Does Short-Time Work Save Jobs? A Business Cycle Analysis[†]

Almut Balleer[1,*], Britta Gehrke[2], Wolfgang Lechthaler[3], and Christian Merkl[2,3]

[1]*RWTH Aachen, Germany, and IIES at Stockholm University, Sweden*
[2]*Friedrich-Alexander University Erlangen-Nuremberg, Germany*
[3]*Kiel Institute for the World Economy, Germany*

January 2014

Abstract

In the Great Recession most OECD countries used short-time work (publicly subsidized working time reductions) to counteract a steep increase in unemployment. We show that short-time work can actually save jobs. However, there is an important distinction to be made: While the rule-based component of short-time work is a cost-efficient job saver, the discretionary component appears to be completely ineffective. In a case study for Germany, we use the rich data available to combine micro- and macroeconomic evidence with macroeconomic modeling in order to identify, quantify and interpret these two components of short-time work.

Keywords: Short-time work, fiscal policy, business cycles, search-and-matching, SVAR
JEL Classification: E24, E32, E62, J08, J63

[†]We would like to thank Alan Auerbach, Jens Boysen-Hogrefe, Tobias Broer, Sanjay Chugh, Susanne Forstner, Matthias Hertweck, Pete Klenow, Per Krusell, Ryan Michaels, Conny Olovsson, Luigi Pistaferri, Chris Reicher, Emmanuel Saez, Alan Spearot, Gianluca Violante, Etienne Wasmer, Henning Weber as well as numerous participants at conferences and seminar presentations for helpful comments. We are indebted to Kai Christoffel and Alessandro Mennuni for discussing a previous version of this paper. Almut Balleer is grateful for support from the Knut och Alice Wallenbergs stiftelse KAW 2011.0144. Britta Gehrke and Christian Merkl are grateful for support from the Fritz Thyssen Research Foundation. An earlier version of this paper circulated under the title: Short-time work and the Macroeconomy.
[*]Corresponding author. Email: almut.balleer@iies.su.se.

1 Introduction

*"Germany came into the Great Recession with strong employment protection legislation. This has been supplemented with a "**short-time work scheme**," which provides subsidies to employers who reduce workers' hours rather than laying them off. These measures didn't prevent a nasty recession, but Germany got through the recession with remarkably few job losses." (Paul Krugman, 2009)*

In the Great Recession 25 out of 33 OECD countries used short-time work as a fiscal stabilizer. In countries such as Germany, Italy and Japan, more than 2% of the workforce were on short-time work in 2009, leading to fiscal expenditures of more than 5 billion Euro in each of those countries (see, e.g., Cahuc and Carcillo, 2011 and Figure 7 in the Appendix or Boeri and Bruecker, 2011). Yet, our knowledge about the business cycle effects of short-time work (STW henceforth) is limited so far. The purpose of this paper is to use German microeconomic and macroeconomic data as well as a macroeconomic model of the labor market in order to study the role of STW as a fiscal stabilizer.[1]

Germany has had a long tradition of STW and has used STW also outside of recessions.[2] Furthermore, Germany offers rich microeconomic data on the use of STW in establishments. In Germany, firms can use STW at any time subject to a set of rules. In order to be eligible, a firm has to convince the Federal Employment Agency ("Bundesagentur für Arbeit") that the expected demand for the firm's products is lower than its production potential and that it thus has to reduce its labor input.[3] If the Federal Employment Agency approves the STW application, it partly compensates workers for their lost income. The purpose of this instrument is to encourage firms to adjust labor input along the intensive margin (hours reduction) rather than the extensive margin (firings). Typically, more firms are eligible to use STW during a recession than during a boom. Thus, similar to the tax system, the institution STW as such can have automatic stabilization effects. We call this the rule-based component of STW. Beyond this, the German government frequently changes specific features of this rule such as the eligibility to use STW, i.e., there is also a discretionary component of this policy.

From the perspective of employers and forward-looking employment relationships, one might expect that the discretionary and rule-based components of STW have rather different effects on the economy. An important goal of this paper is to disentangle the potentially different effects of these two features of STW. The availability of both microeconomic panel data and macroeconomic time-series data from Germany makes this possible. In contrast with existing studies, which do not discuss

[1] Recent empirical cross country studies on STW (Cahuc and Carcillo, 2011, Arpaia et al., 2010, Hijzen and Venn, 2011, IMF, 2010 and OECD, 2010) found positive employment effects but were restricted to the Great Recession and thus miss the time-series perspective. For microeconomic studies with German data see Bellmann et al. (2010), Bellmann and Gerner (2011) and Speckesser (2010). The macroeconomic fiscal policy literature has so far almost exclusively focused on fiscal multipliers of traditional government tax and spending instruments. Blanchard and Perotti (2002), Mountford and Uhlig (2009), and Brückner and Pappa (2012) use structural VARs for this purpose and Cogan et al. (2010) or Christiano et al. (2011) use dynamic stochastic general equilibrium (DSGE) models. See Braun et al. (2013) for a recent normative, non-dynamic study, comparing the effects of STW to unemployment insurance.

[2] See Figure 1 (solid line) for post-unification Germany and Figure 8 in the Appendix for STW usage in Germany back to 1975.

[3] See Burda and Hunt (2011, p. 297) or Brenke et al. (2013) for an excellent description of German "Kurzarbeit".

the possible confounding of the two features of STW, we find that whereas the rule-based component does work as an automatic stabilizer, unexpected discretionary STW appears to have no effect on unemployment. Given that many attribute much of the relatively favorable German unemployment experience during the last recession to the extra efforts at providing short-time work, this is arguably a surprising finding. It suggests more generally that the benefits of having a discretionary component of STW as a standard part of the labor-market policy toolkit are limited.

How can these findings be interpreted? We attempt at an answer by formulating a model of a frictional labor market with STW. This setup allows us to study the relationship between STW and unemployment explicitly. In particular, it highlights the importance of future expectations about political institutions as an important determinant of hiring and firing on the labor market. As a matter of modeling, to our knowledge our paper is the first to integrate STW with both a rule-based and a discretionary component into a frictional labor-market model amenable to quantitative assessment.[4]

Our research strategy consists of three interrelated steps, namely the estimation of an elasticity from microeconomic data, a structural vectorautoregression (SVAR) and the simulation of a macroeconomic model of the labor market. We use establishment level data to estimate the automatic reaction of STW with respect to changes in output. Since all firms are subject to the same rules, we can use the cross-sectional dispersion of STW usage and a measure of output over time in order to estimate this elasticity. This elasticity is required for two purposes: First, we use it as a short-run restriction on the contemporaneous variation between STW usage and output for the identification of a SVAR in the spirit of Blanchard and Perotti (2002). Second, it imposes discipline on the parametrization of our macroeconomic model.

While the SVAR allows us to estimate the effects of unexpected discretionary STW policy interventions, the macroeconomic model allows us to run a counterfactual analysis of an economy with and without STW and hence, to quantify the automatic stabilization effects. Our SVAR results show that the effect of unexpected discretionary STW policy interventions on employment and unemployment is not statistically significant. However, we document a moderate stabilizing effect on output. Our counterfactual model analysis shows that STW acts as a fairly strong automatic stabilizer. In our baseline scenario, unemployment fluctuations are reduced by 21% and output fluctuations are reduced by 4% (compared to the economy without STW).[5]

The model provides an explanation for the differences between automatic stabilization and the effects of discretionary policy changes. The model consists of a standard search and matching frame-

[4]Faia et al., 2013 use a labor selection model and analyze STW as one of several fiscal instruments to stimulate the economy. Krause and Uhlig, 2012 use a search and matching model along the lines of Ljungqvist and Sargent, 2007 to analyze the effects of the German Hartz labor market reforms. They do not model STW explicitly but introduce labor market subsidies for the Great Recession to match the small increase in the unemployment rate during this period. Both studies do not distinguish between the discretionary and the rule-based component, while we show that this distinction is crucial for the evaluation of STW. Furthermore, our model describes the actual institutional features of STW in more detail than these existing studies. This allows us to match the stylized facts of STW that we document in the data. See Section 5 for more details.

[5]As laid out in more detail in Section 5, the tax system that stabilizes employment and unemployment fluctuations to a similar degree represents a much larger share of GDP than STW. Thus, we consider the stabilizing effect of STW as very strong relative to its costs.

work with endogenous separations and firing costs. We assume that STW is the only possibility of labor adjustment along the intensive margin. This assumption can be justified on two grounds. First, it reflects the fact that, in Germany, labor adjustment along the intensive margin mainly happens through institutional channels such as STW (see Section 2 for a discussion). Second, we calibrate the model such that it yields an elasticity of STW with respect to changes in output that is line with our empirical estimates. Thus, we are confident that allowing for other possibilities of adjustment along the intensive margin would not change our results significantly (for more details see Section 5).

In our model, workers are subject to idiosyncratic profitability shocks each period. Whenever the profitability of a worker is low enough such that the worker would otherwise have been fired, the government allows firms to use STW for this particular worker. The firm will decide to send her on STW whenever it is more profitable to keep her at reduced working hours rather than to fire her. By reducing the losses generated by unprofitable workers, STW directly reduces firing. By increasing the value of a job, STW indirectly increases hiring. During a recession more workers become automatically eligible for STW. This implies that more of the labor adjustment can be accomplished through the intensive margin relative to the extensive margin, as intended by the policy. This way, STW automatically stabilizes employment and, with it, output. In contrast, discretionary changes in the eligibility criterion of STW do not lower unemployment in our model if they are not used persistently, and, hence do not affect future expectations. Then, the policy change subsidizes workers that would not have been fired anyway. However, the policy change may have some effects on aggregate output by reducing the working time of inefficient worker-firm pairs.

Our baseline model encompasses institutional features such as firing costs and collective wage bargaining that describe a typical central European economy with relatively low labor market flow rates like the German one. Our analysis shows that these institutions matter for the effects of STW. In an economy with flexible labor markets (low firing costs, high flow rates, individual bargaining), the stabilizing effects of STW are much lower than in an economy with rigid labor markets. This result corresponds neatly to the empirical fact that mainly countries with rigid labor markets make extensive use of STW (see Figure 7 in the Appendix).

The rest of the paper is organized as follows. Section 2 documents some stylized facts on STW in Germany. Section 3 presents the microeconometric evidence on STW. Section 4 discusses the evidence from the structural VAR. Section 5 describes the model. Section 6 shows the simulation results. Section 7 concludes.

2 Short-time work facts

2.1 Short-time work over the business cycle

Germany has had a very long tradition of STW institutions. This allows us to assess the movements of STW over the business cycle. The year 1975 marks the beginning of the systematic use of STW schemes in Germany, although STW has been used even before. Due to the oil price shocks and the

subsequent recession, the German legislature passed a law inscribing the future use of STW schemes to be targeted explicitly to support employment, not to insure workers against wage cuts. In 1975, the legislature also established the reimbursement of workers covered by STW schemes to be 60% of the current wage. This law is still in place today.[6]

The solid line in Figure 1 shows the quarterly fraction of workers that are covered by STW schemes relative to total employment in Germany from 1993 to 2010.[7] We refer to this series as STW usage or the extensive margin of STW in the following. We show the series in logs for easier inspection and since this is the transformation used in the empirical exercises. The dashed line in Figure 1 depicts the intensive margin of STW, measured by the average hours reduction (relative to full time) of workers covered by STW programs. We use the post-reunification period as our baseline sample for two reasons. First, this excludes the usage of STW related to the transition period after reunification as well as the use of STW compensation in lockouts until 1986. This ensures that the VAR attributes movements in STW usage to discretionary policy changes that were implemented to stabilize employment in response to the business cycle ("konjunkturelle Kurzarbeit"). Second, we have information about the cyclical behavior of the intensive margin of STW in the shorter sample. We use this additional information to check the validity of our model.[8]

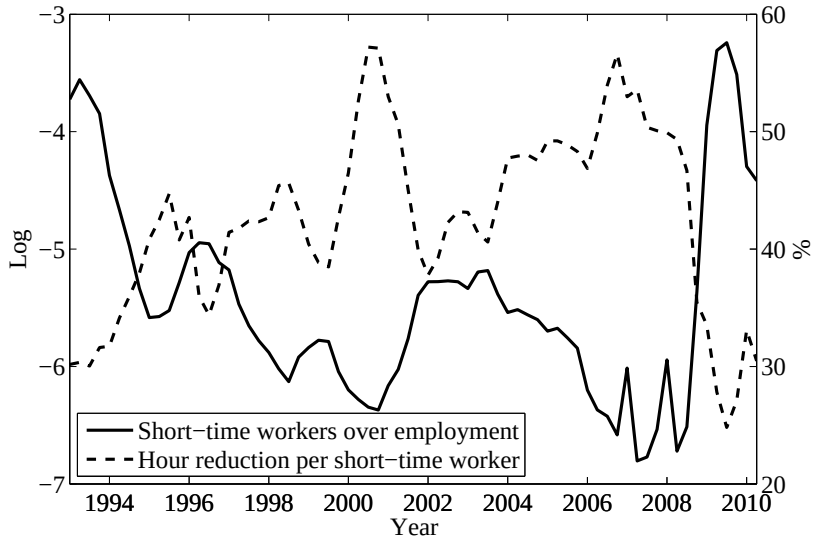

Figure 1: The extensive and the intensive margin of STW 1993-2010. The extensive margin of STW is measured by the log number of short-time workers as a fraction of total employment (left scale). The intensive margin of STW depicts the average hours reduction by those on STW as a fraction of hours worked when full-time employed (right scale).

