though they produce a lot in the future and it would be best for firm and worker to remain in the match if they could adequately divide the surplus. The subsidy STW provides may prevent this. The same subsidy, however can have negative effects. It may result in workers remaining in employment, even though the surplus for firm and worker would be larger if they split.

Which of the two is true in my model depends on the parameters that govern the surplus generated by workers who enter unemployment, and workers who enter STW. The surplus generated when a worker enters unemployment is determined by (a) the time it takes the worker to find a job, and (b) the human capital the worker loses during unemployment. The surplus generated when a workers who enters STW is determined by (c) the duration of STW, (d) the probability with which a worker returns to their job after STW as opposed to becoming unemployed, (e) the human capital loss in STW if there is any.

These parameters are quantified in the following way. The size of the unemployment scar, as well as labor market flows in Germany inform (a) and (b). Since the contribution of human capital to the unemployment scar is a controversial issue, I set the persistence of human capital losses manually to different values and let readers choose the one that corresponds to their views. Section 5.2 describes the details here. In order to measure (c) I directly use data on how long firms remain in STW (Section 5.4). For (d), and (e) I compare wages and employment status of workers who are employed in firms that heavily utilize STW to those who do not use STW as much. Here sections 5.3 and provide the details.

5.2 Internal Calibration

In this section I outline how I inform the losses from unemployment. Three prominent explanations are the decay of human capital in unemployment, undesirable characteristics or worse match quality for new employers which may include less stable jobs, and the lost outside option (Jarosch, 2021; Schmieder et al., 2022). I focus on human capital and the job ladder as an explanation.

The targets of my calibration are the job finding rate, and the unemployment scar as measured by Jarosch (2021) at the three, five, and ten year horizon. Internally calibrated parameters are the rate of on the job search, the human capital loss in unemployment and the cost of vacancy creation. The size of the early wage loss informs how much human capital the worker lost. The persistence of the unemployment scar determines the rate of on the job search. The job finding rate determines the vacancy creation cost.

Since there are varying views about the contribution of human capital to the persistent part of income losses I control this parameter directly. Lachowska et al. (2020) and Burdett et al. (2020) attribute it to human capital and learning on the job. Jarosch (2021) and Schmieder et al. (2022) find that employer characteristics are likely to be most important. I set the rate at which human capital recovers initially such that half of the human capital loss is recovered after 15 years, and calibrate my model accordingly. In a robustness analysis I change the persistence of human capital such that 1% of workers who lost their human capital did not recover it after 15 years. The results of my calibration are depicted in Table 1.

Parameter	Value	Matches
Vacancy creation cost	0.181	P(UE Transition)=0.38 or u=0.05
P(human capital loss in unemployment)	0.065	Unemployment Scar at 3, 5, 10 years
P(human capital gain in employment)	0.017	half of human capital recovered after 15 years
Search intensity on the job	0.301	Unemployment Scar at 3, 5, 10 years

Table 1: Internal Calibration

5.3 Does Short Time Work Prevent or Delay Unemployment?

In order to obtain a better understanding of the surplus generated by a worker entering STW I gather evidence on whether workers mostly remain employed when STW ends, or whether they enter unemployment.

The data I use are based on social security records of employees, combined with administrative information on employers, and a survey panel of employers. I construct a yearly panel for the period form 2007 to 2017, and compare the likelihood of entering unemployment for workers with employers reporting a high uptake in STW, to those with employers reporting a low uptake in STW. I restrict the sample to workers fully employed in 2008 and 200. Workers are considered to be unemployment in one year if they receive unemployment benefits for 3 month at least. STW is measured as the self reported number of workers in STW in a firm, divided by the overall number of workers in that firm.

The empirical model I consider takes the form

$$I(\text{unemployed})_{it} = \delta_i + \sigma_t + \phi_{tk} + \sum_t \gamma_t stw\_share_{j(i)} \times I(t) + \pi' X_{j(i),t} + \phi' Y_{i,t} + \epsilon_{i,t} \quad (19)$$

where i indexes individuals, t the year, and j the employer. $I(\text{unemployed})_{it}$ is a dummy variable that describes whether worker i was unemployed in period t. Besides individual fixed effects (δ_i), time fixed effects (σ_t), and either time varying industry, region, or firm size (ϕ_{tk}), I include the current economic situation of the firm (X_{jt}) in the regression, as well a age polynomials interacted with education ($Y_{i,t}$). $stw\_share_{j(i)}$ measures the share of short-time workers among the workers colleagues. $I(t)$ is a indicator variable for year t. The coefficient of interest γ_t describes the effect of a worker's employer relying more heavily on STW in 2009 on employment in year t.

There is no clear evidence of a positive effect of STW on the probability of being unemployed. Table 2 displays γ_t in percentage points for different specifications. STW ends in the year 2011 for firms who used STW in 2009. Since dateset collects information for the 1st of June for the precious year[12] some short time workers may appear as separating in 2012 only.

I focus on the last column, since it is the least favorable for my story. The probability

[12]Employer have report to the BA on this day

of being unemployed for workers in firms with more STW increases each year, first by about 0.14%, then by about 0.07 %. If all of this increase is due to a higher separation rate in STW, still results in an only slightly higher probability of becoming unemployed for short time workers. Since I make the statement that STW is beneficial I still set the rate at which short time workers enter STW 1% higher than that for workers in productive matches.

P(unemployment)	(1)	(2)	(3)	(4)
2010	-.3704	-.3179	-.1654	0.0000
	(0.00)	(0.00)	(0.00)	(0.9927)
2011	-.3981	-.3037	-.1361	.1465
	(0.00)	(0.00)	(0.0018)	(0.0326)
2012	-.3354	-.2454	-.1003	.2139
	(0.00)	(0.00)	(0.0296)	(0.0022)
Firm Revenue	x	x	x	x
Worker Controls	x	x	x	x
Industry × Time FE				x
Size × Time FE			x	
State × Time FE		x		
N	2,516,319	2,511,220	2,516,319	2,516,319

Table 2: STW and the probability unemployment. Being unemployed for at least three months is the outcome variable. Coefficients are multiplied by 100, thus 0.5 means that the probability is 0.5 percentage points larger. p-values in parentheses.

5.4 Does Short Time Work Prevent the Decay of Human Capital?

In order to obtain a better understanding of the surplus generated by a worker entering STW, I gather evidence on how a workers human capital evolves after entering STW.

The data I base my analysis on come from the source described in the previous section. I again consider the period form 2007 to 2017, and compare the wage of workers with employers reporting a high uptake in STW, to those with employers reporting a low uptake in STW. This time I restrict my sample to workers who are fully employed 2009, 2010, and 2011.

The empirical model I consider is parallel to that in the previous section

$$\ln(\text{wage}_{it}) = \delta_i + \sigma_t + \phi_{tk} + \sum_t \gamma_t stw\_share_{j(i)} \times I(t) + \pi' X_{j(i),t} + \phi' Y_{i,t} + \epsilon_{i,t} \qquad (20)$$

with the only two differences being that the dependent variable now is the log wage of a worker, and I restrict the sample to those who remain employed after exiting STW. The reason for the latter is that I attempt to capture exclusively the effect of human capital decay, and not the effect of job loss.

Table 3 display the coefficient of interest γ_t. Here we observe that after an initial drop in the wage during STW, it quickly recovers and returns to its pre STW level. As a consequence I conclude that STW has a limited effect on human capital.

This observation is unsurprising for three reasons. First, it seems plausible that in order to not lose a skill, it is sufficient to practice it occasionally ("part-time") instead of constantly ("full-time"). Second, part of the human capital loss in unemployment may represent firm specific human capital. This would not be lost in STW, but completely disappear if the worker switches employer. Third, the German government subsidized educational training for workers in short time work. The resulting investment may have offset some of the human capital loss workers may experience.

In line with the evidence in this section and the arguments presented, the human capital loss during unemployment is zero in my preferred calibration. I demonstrate later on that my finding that STW has significant positive welfare effects holds if a moderate degree of human capital is lost during STW.

5.5 The Duration of STW

In order to obtain a better understanding of the surplus generated by a worker after entering STW, I gather evidence on how long firms use STW. Therefore I rely on Data provided by the BA on STW and its duration.

In the model I make the assumption that a constant fraction of firms exits STW at any given point in time. Formally this translates into

$$firms\_stw_{t+k,t} = firms\_stw_{t,t}\phi^k \tag{21}$$

where the first subscript indicates the current month (t+k), and the second subscript indicates in which month the firms first used STW (t). The number of months the firm is

log(wage)	(1)	(2)	(3)	(4)
2009	-4.7051	-5.4677	-4.6120	-3.6101
	(0.00)	(0.00)	(0.00)	(0.00)
2010	-3.1014	-3.1079	-3.0085	-1.2149
	(0.00)	(0.00)	(0.00)	(0.00)
2011	-0.6044	-0.7979	-0.6673	-0.2247
	(0.00)	(0.00)	(0.04443)	(0.2894)
2012	2.1625	1.1550	1.6434	0.5432
	(0.00)	(0.00)	(0.00)	(0.0426)
2013	3.2164	2.5277	2.0609	1.4513
	(0.00)	(0.00)	(0.0000)	(0.0000)
2014	2.8105	2.3890	1.8533	.9488
	(0.00)	(0.00)	(0.00)	(0.0066)
2015	3.3993	3.0337	2.53134	1.8188
	(0.0000)	(0.0000)	(0.0000)	(0.00)
2016	2.1537	2.4674	1.7165	1.1317
	(0.0000)	(0.0000)	(0.0000)	(0.0028)
2017	.4887	.9842	.4668	1.7360
	(0.0970)	(0.0029)	(0.1382)	(0.0001)
Firm Revenue	x	x	x	x
Worker Controls	x	x	x	x
Industry × Time FE				x
Size × Time FE			x	
State × Time FE		x		
N	2,516,319	2,511,220	2,516,319	2,516,319

Table 3: STW and wage loss. Being unemployed for at least three months is the outcome variable. Coefficients are multiplied by 100, thus 0.5 means that the probability is 0.5 percentage points larger. p-values in parentheses.

in STW is k. With some algebra this results in

$$\log\left(firms\_stw_{t+k,t}/firms\_stw_{t,t}\right) = k\log(\phi). \tag{22}$$

Since I observe how many firms have been in STW for less than 6 month, 6 to 12 month, and so on, I can pick the parameter ϕ to minimize the squared distance between the observed data, and the model prediction according to 22.

Figure 2 depicts the result. For the left panel I use firms entering STW in the last 6 months of 2008. The log share of firms remaining shrinks by about -0.64 every 6 months.

The right panel repeats the exercise for firms entering STW in the first 6 months of 2009. The slope is virtually identical, the fit is excellent, and implies that about 10% of workers exit STW every month, or 0.274% every quarter.