[6] See Flechsenhar (1979), Will (2010) and Brenke et al. (2013).

[7] Compare Table 5 in the Appendix for the data sources of all time series used in the analysis.

[8] We have information on the extensive margin of STW since 1975, compare Figure 8 in the Appendix. The long series consists of numbers for West Germany before and West and East Germany after the reunification in 1991. The data for West Germany and total Germany perfectly co-move except for a short period after the reunification in which STW was heavily used in East Germany to alleviate the transition from a planned to a market economy. We use the long time series to check the robustness of our results in Section 4.

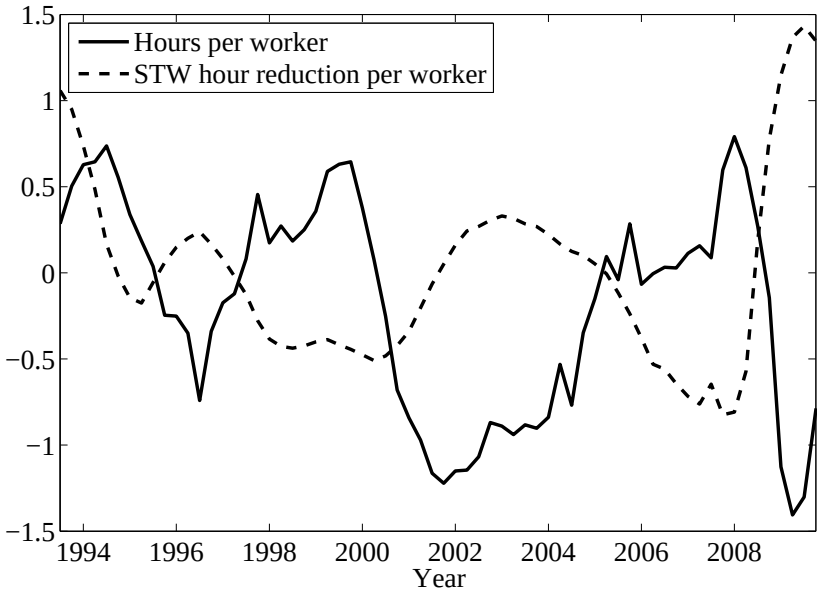

Figure 2: Hours per worker (solid line) are measured by total hours worked divided by employment. The hours reduction per worker due to STW (dashed line) multiplies the hour reduction per STW worker with the fraction of short-time workers in employment. The sample shows annual averages from 1993 to 2010. Both series are HP filtered with $\lambda = 1,600$, the hours per worker cycle is multiplied with 100 for presentational reasons.

On average, 0.69% percent of the workforce were working short-time in the post-reunification period (0.83% in the long sample starting in 1975). Two large peaks indicate heavy use of STW institutions and, possibly, active discretionary policy favoring the use of STW: the post-unification period of the early 1990's and the recent Great Recession (in addition, the mid 1970's and early 1980's in the long sample, i.e. the two oil price shocks). About 1.5 million or 3.8% of workers in Germany were on STW at the peak of the Great Recession in May 2009. But also outside the severe recessions, the graph documents substantial variation in the series. STW usage both inside and outside severe recessions is negatively correlated with growth in GDP and employment and hence the business cycle (see Figure 9 in the Appendix). These contemporaneous correlations are potentially driven by two effects that are of interest to us: the rule-based and the discretionary component of STW. In our model in Section 5, STW automatically increases in a recession because more firm-worker pairs are unprofitable and thus eligible to use STW. Beyond this, policy makers may facilitate the access to STW in a discretionary way. In Section 3 and 4, we estimate the rule-based and discretionary component of STW in the data.

2.2 Adjustment of labor input via STW

For the cyclical adjustment of labor input (total hours worked) in Germany, the extensive margin of labor input (number of workers) is generally more important than the intensive margin (hours per

worker).[9] In contrast to the US, the importance of adjustment along the intensive margin increases in recessions in Germany. This was the case in particular in the Great Recession (10% adjustment along the extensive margin versus 90% adjustment along the intensive margin), as also documented in Burda and Hunt (2011). Our model reflects the fact that labor adjustment along the intensive margin becomes more important in recessions.

The intensive margin of labor input, given by hours worked per worker, can vary because the number of workers covered by STW programs (extensive margin of STW) changes since these workers work fewer hours than the regular full-time employed. Hours per worker can also vary when those on STW programs work more or less within these programs (intensive margin of STW). Figure 1 shows that these two STW margins are negatively correlated (with a correlation of $-.90$). This means that when more workers are covered by STW programs, hours worked of these workers increase, i.e., the more workers are on STW, the lower is the reduction in hours worked due to STW. At first this seems surprising, but our model provides a plausible intuition: Workers whose profitability is too low to be kept full-time employed, but too high to be fired, will work reduced hours under the STW scheme. The less profitable a worker is, the shorter she will work. During a recession more workers are fired. This cleansing effect increases the average quality of short-time workers (in terms of idiosyncratic profitability), and hence lowers the optimal average hours reduction in recessions.

Figure 2 (dashed line) shows a measure of the reduction of hours worked per worker due to STW as the product of the hours reduction per STW worker and the fraction of short-time workers in employment. This measure strongly comoves with hours worked per employee (solid line) in the economy (with a correlation of $-.69$ measured using cyclical deviations from an HP-trend). Although this simple correlation does not provide a formal test, it suggests that STW is an important determinant of labor adjustment along the intensive margin. Complementing our findings, Abraham and Houseman (1994) find in a study for the 1970's and 1980's that the existence of STW schemes renders the hours adjustment in Germany equally flexible as the US adjustment.

Burda and Hunt (2011) decompose the hours reduction in the Great Recession into various different sources of adjustment. Their results emphasize the notion that labor market frictions in Germany are such that adjustment along the intensive margin is relatively costly due to rigid institutional constraints, e.g., heavy working time regulation. Given these constraints, adjustment along the intensive margin mainly happens through institutions, such as STW, but also working time accounts, overtime or regular part-time work.[10] Our establishment survey data described below documents that firms that

[9] Between 1970Q1 and 2012Q2, 57% of labor input in Germany is adjusted along the extensive margin. Outside the large recessions, the extensive margin accounts for about 63% of the overall adjustment of labor input. We measure this as in Fujita and Ramey (2009) using the cyclical components (filtered with the HP filter with $\lambda = 1,600$) of total hours t, hours per worker h and employment n. The proportion of the intensive margin is given by $\frac{cov(t,h)}{var(t)}$, the proportion of the extensive margin is given by $\frac{cov(t,n)}{var(t)}$. Similar to the case of Germany, Reicher (2012) shows that the extensive margin is most important for labor adjustment in most of the continental European countries.

[10] With working time accounts, the total annual working time is kept constant, but hours can be adjusted within the year. In contrast to STW, working time via accounts, overtime or part-time work can change, but is fully compensated by the firm. STW programs subsidize wages and, hence, constitute a regulatory framework which loosens working-time regulations for worker-firm pairs with bad idiosyncratic shocks, particularly in recessions.

operate working time accounts tend to use more STW than other firms. This indicates that working time accounts and STW are complements rather than substitutes when adjusting hours. Taking annual averages at a quarterly basis in Figure 2 helps us to (at least partly) wash out the influence of overtime or working time accounts. Complementary, Burda and Hunt (2011) identify STW as the most important source of labor adjustment along the intensive margin. In our analysis, we focus exclusively on one possibility to adjust the intensive margin of labor input, namely through STW. Hence, we provide a lower bound of stabilization effects taking into account all possible ways of institutional adjustment of hours. Consistent with this assumption, we do not target the overall changes in the intensive margin to changes in output in our model, but use the results from our microeconometric analysis to calibrate the elasticity of STW with respect to changes in output.

3 Estimating the short-time work elasticity using microeconomic data

3.1 Specification

In the time-series data presented in the previous section, it is not possible to distinguish whether STW usage fluctuates because of changes in the business cycle (rule-based component) or because of changes in policy (discretionary component). We estimate the automatic stabilization effects of the rule-based component of STW from microeconomic data and use it for two purposes: First, in order to disentangle the two components of STW in the structural VAR. Second, as the key calibration target of our model and the corresponding stabilization exercise. In our model, the rule-based component of STW describes the elasticity of STW usage to changes in output when STW rules remain unchanged. When output drops, more worker-firm pairs become unprofitable and thus eligible to use STW. Firm output can change because of idiosyncratic shocks or because of aggregate shocks. Without changes in output, STW usage can only change when policy changes. We use this insight from the model in order to estimate the rule-based component from a firm panel for recent years.

The time and cross-sectional dimension of the panel allows us to identify the rule-based component of STW. STW policy in Germany is implemented at the federal level providing the same rules for all firms. Hence, the cross-sectional variation of firm output and STW usage at a given point in time provides information about the rule-based component. However, firms that use STW (or a lot of STW) may systematically differ from firms that do not use STW (or very little STW). Consequently, we use within-firm variation over time rather than between-firm variation in output and STW usage in order to estimate the rule-based component. The following relationship describes the effect of output $\mathbf{x}_{it}$ on the fraction of short-time workers in employment y_{it} in firm i and year t:

$$y_{it} = \mathbf{x}_{it}\beta_1 + \alpha_i + \gamma_t + \mathbf{z}_{it}\beta_2 + u_{it}.$$

Here, α_i controls for time-invariant firm-specific effects in our estimation, hence systematic differences between firms in our sample. In order to rule out that we pick up policy changes in our

estimation, we further include year-specific effects γ_t which measure changes in STW usage over time when output does not change. The error term u_{it} is white noise, $\mathbf{z}_{it}$ denotes the vector of additional control variables that will be specified below. We estimate the elasticity of STW usage to output changes using three different specifications: A linear specification and two non-linear models (a Tobit and a Heckman model) that will be described in detail in the next section.

We employ the Institute for Employment Research (IAB) Establishment Panel, a representative German establishment level panel data set that surveys information from almost 16,000 personal interviews with high ranked managers. The IAB panel contains information on the number of employees in STW in each firm in four waves: 2003, 2006, 2009, and 2010.[11] The number of short-time workers in each firm is measured in the first half of year t. In order to abstract from firm-size, we denote short-time workers relative to the total number of employees within a firm. This is also consistent with our time-series measure and the definition of STW usage in the model. Note that the fraction of short-time workers in employment can be zero for a given firm. In period $t-1$, firms report their expected revenue for period t. We use these values as our measure for firm-level output in period t for three reasons: First, we argue that this is the relevant measure that the firm uses in the STW decision (firms apply at least three months before they use STW). Second, this variable reflects the notion that firms have to show their need for STW, i.e., a danger of a reduction in labor input due to a fall in revenue, already in their application to the employment agency.[12] Third, using expected revenue avoids a potential endogeneity problem in the estimation as the use of STW in period t affects current profits in period t, but not previously expected revenue. As additional controls in the estimation, we use the number of employees in the previous year as a measure of time-varying firm size. Further, industry dummies allow for the possibility that firms within different sectors in the economy use STW differently in a systematic way.