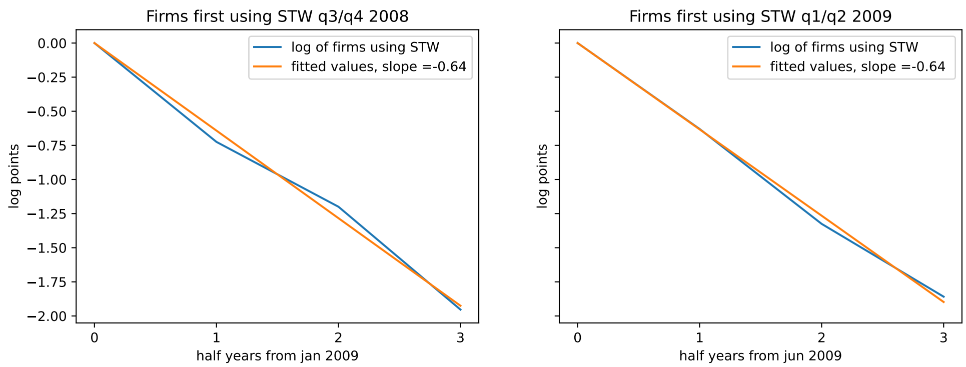

Figure 2: Fitting linear function to log of share of firms remaining in STW. Source: Statistik der Bundesagentur für Arbeit. Tabellen, Realisierte Kurzarbeit (hochgerechnet) (Monatszahlen). Own calculation.

5.6 The Duration of Unemployment

In this section I illustrate how entries and exits into unemployment evolved during the financial crisis in Germany. The purpose of this exercise is twofold. First, the duration of unemployment is a key determinant of the value generated after becoming unemployed. Thus, I need to ensure my calibration is reasonably close to the data. Second, there is evidence that the duration of unemployment in Germany increases during crisis (Schmieder et al., 2022). At the same time the type of model described above exhibits an excessive response of the job finding rate to an increase in unemployment during crisis, if there are more separations but matching is not hindered (Moscarini and Postel-Vinay (2018) describe these mechanics in more detail).

I calibrate the rate of exit from unemployment to match an unemployment rate of 5% which coincides with what I observe for Germany after the financial crisis. The resulting monthly exit rate out of unemployment is between 14% and 15%. When comparing this with rate of exit out of generous unemployment insurance to employment depicted in the upper panel of Figure 3 I find this to be a reasonable, but somewhat optimistic.

A shock to the separation rate is insufficient to describe the dynamics of the job finding rate in crisis well. When I consider a shock which leads to the separation of matches in my model this leads to an increase in the number of firms posting vacancies as more workers with higher human capital and worse outside options are intensely searching for employment. As a consequence workers find jobs faster in a crisis. This is not what happened during the financial crisis, and not in line with what has been previously documented (Schmieder et al., 2022). The upper panel of Figure 3 shows how the job finding rate declines after the first vertical line, which indicates the bankruptcy of Lehman brothers in 2008. Indeed, it takes until February 2010 until it reaches its previous level. The lower panel of Figure 3 provides some evidence on how this comes about.

In order to address this issue and arrive at a more realistic description of the job finding rate I add a shock to the rate at which new matches are generated. This results in an initial decline and a subsequent increase in the job finding rate. The top panel of 3 displays the job finding rate predicted by my model when I reduce the job finding rate. For my welfare analysis the job finding rate is relevant when there is no STW. In this case the job finding rate decreases much less than in reality which improves the output after becoming unemployed, and thus works against the statement that STW is beneficial.

Parameter	Value	Matches
Separation rate bad matches	0.03	0.01 percent higher than normal matches
P(bad match turning good)	0.24	duration of STW
Human capital decay during STW	0	no evidence for human capital loss

Table 4: Estimated Parameters.

Figure 3: Observed/ model generated job finding rate, and observed flows out of and into generous unemployment insurance. Source: Statistik der Bundesagentur für Arbeit. Tabellen, Saisonbereinigte Zeitreihen, Nürnberg. October 2022. Own calculation. The first vertical line is the default of Lehman brothers, the second vertical line is February first 2010, the first time the rolling mean of the job finding rate reaches its pre crisis level.

5.7 Remaining Parameters

I set the parameters governing the matching technology, output, and the remaining part of the labor market, as summarized in Table 5.

Matching Technology. Here Krause and Uhlig (2012), who study the German labor market reform of the early 2000s, serve as a benchmark. As in their paper, I set the matching efficiency μ to 0.3. Further, I set the exponent of the matching function ψ to 0.5.

Parameter	Value	Set according to
Separation rate good matches	0.02	Flow out of employment of 2%
Exponent Matching Function (ψ)	0.5	Krause and Uhlig (2012)
Matching efficiency (μ)	0.3	Krause and Uhlig (2012)
P(Good match turning bad)	0.00	no bad matches in st.st.
P(New match good)	1	no bad matches in st.st.
Output high HC (y_h)	1.2	normalization
Output low HC (y_l)	0.8	ensure there are probabilities describing human capital process
Minimum transfer (k)	0.3	0.6 of mean wage
Wage Floor (w_0)	0.3	equal unemployment benefit
Discount factor (β)	0.995	Bardóczy (2020)
elasticity of intertemporal substitution	0.5	Bardóczy (2020)
Labor tax (τ_{st})	0.3	Bardóczy (2020), Krause and Uhlig (2012)
Share of government bonds retired (δ)	0.02	gov debt stable with interest
Sensitivity of tax to deficit (κ)	0.1	Bardóczy (2020)

Table 5: Externally Calibrated Parameters.

Output. I normalize the output of a worker with high human capital y_h to 1.2. Further, I set the output of a worker with low human capital y_l to 0.8. This low value ensures that there is a probability between 0 and 1 that accurately captures the human capital losses in unemployment. Last, I set the output of a bad match to 0. This captures the idea that bad matches are actually unproductive in crisis and ensures the friction I add to the model have bite.

Transition Probabilities. I choose the probability with which any given match separates as 0.02, which matches German labor market flows. The probability that a new match is of good quality is 1, and the probability that a good match turns bad is zero. This ensures that in steady state there are no bad matches. These only occur in a crisis.

Preferences. For household preferences I use Bardóczy (2020) as a benchmark, who also uses a heterogeneous agents model to study the German labor market. I set the intertemporal elasticity of substitution to 0.5, and the discount factor to 0.995. The latter results in a yearly discount rate of about 2 percent.

Government. In line with both Krause and Uhlig (2012) and Bardóczy (2020) I choose the labor tax rate τ to be 0.3. The sensitivity of the tax to excess debt κ is 0.1 (Bardóczy (2020)) and the share of government bonds retired each period δ 0.01. The reason for this low value is that the shock I study has a substantial impact on interest rate. If government debt is long term as implied by $\delta = 0.01$ this does not translate into higher government debt instantly.

Unemployment Insurance. My description of the German unemployment insurance is and adaption of Bardóczy (2020). I set the unemployment benefits received after the initially high benefits expire to 0.3. The initially higher benefits are equal to 0.6 times the previous wage, but at least 0.3.

Wage Floor and collective bargaining. As a short hand for collective bargaining, and in order to ensure that workers are not purely compensated with the prospect of higher earnings in the future, I set the wage floor $\underline{w} = 0.3$ which is also the minimum payment by the unemployment insurance. Collective bargaining is common in Germany. According to the German statistical office only one third of workers in former West Germany were not covered by collective agreement in 2009. The number for former East Germany is 50%. Note that this does not contradict the job ladder mechanism, as collective bargaining merely provides a lower bound to the wage.

6 Welfare Effects of STW

6.1 Policy Experiment

I consider a shock which results in 1% of the working population transitioning from being in a productive match to being in a temporarily unproductive match. Without STW affected workers transition into unemployment due to credit constraints and wage setting frictions. With STW affected workers remain in their match, and receive STW benefits.

I choose not to increase unemployment benefits in the counterfactual, since a reduction in unemployment benefits in the early 2000s was followed by a sharp decline in unemployment. A reversion of this policy would likely be undesirable (Krause and Uhlig, 2012).

The 1% shock to the economy is accompanied by proportional decrease in the matching efficiency with the same persistence. As outlined above the purpose of this is to reduce the share of valuable and potential matches in the same manner as the share of existing valuable matches.

The reader should be aware that it is beyond the scope of the paper to describe the full dynamics of the financial crisis. Key frictions that determine the course of the crisis and its effect are missing form this model.

6.2 The Effect of STW

STW has substantial positive welfare effects. If 1% of the labor force enters STW instead of becoming unemployed these are equivalent to a one time transfer of 0.72% of GDP per person valued at marginal utility at mean consumption, and 0.81% of GDP at mean marginal utility of consumption.

STW has a number of effects on the dynamics of a crisis. Specifically, STW dampens but prologues the crisis. The first panel of Figure 4 shows how consumption decreases abruptly without STW, but exhibits a much less severe reduction with STW. It further documents how consumption decreases slowly over time with STW before converging to its original value. Without STW it simply recovers.

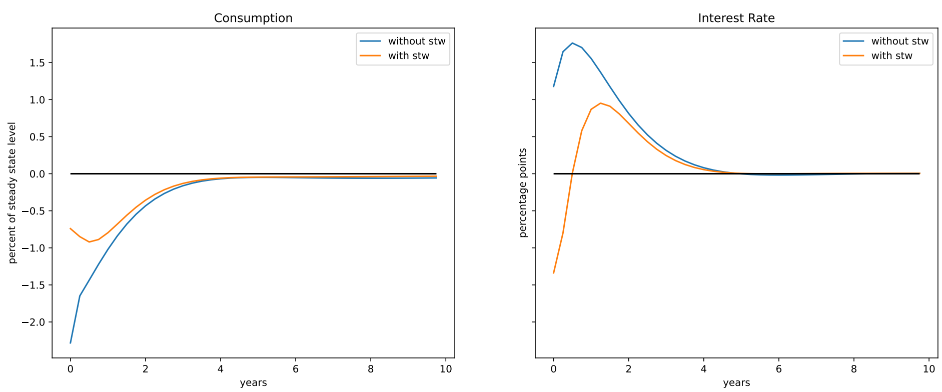

Figure 4: Consumption and interest rate response to shock.

The reason for this pattern becomes apparent when we consider the reaction of the interest rate. The high number of unemployed workers without STW encourages high investment in vacancy creation, resulting in more investment in vacancy creation and a higher interest rate. Without STW labor markets are much less dynamic as employed workers search with a lower intensity and require higher wages. This leads to a low interest rate and a relatively slower recovery.

STW reduces the number of unemployed workers, but increases the number of workers which are not in productive jobs. The left panel of Figure 5 depicts how unemployment spikes without STW but recovers quickly. With STW a less dynamic labor market results in a small hump in the number of unemployed. The high number of short-time workers and the slower speed at which they return to productive jobs limits the number of workers in productive jobs.