3.2 Results

Table 1 documents the estimation results. Across linear specifications (1 to 3), the effect of changes in expected revenue on STW usage is precisely estimated to range between -2.80 and -3.13 depending on whether we add year fixed effects or the size of the firm. These estimates measure the semi-elasticity of STW usage (in levels) to changes in expected revenue (in logs) and imply that in response to a one percent drop in expected revenue, firms have on average about 0.03 percentage points more workers on short-time. Year fixed effects are negative in 2006 and positive in 2009 and 2010 indicating that it is important to control for discretionary policy changes. Further, the larger the firm the more

[11] This dataset is widely used in a number of different studies, see for example Dustmann et al. (2009). Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and subsequently through remote data access. Table 6 in the Appendix provides descriptive statistics of the IAB establishment panel with respect to STW.

[12] See http://www.arbeitsagentur.de/zentraler-Content/Vordrucke/A06-Schaffung/Publikation/V-Kug-101-Anzeige-Arbeitsausfall-ab-01-2012.pdf

STW is used in our sample.[13]

The linear specification ignores an important feature in the data. The firm makes two decisions with respect to STW: First, whether to use STW or not (participation decision) and, second, how much STW to use. In fact, across our sample, only 6.5% of all firms use STW on average, while for the others the number of short-time workers is zero. We therefore estimate two further models, a Tobit model and a Heckman selection model that take these non-linearities in the data into account.

	log exp. revenue	derived elasticity	year fixed effects	employees in firm	observations
Linear fixed effects					
(1)	-2.802^{***}	-4.003			$39,545$
	$[0.306]$				
(2)	-2.968^{***}	-4.240	yes		$39,545$
	$[0.299]$				
(3)	-3.131^{***}	-4.473	yes	yes	$31,824$
	$[0.342]$				
Fixed effects tobit					
(5)	-2.319^{***}	-3.313	yes		$31,824$
	$[0.286]$				
(6)	-2.614^{***}	-3.734	yes	yes	$31,824$
	$[0.311]$				
Fixed effects heckman					
(7)	-4.972^{**}	-7.103	yes		$31,824$
	$[2.57]$				
(8)	-4.87^{*}	-6.957	yes	yes	$35,264$
	$[2.75]$				

Table 1: Elasticity estimates. Dependent variable is the number of workers in STW over total employees in the firm. *** denotes 1% significance, ** denotes 5% significance, * denotes 10% significance.

The Tobit model deals with the censored data, but does not model the participation decision explicitly. Following Wooldridge (2010, p. 835), we estimate a Tobit model with fixed effects using pooled Tobit and Mundlak terms.[14] We report censored marginal effects which means that our estimates summarize the aggregate effect of a one percent change in expected revenue on the STW usage

[13] We look at various additional specifications for robustness of our results. First, for a subsample of those firms that operate working time accounts, the STW reaction is stronger. Hence, more STW is used in firms with working time accounts than in those without. Second, as the usage of STW is likely to differ across industries, we also include industry fixed effects in the estimation as a robustness check. We can identify these effects, since some firms in our sample switch industries over time. Our estimates are robust towards this modification. Last, we further add an interaction term of changes in expected revenue and year-specific effects, allowing for the possibility that firms react differently to output changes in different states of the business cycle. When including interaction terms, we calculate the elasticity based on β_1 and the average of the coefficients of the interaction terms over all years. Including interaction terms hardly changes the estimated elasticity. Detailed results for all robustness checks are available upon request.

[14] As introduced by Mundlak (1978), we include firm-specific means of explanatory variables to capture permanent level effects in our estimation.

of all firms. Due to the nonlinear structure of the model, marginal effects are computed for each value of the right-hand side variables and are then averaged. Our estimate ranges from -2.32 to -2.61 (specifications 5 to 6) which corresponds to a response of STW of about $.025$ percentage points to a one percent reduction in revenue. Again, our results are significant at the 1% level.

Different from the Tobit model, the Heckman selection model explicitly models the participation decision. In particular, we need to argue why and how the decision of a firm of whether to use STW or not is determined differently from the decision on how many short-time workers to use. A panel version accounting for individual fixed effects is derived in Wooldridge (1995).[15] We use the fraction of firms using STW in the firm-specific industry sector as the exclusion restriction to identify our Heckman model. We argue that a large fraction of direct competitors using STW increases the individual firm-specific probability of using STW (as the stigma of admitting the need of STW is gone), while it does not drive the firm-specific number of workers in STW. Indeed, substantial variation in this variable exists across industries and we find significant effects on the STW decision in our estimation. In analogy to above, we want to measure the marginal effect of changes in expected revenue on STW over the whole sample of firms, and not only on those that use STW. In the Heckman approach, this is equivalent to the coefficients from the pooled OLS estimation controlling for selection into STW. Across Heckman specifications (7 to 8), our estimates range from -4.87 to -4.97 which means that a one percent drop in expected revenue generates an increase of about 0.05 percentage points in STW. Our estimates are significant, at least at the 10% level. Standard errors of the inverse Mill's ratios indicate that selection is present in our model specification.

Since we have estimated the automatic feedback effects of changes in expected revenue on the use of STW in levels (a semi-elasticity), but use elasticities in the structural VAR and calibration of the model, we transform this estimate into an elasticity by dividing it by the average STW use in the sample of interest. For our baseline sample of 1993Q1-2010Q4 this corresponds to dividing by an average STW use of 0.69%. We report the derived elasticity estimates in the second column of Table 1. Our most conservative estimate of the STW elasticity across specifications is -3.31, while we obtain -7.10 at maximum.

4 SVAR evidence

4.1 Identifying short-time work shocks in a structural VAR

In the SVAR exercise we estimate the effects of discretionary STW policy on macroeconomic variables such as output and unemployment. The challenge when estimating these effects is that we do not explicitly observe exogenous discretionary changes in STW policy. The reason is that STW policy is effective along many dimensions, e.g., with respect to the eligibility criteria of firms (which are

[15] Estimation is pursued by first estimating a probit for the selection in STW separately for each year t. In a second step, we run a pooled OLS regression on the selected sample accounting for the inverse Mills ratios from step one and time fixed effects. We correct for firm fixed effects by including Mundlak terms and obtain standard errors using a panel bootstrap. See Wooldridge (2010, p. 835).

loosely defined and can potentially be interpreted very differently[16]), the legal allowances of the duration of workers in STW, or the degree to which the government can additionally reduce the firms' cost that is related to the use of STW (such as covering social security contributions of workers in STW[17]). Instead of using a direct measure of STW policy, we use a SVAR in the tradition of Blanchard and Perotti (2002)[18] to estimate the effects of discretionary STW policy shocks based on a simple assumption: Policy reacts with a one period implementation lag to changes in output. This seems to be a reasonable assumption in quarterly data.

The general VAR setup is based on a reduced-form estimation of

$$Y_t = B(L)Y_{t-1} + e_t, \qquad t = 1, ..., T,$$

where Y_t is a $N \times 1$ vector of endogenous variables, and the lag polynomial $B(L)$ represents $N \times N$ coefficient matrices for each lag up to the maximum lag length k. The reduced-form innovations are denoted by the $N \times 1$ vector e_t, which are assumed to be independent and identically distributed with mean zero and covariance Σ_e. We seek to identify the underlying structural shocks ω_t from transforming the reduced-form innovations e_t using a transformation matrix A such that

$$Ae_t = \omega_t.$$

In order to correspond to a model in which economic shocks are independent from each other, the structural innovations ω_t are assumed to be orthogonal (i.e., Σ_ω is diagonal). Without loss of generality, we normalize the diagonal elements of Σ_ω to unity. From orthogonality and normalization, we obtain $N(N+1)/2$ restrictions to identify the N^2 elements of the transformation matrix A. In order to exactly identify this matrix, we need $N(N-1)/2$ additional restrictions in order to obtain the underlying structural shocks. In a simple bivariate VAR, we hence need one additional restriction in order to find A.[19]

Two variables are important for identification in the VAR: output and STW usage. Key to the VAR exercise is to decompose the negative correlation between these two variables into an output (or business cycle) shock and a discretionary STW policy shock. Note that the assumption about the implementation lag of policy implies that all contemporaneous covariation of the STW usage and output is described by the rule-based component of STW. Put differently, output (or business cycle) shocks are defined through their automatic effects on STW usage in the short-run. This does not mean that policy shocks are unrelated to the business cycle. In fact, our results below show that large STW

[16] See the discussion in Burda and Hunt (2011).

[17] See Bundesministerium für Arbeit und Soziales, 2011.

[18] Blanchard and Perotti (2002) seek to identify the effects of a shock in fiscal policy on output, hence the output multiplier. We apply their framework in order to identify STW policy shocks.

[19] The identification in the bivariate VAR can be extended in a straightforward way to include more shocks and more variables. The restrictions to identify output and policy shocks remains unchanged in this case and it is assumed that additional shocks have no effect on output and the policy variable on impact. See Blanchard and Perotti (2002) or Caldara (2010) for a detailed description of the implementation.

policy shocks occur during strong economic expansions and contractions.

We impose the value estimated from the microeconomic data in the previous section as the additional restriction on A as described above. Given that we have identified business cycle shocks via the rule-based component of STW, all remaining variation of STW usage and output is then attributed to discretionary changes in STW policy. Clearly, if the imposed automatic feedback effects from the business cycle onto STW are negative and large, the effect of the policy shock on output is small. In fact, if the negative automatic feedback effect is larger in absolute value than the negative covariation between STW and output, the effect of policy shocks on output becomes positive on impact. Hence, the value of the elasticity potentially plays a crucial role for the estimated effects of the discretionary policy shocks.[20] We look at robustness of the results to different values of this elasticity below and find that, within a reasonable range, the elasticity only matters for the impact period.

Note that we identify the VAR with an elasticity describing how STW usage reacts to output changes on the firm level. This elasticity is not necessarily equal to a macroeconomic measure of the output elasticity of STW usage that would take into account all possible general equilibrium effects. Informing the VAR with this elasticity means that we assume that the two are the same (or very similar). In our model below, we argue that this is the case when labor market tightness does not play an important role in the wage bargaining. This result naturally arises in a model of collective wage bargaining, because the threat-point of the firm bargaining with a union cannot be to dismiss the whole workforce. Collective wage bargaining is a realistic description of European labor markets like the German one. If wages were allowed to adjust to changes in labor market conditions, our model predicts the macroeconomic elasticity to be smaller than the estimated one. Intuitively, wages that react more to business cycle conditions stabilize the value of a worker and thus rely less on STW. This suggests that we might use a value too low for our identification. Our robustness checks below show that smaller elasticities generate the same qualitative results.

4.2 Results

In our baseline estimation of the effects of business cycle shocks and exogenous STW policy changes, we specify a VAR with three variables: the fraction of short-time workers in employment (in logs), GDP growth and the log unemployment rate. We specify GDP in growth rates, since unit root tests suggest that this variable has a unit root.[21] In addition, we use GDP growth as measuring the business cycle component of this variable, since we can compare this to the output of a model with a constant steady state as the one presented below. We estimate the reduced form VAR as described above with four lags in the specification. We then use the formal relationship between the output elasticity of STW and the coefficients in the matrix A (as derived by Caldara (2010) in the case of government spending or tax shocks) in order to implement the short-run restrictions. Here we use our lowest elasticity estimate of -3.3 as our baseline. We estimate the VAR for our baseline sample 1993Q1-2010Q4.

[20] Caldara (2010) has pointed this out with respect to the estimation of government spending and tax shocks.

[21] In the case of unemployment, unit root tests give ambiguous results. If unemployment was integrated, it is clearly not cointegrated with GDP. In line with the model and the literature, we treat unemployment as a stationary variable.