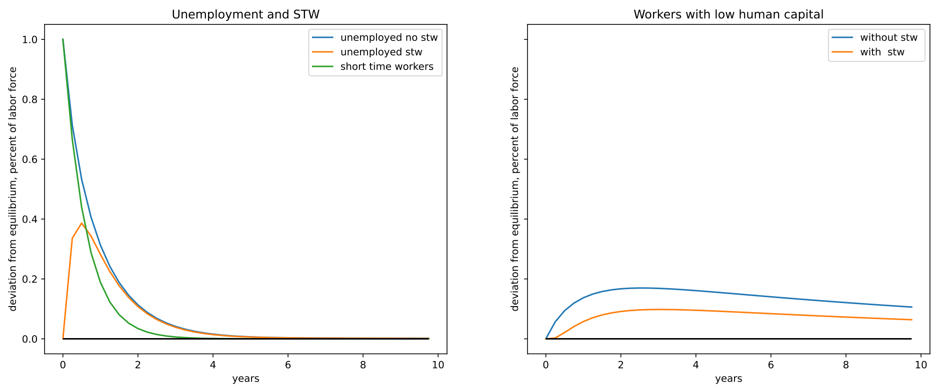

Figure 5: Unemployment and human capital response to shock.

The overall effect of STW on output is composed of its effect on unemployment and human capital. The left panel of Figure 5 depicts how to share of workers with low human capital reacts to the shock. We can observe how with STW more workers get to keep their job and firm specific human capital, and that human capital recovers slowly.

The overall effect on output is depicted in the left panel of Figure 6. It shows how initially the faster recovery due to a dynamic labor market results in higher output. Later on higher human capital results in higher output. The fast initial recovery does not directly translate into consumption as larger investments are necessary to achieve the fast recovery. As a consequence overall welfare effects of STW are strongly positive.

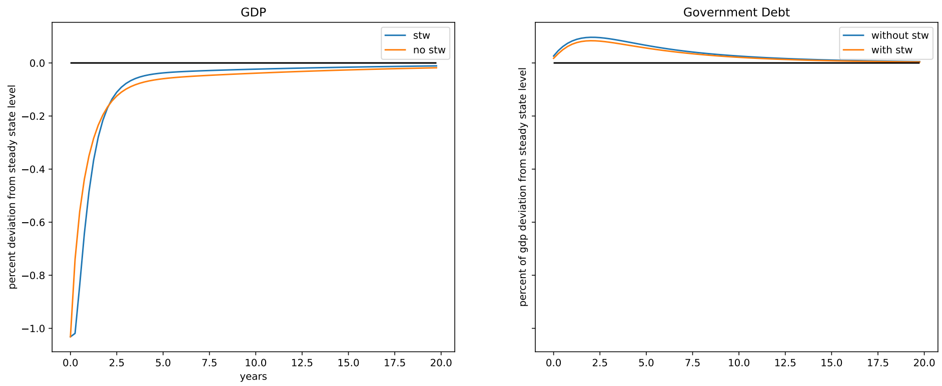

Figure 6: GDP and government debt response to shock.

In this setup the cost of STW is close to zero, and it even leads to a small surplus. Figure 6 shows how government debt with and without STW is effectively identical after the shock hits. The reason is that workers who lose their outside option receive lower wages, which reduces the tax revenue. Further, if workers would not enter STW, they would receive unemployment benefits of similar size.

The welfare effect of STW is not only composed of its effect on GDP. Besides this STW has a large insurance value. The left panel of Figure 7 plots the difference in consumption between workers who lose their and their peers who do not. We can observe that especially workers who negotiated high wages in the past and have job and firm specific knowledge suffer large and persistent consumption losses if they become unemployed.

STW reduces the relative loss in consumption for those who are affected by the shock significantly. The right panel of Figure 7 show how for all groups the relative loss in consumption is much lower with STW, but the absolute size of the value insured is largest for high wage workers with high human capital. Low wage workers with low human capital barely benefit, as they earn close to the minimum income, and primarily forego the prospect of rising wages in the future.

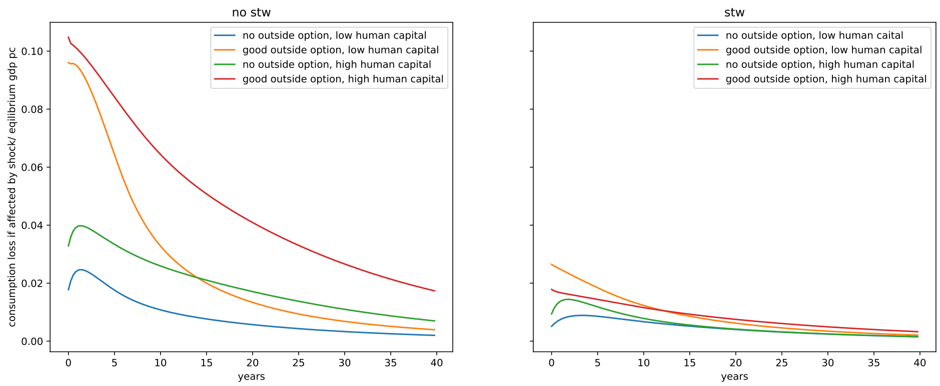

Figure 7: Lost consumption for workers hit by the shock.

6.3 Limits to the Effectiveness of STW

Here I introduce mechanisms and vary parameters that limit the effectiveness of STW. Specifically, I vary assumptions about the loss of human capital in STW, the recovery of human capital after unemployment, introduce recall, and reduce the fraction of firms which are subject to wage setting and credit frictions.

Faster human capital decay in STW. I now consider the case in which human capital decays equally fast in STW as it does in unemployment. STW has a welfare effect that is much smaller in this case. Specifically a transfer of 0.35% of GDP transfer at average marginal utility of consumption, and a 0.39% transfer at marginal utility of average consumption are equivalent to the entire welfare effect. STW still has a positive welfare impact as it has insurance value.