To see whether our estimated STW policy and output shocks are plausible, we consider the historical time series of the two shocks (shown in Figure 10 in the Appendix). Since these shocks are calculated from the reduced form residuals in the VAR, they occur every period, but differ in sign and magnitude. We do not literally interpret every one of these small shocks as an actual output shock or discretionary policy shift. Rather, a moving average of the two shocks indicates periods of economic as well as discretionary policy expansion and contraction. Note that, except for the same quarter, we do not assume whether or how strong policy shocks are related to output shocks. Our identifying assumption merely states that output shocks and policy shocks cannot exactly coincide. Our results show that economic contractions and discretionary policy expansions generally have a (lagged) positive correlation, i.e., discretionary policy changes are related to the business cycle. The graph shows that policy expansions (contractions) sightly lag the economic contractions (expansions), e.g., in the contraction in the late 90's, the expansion around 2008 and in the Great Recession. The graph also shows that discretionary policy was not implemented in the economic contraction in the mid-2000's. These relationships reflect the usage of STW that was documented in Figure 1. Generally, STW policy works along many dimensions most of which we cannot directly observe. One exception is the legal maximum period of eligibility which is shown in Figure 12 in the Appendix. The Great Recession episode illustrates that our estimated policy shocks coincide with periods in which this aspect of discretionary policy is changed such as the reduction in 2008 and the expansion of the eligibility period in 2009 and its reduction in 2010.[22]

Figure 3 shows the quarterly responses of output, STW usage and unemployment to positive one-standard-deviation shocks in output and policy. To be comparable to the model output in Section 5, we show the response of output as deviations from a linear trend, i.e., in growth rates not in levels, and the responses of the unemployment rate in percentage points. The confidence intervals depict 90% bootstrapped bands that were calculated in line with Kilian (1998). The left column of Figure 3 shows the responses to a positive business cycle shock. After this shock, output increases, while STW falls reflecting the imposed short-run restriction of the automatic feedback effects along the business cycle. Unemployment falls in a boom. The right column of Figure 3 depicts the responses to a positive discretionary STW policy shock. After a positive policy shock, STW is used more. Since we have not imposed any restriction on this response, it is reassuring that it is in fact positive. Output does not show any significant impact response to a STW policy shock, except for a marginally statistically significant increase after two quarters. Strikingly, the unemployment rate does not significantly react to a STW policy shock. This is a surprising result, as STW schemes were initially designed to support employment. Our model will provide an interpretation of this result: temporary discretionary changes in STW policy do not affect future expectations, and therefore hiring and firing decisions.

[22] As a robustness check, we can use the small time series of the eligibility period changes as a direct measure of one type of STW policy shocks. As a result, output, STW usage and unemployment all increase as in our SVAR results. The results are insignificant, however, which is the result of very little variation in the series. Hence, the conclusion that discretionary STW policy is ineffective remains. The results are available upon request.

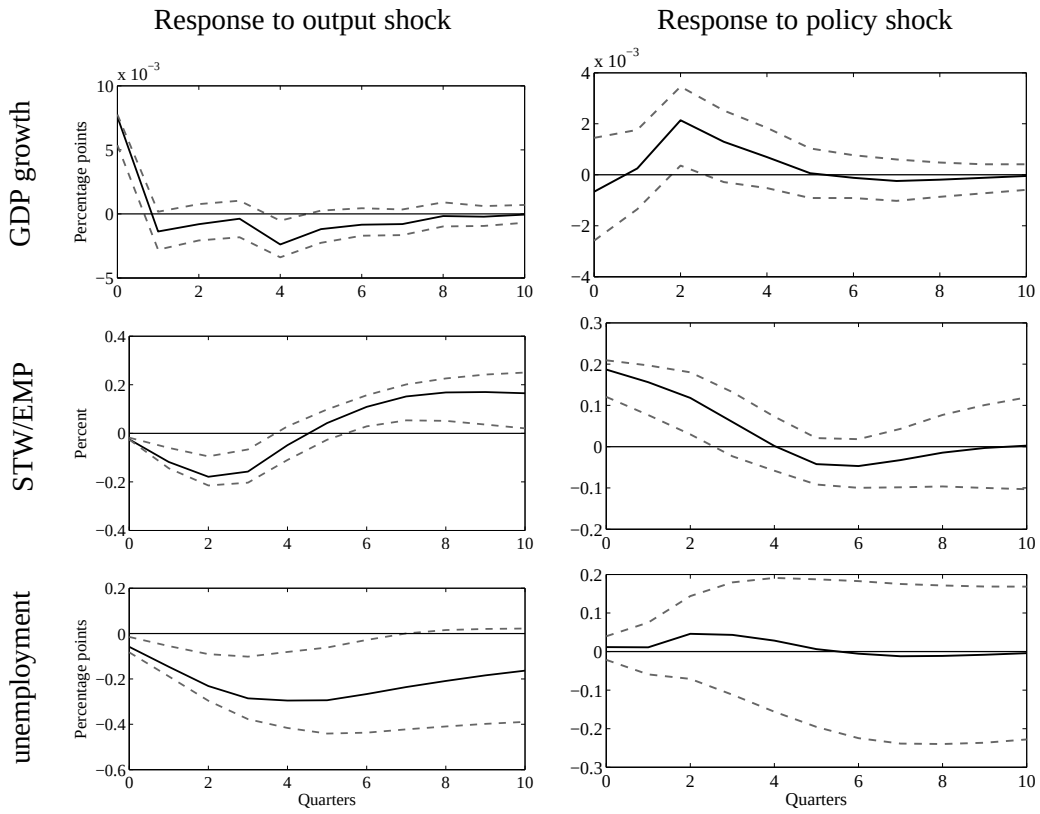

Figure 3: Impulse responses to output and STW policy shocks. SVAR estimated with log STW per employed workers, GDP growth and the log unemployment rate for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped bands with 10,000 draws.

4.3 Robustness

Above, we have discussed the importance of the imposed short-run restriction for the output elasticity of the policy variable. Given this, we would like to know how different assumptions about this elasticity affect the results, in particular the estimated responses of output and unemployment after a policy shock. Figure 11 in the Appendix compares these responses for various values of the elasticity. Varying the elasticity does affect the impact response of GDP to the policy shock[23]. In line with our intuition from above, the more of the negative correlation between output and STW usage is explained by the automatic feedback effects, the larger and possibly positive are the effects of the policy shocks on output. In fact, if the automatic feedback effects are relatively large, output significantly increases on impact. If they are zero or positive, output falls, significantly in the latter case. Note, however, that the estimates for later periods hardly change when different elasticities are used.

The effect of policy shocks on unemployment behaves similarly when varying the elasticity. Unemployment falls for relatively large negative elasticities and increases for zero or positive elasticities. However, except for positive elasticities of unplausibly high values, these effects are all insignificant.

[23]This is similar to what Caldara (2010) has shown in the case of tax shocks.

If we consider variation of the elasticity between -2.90 (corresponding to our most conservative estimate in column one of Table 1 plus the estimated standard deviation), -4.56 (corresponding to our largest Tobit estimate minus the respective standard deviation) and -11.90 (corresponding to our largest Heckman estimate minus the respective standard deviation), the responses of output and unemployment to policy shocks change very little.

We address the robustness of our results along various other dimensions. Table 7 in the Appendix summarizes the results of our robustness checks.[24] Most importantly, we consider whether the two major recessions with a large use of STW in our sample reflect different dynamics in the response to policy shocks than more normal times. In other words, there may be business cycle asymmetries that affect our identification of the dynamics. In order to address this, we estimate our baseline specification including recession dummies for 1991Q1-1993Q1 and 2008Q1-2009Q2[25] and show that the results are not affected in any significant way.

As argued above, identification of STW policy shocks is difficult, as it potentially works along many dimensions and we do not directly observe policy changes. One exception is the legal maximum period of eligibility for a particular worker in STW. We have information about this for our baseline sample, Figure 12 in the Appendix shows a plot. One may associate periods with legal changes to this maximum period as episodes of particular political focus on STW schemes. In order to exclude the possibility that STW policy was conducted in a systematically different way together with these legal changes, we incorporate a dummy controlling for these changes into our VAR. This is similar in spirit to Blanchard and Perotti (2002) who incorporate a dummy for particularly large tax reforms into their fiscal VAR. Table 7 in the Appendix shows that our results are robust to controlling for legal changes this way.

In our model, business cycle shocks are measured by changes in output or labor productivity. Table 7 shows that our results are robust to replacing GDP with GDP per employed worker in the specification. This result may reflect the fact that relatively unproductive workers work short-time, while relatively productive workers continue to work full time or even increase their labor input. Hence their weight in aggregate productivity increases. We also use the GDP deflator instead of the CPI to deflate output. This does not change our results substantially. In order to consider the robustness of the unemployment response to policy shocks, we replace the unemployment rate by employment and total hours worked respectively. As with unemployment, both variables react insignificantly to the policy shock. Clearly, policy shocks do not have a significantly positive effect on hours or employment. Output does not react significantly to policy shocks in this setup.

One may wonder whether our identified shocks pick up the effects of other shocks that are important for the macroeconomy. One candidate are shocks that cover future information about the business cycle, so-called news shocks. In order to control for the presence of news shocks or any type of anticipation effects in the economy, we include a business confidence indicator (the ifo business

[24] Compare Table 5 in the Appendix for the data sources of all time series used in the analysis. More detailed results are available upon request.

[25] We measure recessions, also in the long sample, as peak to trough of the GDP series that is HP-filtered with $\lambda = 1,600$.

climate index) into our specification. With this indicator, both unemployment and output do not react significantly to policy shocks. Another candidate shock that may be captured in the business cycle shock is a monetary policy shock. In order to control for this shock, we further include the interest rate as measured by the 3-months money market rate into the specification. Table 7 shows that including the interest rate into our specification does not change our baseline results. Moreover, we control for movements in aggregate consumption and investment in two further VAR specifications. Again, this does not change our results (cp. Table 7 in the Appendix).

Finally, we consider the long sample which covers 1975 to 2010. Starting our estimation in 1975, we capture important economic events such as the oil crises in the data. However, we also face a severe structural break in the macroeconomic data due to the German reunification in 1991. To eliminate the level effect in the data, we regress the growth rates of GDP and unemployment on a reunification dummy. We further account for a general structural break in the VAR using a broken constant before 1991 and afterwards. In order to circumvent potential problems with the heavy use of STW in East Germany directly after reunification for reasons not related to the business cycle, we only use STW data for West Germany.[26] Since the mean STW usage in the long sample is higher than in the short sample (0.83%), we reduce our elasticity estimate to -2.79. Note that our elasticity estimate stems from microeconomic survey data for the years 2003, 2006, 2009 and 2010. Thus, our estimate possibly deviates from the true elasticity estimate in the long sample. This is less of a concern in the short sample. In addition to estimating our baseline specification in the long sample, we also add recession dummies (1973Q1-1975Q2, 1980Q1-1982Q2, 1991Q1-1993Q1 and 2008Q1-2009Q2). Table 7 shows that the results are quite similar to the ones from the short sample. In contrast to the short sample, output does not show any significant increases anymore. Unemployment increases, though insignificantly. This documents that when taking into account early recessions, discretionary STW policy changes have on average not been very successful in stabilizing employment or output in recessions.

5 A labor market model with short-time work

5.1 Model description

Our paper quantifies the effects of the rule-based and the discretionary component of STW. While the SVAR has shown the non-effects of discretionary policy changes on unemployment, it is silent about the underlying economic rationale. In addition, we analyze the automatic stabilization of the rule-based component of STW for which we need to model the counterfactual economy without STW. Thus, we need a model that integrates important institutional features of the German economy to deliver credible results and that is rich enough for quantitative analysis. We use the search and matching framework of Diamond (1982) and Mortensen and Pissarides (1994) to model job findings and en-

[26] As mentioned above, the series for the number of short-time workers in total and West Germany excluding the reunification period have a strong correlation of 0.99.

dogenous job separations assuming that worker-firm pairs are subject to idiosyncratic shocks. We then incorporate STW in this model.

A few words on specific assumptions of the model are in order: First, we assume that STW is the only way to use the intensive margin of labor adjustment. This assumption can be justified on the grounds that in normal times the extensive margin is far more important than the intensive margin, while in deep recessions, STW plays a very important role in rendering the intensive margin more flexible (see Section 2). Hence, we do not consider the role of instruments other than STW that may make the intensive margin more flexible such as working time accounts. Note, however, that we calibrate the model in such a way that the model-elasticity of STW with respect to changes in output corresponds to its empirical counterpart (for more details see Section 6.1). Thus, if we included other means of adjustment along the intensive margin in our model and did not change the parameters of the model, the effects of STW would be diminished (as firms could use the other means of adjustment as substitutes[27]) However, as a consequence the elasticity of STW with respect to changes in output would not correspond to the empirical elasticity any more. Thus, we would have to recalibrate the model to match the empirical elasticity. This would re-establish the importance of STW. We are thus confident that the quantitative results would remain similar if we included other means of adjustment along the intensive margin.

This issue would only be worrisome if we calibrated our model such that STW is responsible for the adjustment of the entire intensive margin in deep recessions. Instead, we calibrate our model to the elasticity of STW with respect to output that we have estimated in Section 3.

Second, firms in our model would reduce the working time of unprofitable workers to zero unless they are subject to some form of adjustment cost. The data shows that a 100% working time reduction rarely happens. Only for 8% of workers on STW the working time is reduced to zero. On average the working time for workers on STW is reduced by approximately one third.[28] To allow for a working time reduction of less than 100% and to keep our model tractable, we assume that firms are subject to convex costs of reducing working time. Below we provide some institutional underpinnings, but we do not provide deep microfoundations for the observed firm behavior.

Third, we assume that wages are determined on the collective level (which is true for the majority of contracts in Germany) and that the wage for a full-time worker is unaffected by the STW decision of the firm (although a working time reduction obviously reduces the paid-out wage for a worker on short-time). We also check for the robustness of our results by simulating a US style economy with individual bargaining.

For normative work, it is crucial to provide a deep microfoundation as well as a constrained efficient benchmark for the interaction between the firm and the worker with STW. For our purposes, i.e., the quantification of the rule-based component and an interpretation of the SVAR results, these

[27] Evidence from the German establishment data in Section 3 suggests that firms that use working time accounts are also more likely to use STW.

[28] From 1993-2010, 44% of all employees who used STW in Germany reduced their working time up to 25%, 33% between 25 and 50%, 8% between $75-99\%$ and 8% to 100% (Source: Federal Employment Agency).

limitations are only of second order. Most importantly, the model does a very good job in replicating the business cycle features of the extensive and intensive margin of STW and offers a plausible explanation for the SVAR results. We further check the robustness of our results with respect to some of the above mentioned assumptions, such as changing the bargaining rule or varying the level of firing costs.

The timing in the model is as follows: First, agents in the economy learn about the level of aggregate productivity. Second, unemployed workers search for a job and firms post vacancies. Third, the matching function establishes contacts between workers and firms. Fourth, new contacts and incumbent workers are hit by an idiosyncratic shock. Fifth, the wage is determined. Finally, firms make their endogenous separation and STW decisions, based on the idiosyncratic shock realization.

5.2 Separation and short-time work decisions

Since STW is targeted at reducing separations, we start by deriving the separation decision and show how it is affected by STW. As is standard in the literature we endogenize separations by assuming that the profits generated by a worker depend on the realization of an idiosyncratic shock, ε. We assume that the idiosyncratic component is additive and has the interpretation of a profitability shock. With additivity, worker-firm pairs may generate negative contemporaneous value added, even with zero fixed costs.[29] The shock ε_t is drawn from the random distribution $g(\varepsilon)$ and is i.i.d. across workers and time. We will first describe the STW decision and then the firing decision because the latter depends on the former.

The value of a worker with a specific realization of the idiosyncratic shock ε, who is not on STW, is given by

$$J(\varepsilon_t) = a_t - w_t - \varepsilon_t - c_f + \beta E_t J_{t+1}, \tag{1}$$

where a is aggregate productivity, w is the wage of the worker, c_f is a fixed cost of production, β is the discount factor and J_{t+1} the expected value of the worker next period (see equation (11) for the definition). The fixed cost of production c_f was introduced by Christoffel and Kuester (2008) to generate the large volatility of unemployment over the business cycle found in the data, without resorting to wage rigidity or using a large value of unemployment benefits/home production.[30]

We assume that the government defines an eligibility criterion D for STW such that only workers whose value is below that threshold are allowed to be sent on STW

[29] Interestingly, negative contemporaneous value added allows us to provide an interpretation for the SVAR results, i.e., why discretionary short-time work may have a positive effect on output. Note, however, that our result that discretionary STW leaves employment unaffected does not depend on the additivity of the shock.

[30] It is well known from the literature that the search and matching model has trouble to replicate the labor market amplification effects over the business cycle from the aggregate data (Shimer, 2005). See Costain and Reiter (2008) for a discussion. We choose fixed costs as proposed by Christoffel and Kuester (2008) to solve this problem because it seems the most innocuous assumption in the context of our approach (the alternative of larger unemployment benefits would, for example, show up in the government budget constraint and thereby distort the cost and benefit analysis of STW).

$$a_t - w_t - \varepsilon_t - c_f + \beta E_t J_{t+1} < D_t. \tag{2}$$

We interpret D as an instrument to conduct discretionary STW policy. By lowering D, the government makes the eligibility criterion more stringent and, thus, directly reduces the number of workers on STW. In our benchmark calibration, we assume $D = -f$, where f is the cost of firing a worker. This implies that the STW-threshold in equation (2) coincides with the firing condition of an equivalent matching model without STW. This assures that only those workers are allowed to be sent on STW that would otherwise have been fired. With this modeling choice we replicate the German rule that says that any firm that is in difficulties such that it would otherwise have to fire a substantial part of its workforce, can apply for STW. When quantifying and simulating the model in Section 6, we show the effects of loosening the eligibility criterion, i.e., of increasing D.

Based on equation (2) we can define a threshold-level v^k for the idiosyncratic component ε

$$v_t^k = a_t - w_t + \beta E_t J_{t+1} - c_f - D_t, \tag{3}$$

such that workers with $\varepsilon_t < v_t^k$ work full-time, while workers with $\varepsilon_t > v_t^k$ are allowed to be sent on STW.[31]

When a worker is eligible for STW, the firm has the option to adjust along the hours margin. Without any further restrictions, firms would choose 100% STW for unprofitable workers in our model. However, as described above, the average working time reduction is only about one third. Assuming a linear cost function would not solve this problem because it would imply corner solutions such that workers either work full time or their working time is reduced by 100%. Therefore, we assume that the optimal working time reduction K is subject to convex STW costs $C\left(K\left(\varepsilon_t\right)\right)$, with $\frac{\partial C(K(\varepsilon_t))}{\partial K(\varepsilon_t)} > 0$ and $\frac{\partial C(K(\varepsilon_t))^2}{\partial^2 K(\varepsilon_t)} > 0$, which assures interior solutions. There are many institutional reasons in Germany for such a convexity. First, although the employer reduces the labor costs with STW, the reduction is not necessarily proportional to the working hours reduction because the employer has to pay the social security contributions for the full time equivalent.[32] Second, the implementation of STW must be approved by the workers' council.[33] As long as there is no approval, workers have the right to obtain their full wage. Workers' councils are generally more willing to approve small working time reductions than larger working time reductions because employees only receive a partial compensation for their wage loss. Our convex adjustment function is a short-cut for the interaction of many factors (besides the institutional features, the shape of the production function or variable capital utilization may matter in reality). We defend our short-cut based on its empirical performance. We will show in

[31] In contrast to Faia et al. (2013), this defines the rule-based component of STW. Worker-firm pairs with a lower profitability level can automatically use STW and choose an optimal hours reduction. This allows us to calibrate our model with the estimated elasticity and to quantify the automatic stabilization effects of STW.

[32] See Bach et al. (2009) who show that these institutional features generate a convexity in the cost of STW. See also Boeri and Bruecker (2011).

[33] German labor law makes it mandatory for firms from a certain size onwards to allow their employees to elect representatives ("Betriebsrat", English: workers' council).

the simulations that our model replicates the cyclical movement of the number of workers on STW and the average hours reduction due to STW very well.

The firm chooses the optimal level of the working time reduction K by maximizing the contemporaneous profit of a worker on STW:[34]

$$\max_{K(\varepsilon_t)} \pi_t = (a_t - w_t - \varepsilon_t)\left(1 - K\left(\varepsilon_t\right)\right) - c_f - C\big(K\left(\varepsilon_t\right)\big). \tag{4}$$

Note that the reduction in working time does not only reduce the output of the worker but also reduces the wage payments and the idiosyncratic cost. However, it does not reduce the fixed cost c_f which is independent of the production level. We impose a quadratic functional form for the costs of STW

$$C\big(K\left(\varepsilon_t\right)\big) = c_K \frac{1}{2} K\left(\varepsilon_t\right)^2. \tag{5}$$

This implies that the optimal hours reduction of STW for a given ε is

$$K^*\left(\varepsilon_t\right) = -\frac{a_t - w_t - \varepsilon_t}{c_K}. \tag{6}$$

Naturally, the lower the profitability of a worker, i.e., the higher the realization of ε, the higher the working time reduction ($\frac{\partial K^*(\varepsilon_t)}{\partial \varepsilon_t} > 0$). We can now describe the firing decision of the firm, which depends on the working time reduction K. Workers are fired if the losses they generate are higher than the firing cost:

$$(a_t - w_t - \varepsilon_t)\left(1 - K\left(\varepsilon_t\right)\right) - C\left(K\left(\varepsilon_t\right)\right) - c_f + \beta E_t J_{t+1} < -f. \tag{7}$$

This defines a firing threshold v^f at which the firm is indifferent between firing and retaining a worker on STW:

$$v_t^f = a_t - w_t - c_f + \frac{E_t \beta J_{t+1}}{1 - K\left(v_t^f\right)} + \frac{f}{1 - K\left(v_t^f\right)} - \frac{C\left(K(v_t^f)\right)}{1 - K\left(v_t^f\right)}. \tag{8}$$

Thus, the endogenous separation rate is

$$\phi_t^e = \int_{v_t^f}^{\infty} g\left(\varepsilon_t\right) d\varepsilon_t, \tag{9}$$

[34] This is an important difference to the earlier models in Faia et al., 2013 and Krause and Uhlig, 2012. In contrast to these, firms in our model decide optimally about the working time reduction of workers on STW, while in Krause and Uhlig, 2012 hours are not reduced at all and in Faia et al., 2013 the hours reduction is exogenous and the same for all firms. Endogenous hours reduction is not only realistic but allows us to distinguish between the extensive margin and the intensive margin of STW and base them both on optimal firm decisions. As demonstrated further below our model replicates well the empirical movements of both margins.

and the rate of workers on STW is

$$\chi_t = \int_{v_t^k}^{v_t^f} g\left(\varepsilon_t\right) d\varepsilon_t. \tag{10}$$

All workers with a profitability shock realization above the STW threshold v_t^k are eligible for STW, but workers above the firing threshold v_t^f are so unprofitable that they are fired despite the possibility to send them on STW.[35] Note that STW exists in this economy if $v_t^f > v_t^k$. This is the case as long as STW costs are not prohibitively high. If the scale parameter or the STW cost function c_K approaches infinity, then $K = 0$ from equation (6), i.e., firms do not use STW. In this case the STW cutoff and the firing cutoff are identical: $v^f = v^k$. This limiting case will be used for the counterfactual analysis in the numerical part. If c_K is smaller than $a_t - w_t - \varepsilon_t$, the firm optimally reduces hours worked for those on STW to zero. In that case, no firing occurs. For the value of c_K that we calibrate, the working time reduction for those on STW will be strictly between zero and 100%.

From equation (8) follows that positive values of the working time reduction K affect the firing cutoff v^f positively due to a direct effect and a reinforcing indirect effect. The working time reduction directly reduces the losses generated by a worker and thereby makes the firm more reluctant to fire a worker. At the same time, the possibility to reduce the future losses generated by a worker increases the expected value of a worker, which indirectly lowers the incentives to fire. Both effects shift the threshold v^f upwards relative to v^k and imply both a positive range of workers on STW and a smaller range of workers being fired compared to the situation without STW in which $v^f = v^k$.[36]

Note that the existence of STW in our model does not depend on the exact bargaining regime, nor on the assumption of positive fixed costs and/or firing costs. We need the fixed costs of production to calibrate our model to the estimated elasticity of STW with respect to output. And we add firing costs and collective bargaining to replicate realistic European institutions. But even if $f = c_f = 0$ and under individual bargaining, some workers exist who would generate contemporaneous losses, but who would not be fired. The reason is that costly hiring due to search and matching frictions (see the next section) implies that the future value of a worker is always positive. So even in this setup, some firms have an incentive to use STW.

It should further be noted that it is both in the interest of the firm and the worker to use STW rather than to separate the match. The firm is free to choose the optimal working time reduction. Thus, it will only use a positive level of STW if this increases profits. Although the worker has no choice in our model, her participation constraint will not be violated. Even though STW reduces her income relative to full employment, the worker is even worse off if she quits. In that case the income in the current period would be just the unemployment benefit b, while it is $bK + (1 - K)w$ if the worker stays employed and on STW (as usual under German STW rules). Thus, since $w > b$, a quit would imply a loss in contemporaneous income. Furthermore, quitting the job implies a lower chance of

[35] See Figure 13 in the Appendix for a graphical illustration of the distribution of the idiosyncratic shock and both threshold values.