Since workers return to productive jobs slower with STW than without it, output overall is lower. The left panel of Figure 8 shows how GDP is lower with STW than without at any given point in time. The right panel illustrates that there are more workers with low human capital when it decays in STW as it does in unemployment, and the effect of human capital is now small and reversed.

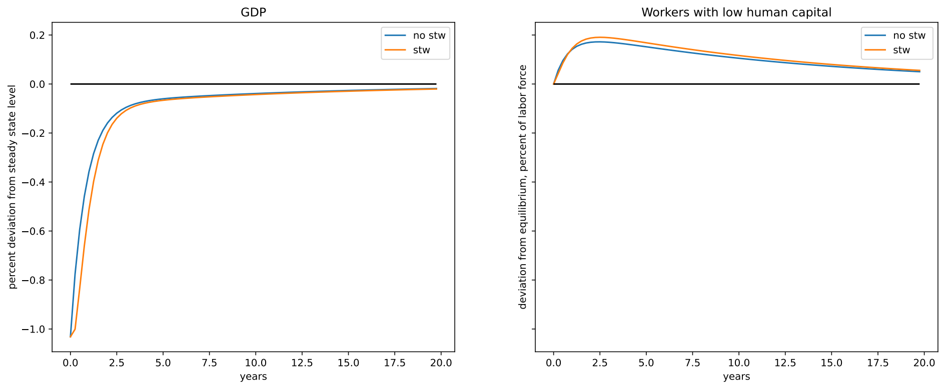

Figure 8: GDP and government debt response when human capital decays in STW as it does in unemployment.

The key takeaway here is that human capital is an important determinant of the welfare effects of STW. In my setup it contributes half of its welfare effect. The German government seems to share this view, as it introduced substantial financial incentives (amounting to half the social security contributions paid by the firm) to encourage training on the job during STW.

Faster human capital recovery in employment. I now consider the case in which only 1% percent of the workers who lost their human capital in STW did not recover it after 15 years. Welfare effects of STW are still large at 0.63% of GDP and 0.69% of GDP (at mean marginal utility, and marginal utility of mean consumption). This is unsurprising as STW keep its insurance value, and it still preserves some human capital. Further, if firm and job specific human capital accumulates quickly, many workers have it before the recession, and stand to lose it in a recession. This increases the overall amount of human capital saved and the welfare benefits of STW.

Recall. In a second robustness test I introduce recall. Specifically, firms and workers only separate partially when they are affected by the shock. The match completely separates with a probability which is chosen such that about 15% of workers who lost their job return to their old employer. If the match returns to its old value the worker is hired back by its previous employer, and workers on recall search with the same intensity as normal workers, but lose their human capital at a rate between unemployment and STW[13]

In this case welfare effects shrink but are still substantial. For 1% of workers entering STW instead of becoming unemployed the welfare effect is equivalent to a 0.22% of GDP transfer at mean marginal utility and 0.29% at marginal utility of mean consumption. The left panel of Figure 9 shows how workers transition first into partial separation, before their jobs completely separate or they return to their previous employer. The right panel shows how with recall employees return to their jobs faster, relative to the setup of the model without recall. The difference is small as workers would find employment on the labor market relatively fast as well.

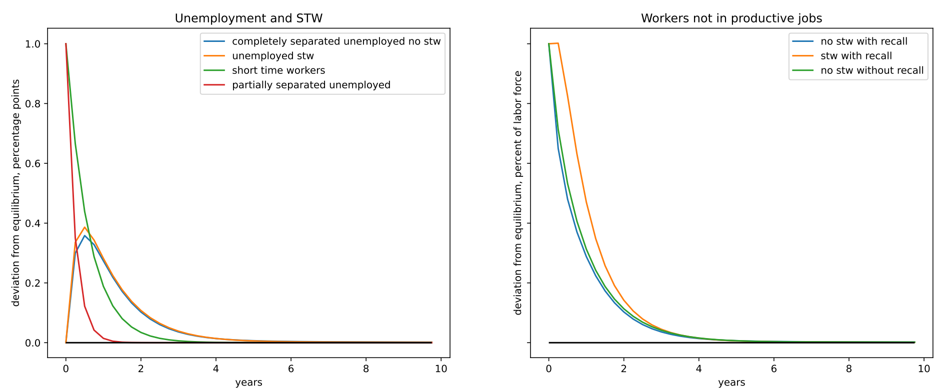

Figure 9: GDP and government debt response when human capital decays in STW as it does in unemployment.

Few firms constraint. Here I consider the case in which one out of fours firms is affected by wage setting frictions or credit constraints. I consider this conservative as among firms that actually negotiated with banks 31% reported credit financing impairments (Heinz and Wiegand, 2011), and according to the German statistical office only one third of workers in former West Germany were not covered by collective agreement in 2009. The number for former East Germany is 50%. In this setting STW has small positive welfare effects of 0.01% to 0.09% of GDP valued at average marginal utility, and marginal utility of average consumption.

The benefits of STW are now much lower, as the counterfactual changes and workers

[13] As compared to short-time they do not work at all, and most of them eventually find a different job.

who are productive in the future are likely to stay with their employer. As a consequence STW prevents much fewer inefficient separations, and less firm and job specific human capital is lost. The left panel of Figure 10 depicts the consequence of this in terms of GDP. There is barely any difference in output with and without STW. Accounting for this in the welfare calculations and computing the benefits of STW per 1% of working population kept in employment results in welfare effects of 0.37% of GDP at average marginal utility and 0.41% of GDP at marginal utility of mean consumption. Thus the policy still has a substantial positive effect.