[36] Note that the increase in J_{t+1} also indirectly shifts the STW threshold. However, the described direct effect is absent and therefore v^f shifts by more than v^k.

having a job in the next period and, thus, reduces the continuation value of the worker.

We are now in a position to define the expected value of a worker, before the realization of the idiosyncratic shock ε is known:

$$\begin{aligned} J_{t+1} = & (1-\phi^x) \int_{-\infty}^{v_{t+1}^k} (a_{t+1} - w_{t+1} - \varepsilon_{t+1})\, g(\varepsilon_{t+1}) d\varepsilon_{t+1} \\ & + (1-\phi^x) \int_{v_{t+1}^k}^{v_{t+1}^f} \left[(a_{t+1} - w_{t+1} - \varepsilon_{t+1}) \left(1 - K\left(\varepsilon_{t+1}\right)\right) - C\left(K\left(\varepsilon_{t+1}\right)\right) \right] g\left(\varepsilon_{t+1}\right) d\varepsilon_{t+1} \\ & - (1-\phi_{t+1})\, c_f - (1-\phi^x)\, \phi_{t+1}^e f + (1-\phi_{t+1})\, E_{t+1} \beta J_{t+2}. \end{aligned} \tag{11}$$

Here,

$$\phi_{t+1} = \phi^x + (1-\phi^x)\, \phi_{t+1}^e, \tag{12}$$

is the overall rate of job destruction, which depends on the endogenous rate of job destruction defined in (9) and on the exogenous rate of job destruction ϕ^x. The first integral in equation (11) is the expected revenue of workers who work full-time. The second integral is the expected revenue of workers on STW. Here, we need to take into account that these workers have reduced working time, but that the firm has to incur the cost of STW. The fixed cost has to be paid for all employed workers. The firing cost has to be paid only for endogenous, not for exogenous separations.

5.3 Matching on the labor market

While we have focused on the firing and STW decision of the firm so far, we now formulate the rest of the labor market. Matches m are determined by a Cobb-Douglas matching function

$$m_t = \mu u_t^{\alpha} v_t^{1-\alpha}, \tag{13}$$

where u is unemployment, v are vacancies and α is the matching elasticity with respect to unemployment. The parameter $\mu > 0$ is the matching efficiency. We assume free entry of vacancies. The worker finding rate q (i.e., the probability of a firm to fill a vacancy) is

$$q_t = \mu \theta_t^{-\alpha}, \tag{14}$$

where $\theta = v/u$ is the labor market-tightness. Consequently, the job finding rate η (i.e., the probability of an unemployed worker to find a job) is

$$\eta_t = \mu \theta_t^{1-\alpha}. \tag{15}$$

The present value of a vacancy is defined as[37]

$$V_t = -\kappa + \beta E_t q_t J_{t+1} + E_t \beta \left(1 - q_t\right) V_{t+1} \tag{16}$$

where J is the value of a job and κ are the vacancy posting costs. Free entry implies that in equilibrium $V_t = 0 \; \forall \; t$ which simplifies the above equation to

$$\kappa = \beta E_t q_t J_{t+1}. \tag{17}$$

Thus, in equilibrium the vacancy posting cost has to equal the expected payoff of the vacancy, which consists of the probability to find a worker and the value of a successful match.

5.4 Employment evolution

The evolution of the employment rate $n_t = 1 - u_t$ in this economy is described by

$$n_t = \left(1 - \phi_t\right) n_{t-1} + \left(1 - \phi_t\right) \eta_{t-1} \left(1 - n_{t-1}\right). \tag{18}$$

Thus, the employment rate in the current period includes workers of the previous period who were not fired and unemployed workers who got newly matched. As stated above, this law of motion reflects that both existing and new matches are subject to the separation risk. Workers on STW are treated as employed, corresponding to the official German employment statistics (although they do not work full time).

5.5 Wage bargaining

Finally, we specify wage formation. Collective wage bargaining is the predominant regime in continental Europe and especially in Germany.[38] Therefore, we use a simple model of collective wage bargaining for our baseline simulation. We assume that the wage is bargained between the representative firm and the incumbent worker for whom the realization of the profitability shock equals its expectation of zero. Every worker who is working full time earns this wage. Every worker who is on STW gets a share of this wage, according to her working time (plus some reimbursement for the lost wage income). Hence, the wage does not depend on the idiosyncratic profitability of a worker, which implies inefficient separations. However, we will also show the results for individual wage bargaining.

The profit of the median worker-firm pair (with idiosyncratic profitability shock zero) of a match

[37] Note that we have assumed that new matches are also subject to separation risk. This is taken into account in the definition of J_{t+1} in equation (11).

[38] According to OECD (2012a), the collective bargaining coverage (share of contracts covered by collective bargaining) in Germany was 72% in 1990 and 62% in 2009.

is[39]

$$F_t = a_t - w_t - c_f + \beta E_t \left(1 - \phi_{t+1}\right) J_{t+1}. \tag{19}$$

In case of disagreement, production will come to a halt (e.g., due to a strike), and bargaining will resume in the next period. Hence, the match stays intact in the case of disagreement. This particular feature of the bargaining setup is described in more detail in Hall and Milgrom (2007) and used in Lechthaler et al. (2010) or Christiano et al. (2012). It is especially plausible under collective bargaining since it is unlikely that all workers become unemployed in case of a disagreement. Thus, the fall-back option of the firm is

$$\tilde{F}_t = -c_f + \beta E_t \left(1 - \phi_{t+1}\right) J_{t+1}. \tag{20}$$

The median workers' surplus W from a match is

$$W_t = w_t + \beta E_t \left(1 - \phi_{t+1}\right) W_{t+1} + \beta E_t \phi_{t+1} U_{t+1} \tag{21}$$

where U is the value of unemployment, defined as $U_t = b + \eta_t \left(1 - \phi_{t+1}\right) W_{t+1} + \left(1 - \eta_t \left(1 - \phi_{t+1}\right)\right) U_{t+1}$. The workers' fall-back option under disagreement is then

$$\tilde{W}_t = b + \beta E_t \left(1 - \phi_{t+1}\right) W_{t+1} + \beta E_t \phi_{t+1} U_{t+1}. \tag{22}$$

This means that in case of no production, workers are assumed to obtain a payment b, which is equal to the unemployment benefits in the economy.

Defining γ as workers' bargaining power and maximizing the Nash product yields the following wage equation:

$$w_t = \gamma a_t + \left(1 - \gamma\right) b. \tag{23}$$

In the Section 6, we will check for the robustness of our results by using individually bargained wages (including the profitability shock and the market tightness).

5.6 Government budget constraint

The government has a balanced budget and finances STW expenses and unemployment benefits through a lump-sum tax:

$$bn_t \int_{v_t^k}^{v_t^f} K\left(\varepsilon_t\right) g(\varepsilon) d\varepsilon_t + bu_t = T_t. \tag{24}$$

We explore the robustness of our results to the possibility to finance STW through (distortionary) income taxation instead of lump-sum taxes below.

[39] Note that the median worker-firm pair does not use STW (empirically, on average only 0.69% of German employees are in STW programs).

5.7 Equilibrium and aggregation

The labor market equilibrium is defined by equations (3), (7), (8), (9), (10), (18) and (23). Aggregate output (Y) in our model is defined as

$$Y_t = \frac{n_t}{1-\phi_t^e}\int_{-\infty}^{v_t^k}(a_t-\varepsilon_t)\,g(\varepsilon_t)\,d\varepsilon + \frac{n_t}{1-\phi_t^e}\int_{v_t^k}^{v_t^f}(1-K(\varepsilon_t))\,(a_t-\varepsilon_t)\,g(\varepsilon_t)\,d\varepsilon$$
$$- n_t c_f - \frac{n_t}{1-\phi_t^e}\phi_t^e f - v_t\kappa. \tag{25}$$

Aggregate output equals production (first line) minus resource costs (second line). Note, that n_t is the number of all workers employed in period t, i.e., after taking into account the separation risk. Therefore, we need to divide n_t by $(1-\phi_t^e)$ to get the number of available workers before endogenous separations. When determining production we need to take into account the idiosyncratic profitabilities of all relevant workers, i.e., those that work full time and those that work reduced hours on STW. The resource costs include vacancy posting costs, firing costs and fixed costs of production. Since our model does not contain any other aggregate demand components, aggregate output equals aggregate consumption in our model.

6 Numerical simulation

This section first describes our calibration strategy. Then we present the results of numerical simulations. Our model allows for two types of shocks: a discretionary change in STW policy and a business cycle shock. We first analyze the effects of the policy shock and compare them to our SVAR results. Then we analyze how large the automatic stabilizing effects of STW are in response to business cycle shocks.

6.1 Calibration

We calibrate the baseline model to the German economy. Table 2 summarizes our parameters and our calibration targets. The quarterly discount factor β is 0.99, which matches an annual real interest rate of 4.1%. Following Christoffel et al. (2009), we target a steady state value for the quarterly worker finding rate q of 70% and a separation rate of 3%. As in Krause and Lubik (2007) one third of separations is endogenous, whereas two thirds are exogenously determined. We target the quarterly job finding rate η to 31.2% to obtain a steady state unemployment rate of 9% (Christoffel et al., 2009). The matching elasticity α is set to 0.6. We calibrate unemployment benefits b to 65% of the wage and set the bargaining power to an intermediate value of $\gamma = 0.5$.

We have to set several parameters to obtain the steady state values of the labor market flow rates. We assume that the idiosyncratic profitability shock follows a logistic distribution,[40] which we nor-

[40] A logistic distribution is very close to a normal distribution, but allows for closed form solutions.

Parameter		Value
β	discount factor	0.99
κ	cost of posting a vacancy	1.21
α	matching elasticity w.r.t unemployment	0.60
μ	matching efficiency	0.43
b/w	replacement rate	0.65
f	linear firing costs	2.40
s	scale parameter of the profitability distribution	1.03
c_K	shift parameter in STW cost function	20.22
a	productivity	1
c_f	fixed cost of production	0.23
Steady state targets		**Value**
q	worker finding rate	0.70
ϕ	overall job destruction rate endogenous 1/3, exogenous 2/3	0.03
η	job finding rate	0.31
u	unemployment rate	0.09
χ	short-time work rate	0.007

Table 2: Calibration.

malize to have an unconditional mean of zero. To achieve our calibration target, we set the scale parameter s of the distribution to 1.03. The costs of posting a vacancy κ is set to 1.21 and the efficiency of matching μ is set to 0.43. In line with Bentolila and Bertola (1990), we set firing costs to 60% of annual productivity. In the numerical section, we will check the robustness of our results by reducing this value to 30% and 0%.

The steady state short-time work rate χ is targeted to 0.69%, which is in line with German data. Note that this implies a value for c_K of 20.22. This value appears to be large, but in the aggregate the convex STW costs amount to only 0.3% of output.

We set the fixed costs of production c_f to 0.23 in order to target the contemporaneous elasticity of the extensive margin of STW with respect output changes of -3.3. This estimate corresponds to our lower bound. As discussed above, our estimated elasticity may not take into account the general equilibrium effects of changing labor market tightness on wages and hence other aggregate variables. However, these effects are absent in our baseline model due to the assumed bargaining game. Thus, the calibration strategy is consistent with our model.

6.2 Policy shock

We simulate the responses of the model economy to a change in STW policy. More precisely, the government weakens the eligibility criteria for STW, i.e., it increases the level of D, for only one period and returns to the old rules one period later. Figure 4 illustrates the results. Due to the increase

in D, the STW threshold v_t^k falls (see equation (3)). Thus, the fraction of short-time workers χ increases. Interestingly, although the policy increases STW, it has no effects on unemployment. The policy intervention allows more workers to use STW that would not have been fired even in absence of the policy intervention and thus leaves firing unaffected (compare equation (8) which does not depend on D). This means that the policy has a deadweight effect of 100%. Thus, our model provides a rationale for the non-effect of the discretionary policy shock on unemployment, found in the SVAR.

Despite the ineffectiveness of the policy in terms of unemployment, our model shows a one period effect on output. The reason is that unprofitable worker-firm pairs can reduce their working time. This leads to a positive effect in the resource constraint. At first it might seem surprising that a working time reduction can increase output, but it is in fact quite plausible that a temporary downscaling of inefficient production units has a positive effect on output. This is again in line with the results from the SVAR, albeit with a somewhat different timing.