The cost of STW in terms of government expenditures and forgone taxes are now higher. With STW all employers affected by the shock use STW, and the state pays STW benefits to a large number of workers. Without STW most of the affected employers are not constraint, and keep their workers fully employed such that the state has zero social security expenditures for those workers. In fact, the state receives tax payments on their wages. The benefits of STW remain similar, but are scaled down. Figure 10 illustrates this by depicting the ratio of government debt with and without STW, and the ratio of GDP with and without STW.[14]

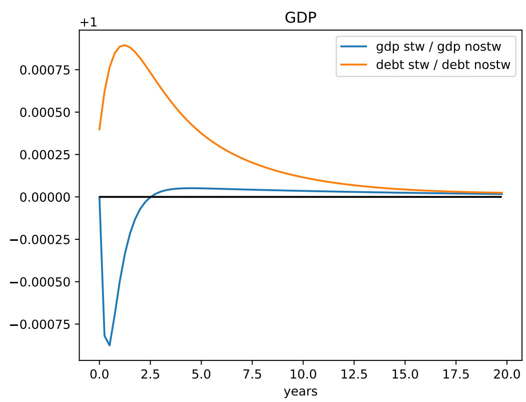

Figure 10: Relative GDP and government debt response when few firms face frictions.

[14] The figure does not display absolutes because the differences between the paths for the STW and no STW policy are hard to discern, as aggregate movements of the variables are much larger than the distance.

6.4 In What Type of Recession is STW Effective

Not every crisis is a financial crisis characterized by credit constraints on firms. In the previous section it was already demonstrated how a reduction in credit constraints and wage setting frictions limits the effectiveness of STW. In what follows I highlight two more situations in which STW has limited benefits.

Workers do not return to their jobs. I now assume that a smaller fraction of workers actually returns to their job after STW benefits end, while keeping the duration of STW constant. Specifically only 1 out of 10 workers in STW returns to their job. This could for instance be the case if unemployment is caused by a structural change in the economy, instead of a temporary crisis.[15]

In this case welfare effects amount to -0.06% and -0.07% of GDP valued at marginal utility at mean consumption, and mean marginal utility respectively. Figure 11 demonstrates how short time workers now quickly become unemployed, and the loss of human capital is similar to that without STW.

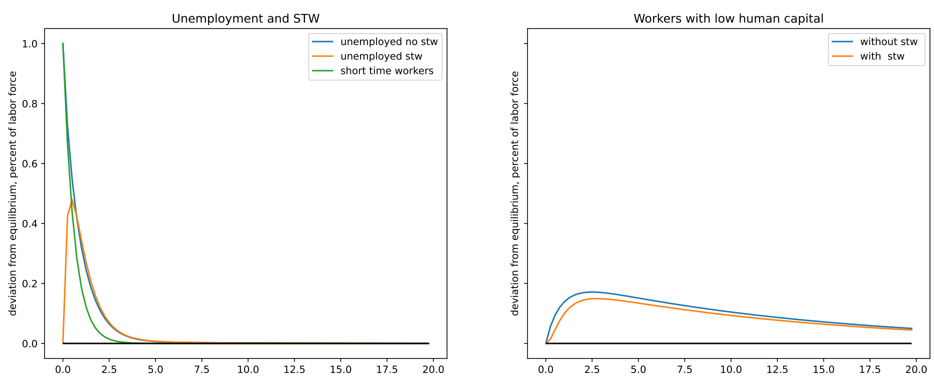

Figure 11: Unemployment and human capital response when few firms face frictions.

This exercise illustrates that it is crucial for workers to return to their jobs in order for STW to have welfare benefits. It is easy to imagine a scenario in which in addition to more workers entering unemployment instead of returning to their job, the duration of

[15] If after COVID everyone uses Zoom instead of flying, such that pilots are out of work permanently.

STW increases such that workers are unproductive for a longer period of time and welfare effects are even more negative.

Different groups of workers affected. The welfare effects of STW depend on what type of workers are affected. Table 6 shows that they are largest if workers who advanced far in their career with high wages, and high firm and job specific human capital stand to lose their job. In this case STW if efficient as it insures a large risk, and preserves valuable human capital. The cost of STW still tends to be low, as long as those workers face wage rigidities or are employed in constraint firms and would receive unemployment benefits in the counterfactual.

Table 6: Welfare effect of STW in terms of % of GDP by affected group

	high HC, high wage	high HC, low wage
at mean marginal utility	0.718	0.6
at marginal utility of mean consumption	0.802	0.67
	low HC, high wage	low HC, low wage
at mean marginal utility	0.034	0.033
at marginal utility of mean consumption	0.037	0.037

STW as an automatic stabilizer. Based on the three counterfactual above I conclude that STW is not suitable as an automatic stabilizer. The reason is simple. Not every crisis is temporary like COVID, or accompanied by significant credit frictions like the financial crisis. Similarly, the type of worker affected may vary from crisis to crisis.

The current approach of the German government seems to reflect many of the mechanics outlined above. Having a less generous STW system in place and expanding it in crisis when needed, is in line with the observation that STW is not beneficial in every crisis. Similarly, the condition that a firm is only eligible to receive STW benefits if things are likely to go back to normal, reflects the idea that STW cannot be beneficial if it simply delays unemployment.

6.5 Winners and Losers

I now move back to the original setup and identify who wins and loses due to STW. The comparison is ex ante, so workers in each group do not know whether they will be affected by the shock and become a short time worker instead of entering unemployment. Table 7 displays the welfare effect on each group of workers.

First I focus on workers with high human capital. Here I find that workers who negotiated high wages benefit the most. This is unsurprising as these workers remain productive if affected by STW, keep their high wage, and receive the benefits of their high productivity. In contrast, workers with high human capital who negotiated low wages previously suffer. Even though STW is welfare enhancing if these workers are affected as it preserves their high productivity, they do not themselves appropriate the surplus they generate. Lower earnings prospects with STW because of a less dynamic labor market have a larger impact on their welfare.

For workers with low human capital the pattern is similar. Workers who negotiated high wages benefit, whereas the less dynamic labor market prevents the others from climbing the job ladder. Welfare effects are smaller as the overall output produced by these workers is lower. [16]

Table 7: Welfare effect of STW in terms of % of GDP by affected group

	high HC, high wage	high HC, low wage
at mean marginal utility	1.18	-1.41
at marginal utility of mean consumption	1.31	-1.57
	low HC, high wage	low HC, low wage
at mean marginal utility	0.65	-0.47
at marginal utility of mean consumption	0.72	-0.52

7 Conclusion

I find that STW has potentially large positive welfare effects, and that workers at the top of the job ladder benefit most. When accounting for substantial human capital loss, and recall at levels observed in the German labor market, welfare effects remain substantial. When few firms are credit constraint overall welfare effects are much smaller, since less jobs are saved. Each saved job, however, still has substantial positive welfare effects.

[16] These welfare effect aggregate to an overall positive one, as outside a recession unemployment is low, workers accumulate relatively high levels of human capital, and have opportunities to climb the job ladder such that at the onset of the recession a large fraction has high human capital and negotiated high wages.

I find that STW is unlikely to be well suited as an automatic stabilizer. If the respective crisis is not a financial crisis fewer firms are constraint, and STW is less efficient. Further, if a shock is structural such that workers in STW will eventually become unemployed, STW has little benefits. Last, its effectiveness depends on whether it saves the jobs of workers who stand to lose firm and job specific human capital, and negotiated high wages in the past.

My conclusions are reflected in policy provisions already present in Germany. The important role human capital plays is embodied in the financial incentives for on the job training during STW. During a crisis STW benefits may be augmented to be more generous, but without this firms are left with a substantial financial burden of about 34% of the wage and may useSTW for a maximum of 1 year.

The present paper opens two natural avenues for future research. First, the COVID crisis offers an exciting opportunity to study STW, with richer data and a different economic environment which may well lead to very different welfare effects. Second, introducing a job ladder mechanism as described by Krolikowski (2017), would be an exciting exercise.

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A Data

A.1 LIAB Data

I use linked employer employee social security data for Germany (Ruf et al., 2021b). See Ruf et al. (2021a) for a detailed description of the data source. Data access was provided via on-site use at the Research Data Center (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and subsequently remotely.

I construct a yearly panel from the employment and unemployment spells and match administrative employer and employee data I follow Dauth and Eppelsheimer (2020) and Schmucker and vom Berge (2021). In order to create a panel form firm surveys I largely rely on Umkehrer (2017).

I identify a worker as losing their job if they are fully employed in the previous year, and works for less than 9 month in the following year (to my knowledge there is no clean definition, see Kruppe et al. (2007)). My measure of STW exposure is generated by dividing the self reported number of short-time workers within an establishment by the number of employees in the establishment. I define an establishment as using STW if it indicates that it does in the survey.

A.2 Other Data

In order to obtain information on STW, unemployment, and the vacancy rate in Germany I utilize Statistik der Bundesagentur für Arbeit, the Eurostat labor flow survey, and for minimum wages the ILOSTat database. This information is used to cross check that the calibration of my model is reasonable, and to match the duration of unemployment.

B Algorithms and Equilibrium Definition

Equilibrium definition. Given the target tax rate τ^{st}, the initial joint distribution of households across $\mathcal{S}$ and assets, and the initial level of government debt, and a path for the job finding rate $\{\mu_t\}$ an equilibrium is a sequence of government debt and taxes $\{b_t, \tau_t\}$, prices $\{r_t, w_{bl,t}, w_{bh,t}, w_{gl,t}, w_{gh,t}\}$, value functions $\{U(.), J(.)\}$, policy functions $\{a(.)\}$ distributions of workers across $\mathcal{S}$ and asset levels, market tightness $\{\theta_t\}$, and dividends $\{DIV_t\}$ such that wages are determined as described above, the free entry condition holds, households solve their optimization problem, the asset market clears, the government budget constraint holds, taxes are determined as described above, and the $J(.)$ solves the firms difference equation.

Algorithm for steady state. I first fix the interest rate $r = 0.01$ and the tax rate to 0.3. Second, I guess θ and wages, which allows me to compute income and Markov process for household and firm.[17] Third, I solve the household problem and compute the equilibrium asset distribution. Fourth, I use the free entry, and wage setting conditions to update guesses for wages and market tightness. Finally, market clearing determines the asset level that results in an interest rate of 0.01, and I choose other government expenditure G to hit this asset level. This procedure is repeated until wages and θ converge. I then check that taxation is costly.

Algorithm to find transition path. To solve for the transition path I follow Boppart et al. (2018) and compute the response of the economy to an MIT shock. First I guess a path for all equilibrium quantities, and use it to calculate the household policy function backwards starting in equilibrium. Second, I determine the impact the respective shock has on the distribution of households across states and assets at the time when it occurs. Third, I compute the distribution of households across states and assets forward using the policy function from the first step, and the initial distribution from the second step. Finally I use the free entry, market clearing, and wage negotiation conditions to back out the equilibrium. This procedure is repeated until the paths for wages, market tightness, interest rate, and government debt converge.

[17] For firms this already possible at this stage because wages do not depends on assets