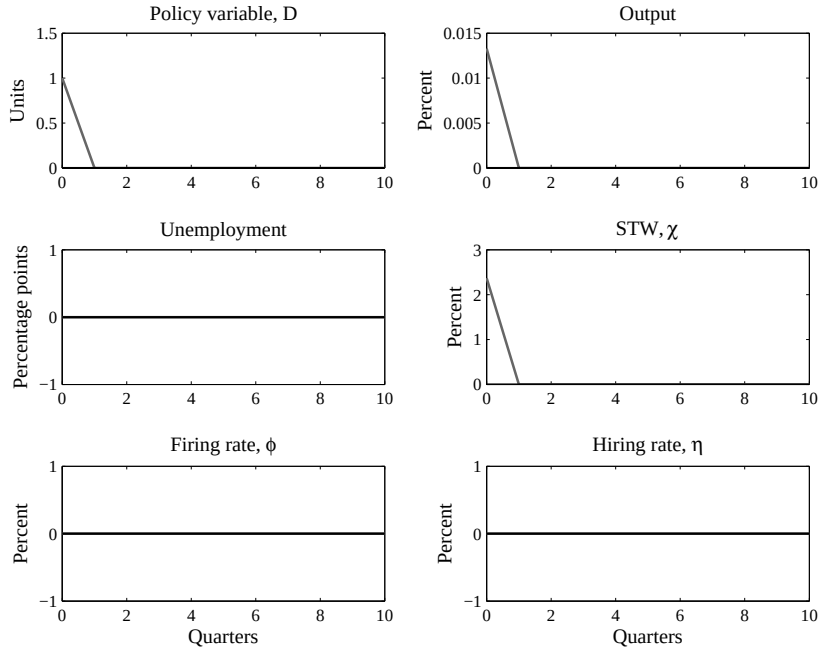

Figure 4: Impulse responses of a positive one unit shock to D. Impulse responses are given as deviations from the steady state. The shock is implemented as a temporary, one-period loosening of the STW eligibility criterion.

In contrast to the SVAR, our model allows us to experiment with different policy interventions. Figure 5 illustrates this for a persistent increase in D, with an autocorrelation coefficient of 0.5. Such a policy intervention has an effect on hiring, firing and unemployment. Increasing D persistently allows firms to send more workers on STW in the future and to reduce the potential losses in case of an adverse profitability shock. Consequently, the expected value of a job J goes up, firing goes down and vacancy posting goes up (see equations (8), (11), and (16)). Note, however, that the effects of the persistent policy on unemployment are quantitatively very small.

All in all, the model results and the SVAR results are very coherent. According to the model,

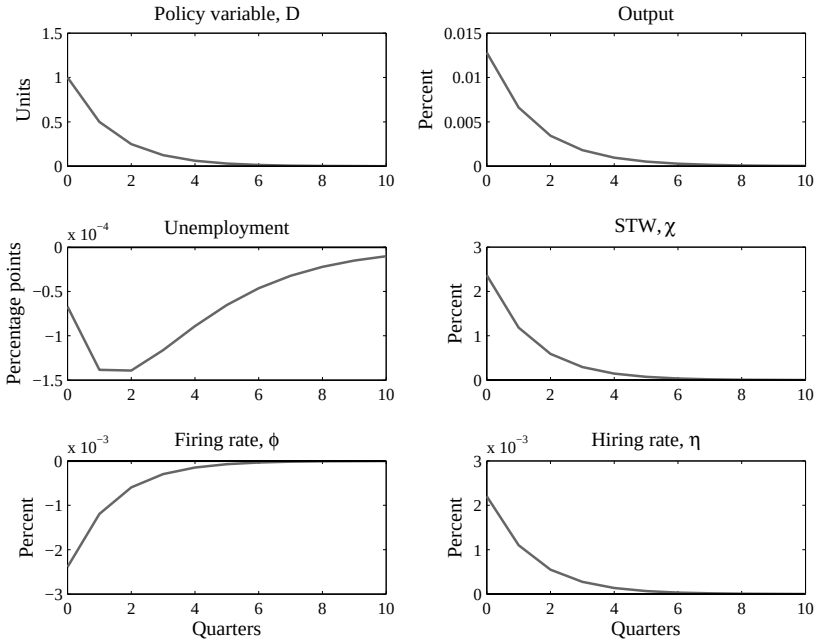

Figure 5: Impulse responses of a positive one unit shock to D. Impulse responses are given as deviations from the steady state. The shock is implemented as a temporary autoregressive loosening of the STW eligibility criterion.

very temporary discretionary interventions are ineffective. However, discretionary policy interventions may have a small effect on unemployment if they are used more persistently and thus exert a stronger effect on future expectations. The results from the SVAR indicate that the discretionary policy component is used in a very temporary fashion in Germany. The significant increase of STW after a policy shock lasts for at most two periods, as Figure 3 documents. Thus, it is not surprising that firms' future expectations are hardly affected.

6.3 Automatic Stabilization

6.3.1 Baseline Scenario

Figure 6 shows the impulse responses to a positive, one standard deviation shock (normalized to 1%) to aggregate productivity a, with autocorrelation 0.95 (see solid lines for IRFs in the economy with STW). An increase in productivity increases the value of a filled job J, which implies that firms post more vacancies. Consequently, the labor market tightness θ and the hiring rate η go up. The increase in productivity also has a positive effect on the firing cutoff v_t^f, i.e., the endogenous firing rate ϕ_t^e goes down. The reduction in firing and the increase in hiring lead to an increase in employment and output and a decline in unemployment. Due to our assumption of fixed costs of production, our model replicates two important stylized facts of the business cycle. First, our model shows a Beveridge curve, i.e., a negative correlation between unemployment and vacancies. Second, the labor market variables are more volatile than productivity and output. The standard deviation of unemployment in our simulation is 3 times larger than the standard deviation of the underlying productivity shock.

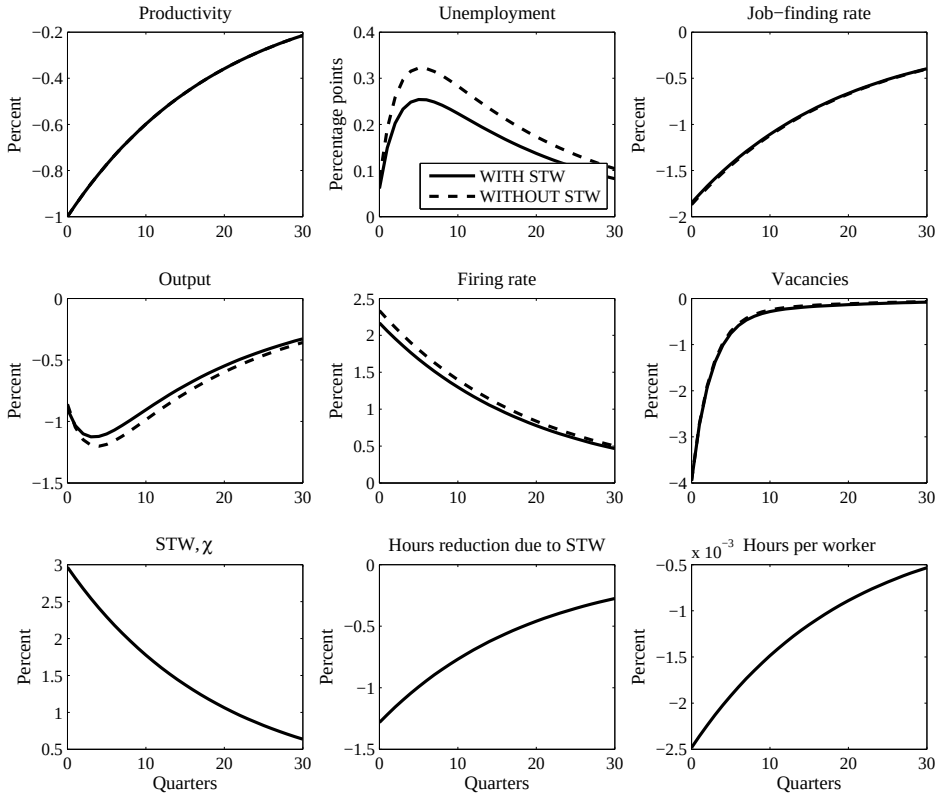

Figure 6: Impulse responses of a positive shock to aggregate productivity. Impulse responses are given as deviations from the steady state. The shock is implemented as a temporary autoregressive reduction in aggregate productivity.

What happens to STW in a recession? With a negative aggregate productivity shock, more worker-firm pairs are automatically eligible for STW and the share of workers on STW increases. However, the average quality of workers on STW increases in a recession, because more low-quality workers are fired. It follows that the average reduction of working hours due to STW decreases. Overall, hours per worker in the economy fall.

Remember that this is well in line with the stylized facts presented in Section 2: the extensive margin of STW (the share of workers on STW) moves countercyclically while the intensive margin of STW (the average hours-reduction of a worker on STW) is procyclical. Overall, hours per worker fall in recessions. Our model replicates all those facts very well. In the dynamic simulation, output and the share of workers on STW have a correlation of -0.96. Output and the average reduction of working hours have a correlation of 0.96.

In order to assess the role of STW as an automatic stabilizer of the labor market and the macroeconomy, we compare business cycle statistics of an economy with and without STW. We keep all parameters the same in both scenarios. This assures that our stabilization results are not driven by parameter changes, but has the drawback that the steady states differ between the two scenarios. In Section 6.3.2 below we recalibrate the model without STW so that both models yield the same steady state and show that the differing steady states are not responsible for our results.

Stabilization in %	baseline	lower firing costs		distortionary taxation	fixed steady states
		$f = 1.2$	$f = 0$		
Output y	3.8	3.5	2.7	3.9	6.3
Unemployment u	21.2	13.1	6.5	20.9	14.9

Table 3: Reduction of the standard deviation in the model with STW compared to the model without STW. We use HP filtered deviations from steady state (smoothing parameter $\lambda = 1,600$). For output, we use log-deviations, for unemployment level deviations, since this variable is already denoted as a percentage.

The second column in Table 3 shows the difference in the volatility of output and unemployment for our baseline scenario with constant parameters. The presence of STW reduces the standard deviation of the cyclical component of output, by roughly 4% and reduces unemployment fluctuations measured by the absolute deviation of the cyclical component by roughly 21%. With a negative aggregate productivity shock, more firms are automatically eligible to use this instrument. Thus, in contrast to the economy without STW, some firms reduce the working time instead of firing workers and, therefore, reduce unemployment fluctuations.

The stabilization of unemployment comes at the cost that STW induces firms to keep unprofitable workers employed, who would otherwise have been fired. With and without STW, the average quality of the workforce increases in a recession because relatively more unprofitable workers are fired. This effect tends to counteract the decrease in aggregate productivity and thus reduces fluctuations in aggregate output. Since less workers are fired, the average quality of the workforce increases by less in recessions in the economy with STW compared to the economy without STW. Put differently, we have two counteracting effects: On the one hand, STW reduces unemployment fluctuations and thus output fluctuations via the production function. On the other hand, STW reduces the stabilizing effect of adjustments in the quality of the workforce (smaller cleansing effect of recessions). Naturally, the first effect dominates, but the second effect implies that STW stabilizes output by less than unemployment.

Is a stabilization of 4% of GDP fluctuations and 21% of unemployment fluctuations a lot? To evaluate the cost-effectiveness of the automatic stabilization, we have to relate the stabilization effects to the expenditures. Between 1998 and 2011 on average 0.7% of all workers are on STW. The average costs of STW accounted for just 0.01% of GDP in our model. In the data, the cost of STW in terms of GDP was 0.03%.[41] How does this compare to other automatic stabilizers such as the tax system? The estimated size of the automatic stabilization of the income tax system depends on the employed methodology and the analyzed country. The existing literature predicts an automatic output stabilization between 8% and 30% (see Table 2 in in't Veld et al., 2012). Given that the income tax system accounts for roughly 10% of GDP in the OECD average (see OECD Statistics, OECD, 2012b), the stabilization through STW appears to be large relative to the costs.[42]

[41] To calculate this number, we have used the gross transfers to workers due to STW according to the balance sheet of the Federal Employment Agency. At the peak in 2009 the costs were 0.13% of GDP.

[42] Note that we compare the income tax system to STW based on GDP-shares and stabilization effects only, not taking

6.3.2 Robustness

In a first robustness check, we reduce firing costs from 240% of quarterly productivity (i.e. 60% of the annual productivity) to 120% and 0%, respectively. All the other parameters remain the same. Two results are worthwhile to be pointed out. First, lower firing costs lead to a smaller automatic stabilization effect of STW. In this case, frictional costs fluctuate less and, hence, the possibility of STW to dampen these fluctuations is reduced. Second, STW also stabilizes an economy without firing costs. This certainly does not correspond to German institutions, but it illustrates that firms have an incentive to use STW even when firing is costless. This is the case, because finding new workers is costly in a labor market with search and matching and, thus, some labor hoarding is optimal.

Next we assume that additional expenses due to the cyclical variation in STW are financed by an immediate increase in a distortionary proportional income tax.[43] Given that we assume a balanced budget, the bargaining outcome is directly affected by tax increases. As expected, a distortionary financing of STW reduces the unemployment stabilization effects. The reduction is surprisingly small, however. The reason is that the STW in our model is very cost-efficient and thus the extra costs in a recession due to the automatic reaction of STW are small.[44]

In order to exclude that our results are driven by steady state shifts, we adjust the standard deviation of the idiosyncratic profitability shocks and the vacancy posting costs to obtain the same steady states for the labor market flows in all versions of the model.[45] Interestingly, with fixed steady states all results are very similar compared to the scenario with fixed parameters. In our baseline scenario, output fluctuations drop by 6% and employment fluctuations by 15%. Lower firing costs lead to somewhat less stabilization and distortionary taxes leave the results almost unchanged.

6.3.3 Simulation for the US Economy

So far, we have performed our simulations based on German labor market flows (which are roughly three times smaller than in the United States), collective bargaining and substantial firing costs. Lowering firing costs as a robustness check has indicated that labor market institutions are important for the quantitative results. To obtain an idea about the potential effects of STW in an anglosaxon country, we repeat our exercise under standard individual Nash bargaining, where the threat point of worker and firm is the termination of the match, and recalibrate the model to match the US economy. This is of course only a rough quantification of the potential stabilizing effects of STW in the US, since, in contrast to our earlier analysis, it is not based on an empirically estimated elasticity of STW. However, this scenario demonstrates that STW is likely to be less stabilizing in more flexible labor markets.

into account other potentially important aspects such as the effect on governmental revenue or the reduction of income inequality.

[43] Thus, the bargaining equation changes to $w_t = \gamma a_t + (1-\gamma)\, b/(1-\tau)$, where τ is the proportional income tax.

[44] Output fluctuations are even a little bit smaller with distortionary taxes than without. The reason is that not only employment fluctuates somewhat more with distortionary taxes, but also the frictional costs, which are deducted in the resource constraint.

[45] Note, however, that we do not adjust the fixed costs of production, which are the driving force for the amplification and the elasticity of STW with respect to output.

Thus, the wage is given by

$$w_t(\varepsilon_t) = \gamma(a_t - \varepsilon_t - c_f + \kappa\theta_t) + (1-\gamma)b. \tag{26}$$

Note that in contrast to our baseline with collectively bargained wages, the wage now depends on the tightness of the labor market and the idiosyncratic profitability of a worker. The latter implies that the risk stemming from idiosyncratic shocks is better shared between worker and firm. Note, however, that there is still some scope for STW. Due to costly hiring (vacancies are associated with costs and are only filled with a certain probability), the future value of a worker is positive. This implies that some workers are retained even though they generate contemporaneous losses. Putting these workers on STW reduces the losses they generate and is therefore beneficial for the firm.

In our parametrization, we target US labor market flows, namely a job destruction rate of 0.1, a job finding rate of 0.81 and a worker finding rate of 0.7 (Krause and Lubik, 2007). The efficiency of the matching function, the costs of posting a vacancy and the scale parameter of the idiosyncratic profitability distribution are used to match these targets. In line with US institutions, we set firing costs to zero and the replacement rate to 0.4. All other parameters remain the same (and are summarized in Table 8 in the Appendix). We run two STW scenarios: one with the German parameter c_K and one with the German steady STW rate χ, which necessitates a recalibration of c_K (values in parentheses in Table 8 in the Appendix).

Using the same parameter value for STW costs c_K as in our baseline calibration leads to a much lower STW take up than in our previous simulations. The share of workers on STW, χ, in the steady state drops from 0.7% to 0.1%. This is not surprising. Lower firing costs and larger labor market flows imply that adjustments via the extensive margin are much easier and less costly than in our baseline scenario. Additionally, the flexibility of individually bargained wages allows easier adjustments in response to idiosyncratic shocks. Thus, the possibility to adjust via the intensive margin appears much less attractive. This is, in fact, well in line with Figure 7 in the Appendix, showing that STW is not much used in the United States. Naturally, this leads to much lower stabilization (see Table 4). Output fluctuations are reduced by only 0.1% and unemployment fluctuations are reduced by 0.7% compared to an economy without STW.

Stabilization in $\%$	German case	US case	
	baseline	German c_K	German STW share
Output y	3.8	0.1	0.5
Unemployment u	21.2	0.7	4.0

Table 4: Reduction of the standard deviation in the model with STW compared to the model without STW. We use HP filtered deviations from steady state (smoothing parameter $\lambda = 1,600$). For output, we use log-deviations, for unemployment level deviations, since this variable is already denoted as a percentage.

Suppose next that the US government promotes the use of STW with the goal of achieving a similar steady state proportion of workers on STW as observed in Germany. To analyze this scenario,

we recalibrate c_K to 3.5, which implies that χ rises to 0.7%. Nevertheless, the stabilization through STW over the business cycle is still much lower than in our baseline scenario for Germany. Table 4 shows that unemployment fluctuations are reduced by 4% and output fluctuations by 0.5%. Based on the most optimistic stabilization results, a back-of-the envelope calculation suggests that STW would have buffered the increase in US unemployment from 5 to 10% in October 2009 by only 0.2 percentage points, i.e., to 9.8%. Again, this is due to the higher flexibility of the US economy. Making STW cheaper, implies of course that more firms use it in steady state, but still the other margins of adjustment appear more attractive in response to business cycle shocks. Overall, our analysis suggests that STW can be an important margin of adjustment for otherwise rigid labor markets, but the additional benefit for labor markets which are already flexible is rather limited.

7 Lessons and Outlook

"... it's time to try something different." (Paul Krugman, 2009)

Does our analysis suggest that Paul Krugman (2009) is right that STW was an important job saver in the Great Recession? We argue that STW can act as a powerful automatic stabilizer, but that the empirical evidence concerning discretionary policy changes is rather disappointing. According to our SVAR evidence a discretionary change in STW policy has no effect on unemployment. Our theoretical model provides a plausible explanation for this puzzling result. A discretionary loosening of the STW eligibility criterion only subsidizes worker-firm pairs that would not have been destroyed even in absence of the intervention. If the discretionary intervention is used in a transitory way, firms' future expectations remain unaffected and no additional jobs are saved. In contrast, rules both have a direct effect on unemployment through a reduction of the firing threshold and indirectly affect firm's hiring and firing decisions via future expectations.

These results suggest that it is crucial to disentangle those two components. One additional worker on STW due to a discretionary intervention may have no effect, while one additional worker on STW due to automatic adjustments may stabilize the economy. Not differentiating these two different cases may lead to biases when estimating the effects of STW on the macroeconomic level.

Our empirical results for the discretionary component of STW are derived from a SVAR for the post-reunification period (note that it is impossible to run a SVAR just for the crisis). Since the results remain largely unchanged when we include dummies for deep recessions (Great Recession, unification and oil price crises), we infer that the discretionary interventions in Germany in the Great Recession did not save jobs.

However, the automatic stabilization effects of STW were also at work in the Great Recession. When we feed a GDP shock into our SVAR that leads to a 6.6% decline of GDP, equivalent to the German peak-to-trough movement in the Great Recession (Burda and Hunt, 2011), this shock generates an increase of unemployment of 4.82 percentage points within a year according to the SVAR. To quantify the automatic stabilization effects of STW in the Great Recession, we feed an aggregate

shock into our model with STW that also leads to a peak increase of unemployment of 4.82 percent points. In the model without STW the same aggregate shock leads to an increase of unemployment of 6.11 percentage points. Thus, our counterfactual analysis predicts that the automatic component of STW has prevented an increase in German unemployment of 1.29 percentage points, i.e., it saved roughly $466,000$ German jobs in the Great Recession.

Our calculation suggests that STW saved many jobs but STW alone cannot explain the non-response of unemployment in Germany in the Great Recession. Thus, additional forces must have been at work. Möller (2010) and Burda and Hunt (2011) point towards the role of working time accounts, which gained importance in the recent years and have contributed to make the intensive margin more flexible in the Great Recession. Boysen-Hogrefe and Groll (2010) show that unit labor costs (wages normalized by productivity) fell a lot before the recession. This may have had an impact on firms' labor demand. Burda and Hunt (2011) argue that firms were overly pessimistic in the 2005-2007 economic upturn, did not hire enough workers and thus had to reduce the employment stock by less in the Great Recession. Clearly, some or all of these aspects could be incorporated into our model-based analysis. We leave this to future research and focus on a more detailed investigation of STW instead.

Thus, Krugman is right that STW has indeed contributed to the German labor market miracle. But our analysis also shows that the institutional setup is crucial for the automatic stabilization effects of STW. According to the model simulations, economies with larger firing costs and collective wage bargaining can expect stronger stabilization effects from STW. Individually bargained wages allow the adjustment of wages in response to idiosyncratic shock. Under collective bargaining this adjustment is precluded, implying that idiosyncratic shocks are more costly to the firm. STW partly reduces the inflexibility imposed by collective bargaining and thereby stabilizes employment.

Large firing costs make it costly to adjust along the extensive margin. In such an environment STW increases the flexibility of the intensive margin of labor adjustment and hence prevents firings that constitute resource costs to the firm and the economy. Cahuc and Carcillo (2011) show that there is indeed a positive cross-country correlation between the average level of firing costs (measured by the OECD employment protection legislation index) and the STW take-up rate in the Great Recession. Thus, policy makers seem to understand well that the largest benefits of STW can be reaped in economies with large firing costs.

References

ABRAHAM, K. AND S. HOUSEMAN (1994): "Does Employment Protection Inhibit Labor Market Flexibility? Lessons from Germany, France, and Belgium," in *Social Protection versus Economic Flexibility: Is There a Trade-Off?*, ed. by R. Blank, University of Chicago Press, 59–94.

ARPAIA, A., N. CURCI, E. MEYERMANS, J. PESCHNER, AND F. PIERINI (2010): "Short-time Working Arrangements as Response to Cyclical Fluctuations," *European Economy Occasional Paper*, 64.

BACH, H.-U., A. CRIMMANN, E. SPITZNAGEL, AND F. WIESSNER (2009): "Kurzarbeit: Atempause in der Krise," , IAB Forum Spezial, Institute for Employment Research (IAB).

BELLMANN, L., A. CRIMMANN, AND F. WIESSNER (2010): "The German Work-Sharing Scheme: An Instrument for the Crisis," *Conditions of Work and Employment Series*, 25.

BELLMANN, L. AND H. GERNER (2011): "Reversed Roles? Wage and Employment Effects of the Current Crisis," in *Who Loses in the Downturn? Economic Crisis, Employment and Income Distribution*, ed. by H. Immervoll, A. Peichl, and K. Tatsiramos, Research in Labor Economics, vol. 32, 181–206.

BENTOLILA, S. AND G. BERTOLA (1990): "Firing Costs and Labour Demand: How Bad Is Eurosclerosis?" *Review of Economic Studies*, 57, 381–402.

BLANCHARD, O. AND R. PEROTTI (2002): "An Empirical Characterization Of The Dynamic Effects Of Changes In Government Spending And Taxes On Output," *The Quarterly Journal of Economics*, 117, 1329–1368.

BOERI, T. AND H. BRUECKER (2011): "Short-Time Work Benefits Revisited: Some Lessons from the Great Recession," *Economic Policy*, 26, 697–765.

BOYSEN-HOGREFE, J. AND D. GROLL (2010): "The German Labour Market Miracle," *National Institute Economic Review*, 214, R38.

BRAUN, H., B. BRÜGEMANN, AND K. MICHALEK (2013): "Welfare Effects of Short-Time Compensation," *Mimeo*.

BRENKE, K., U. RINNE, AND K. ZIMMERMANN (2013): "Short-Time Work: The German Answer to the Great Recession," *International Labour Review*, 152.

BRÜCKNER, M. AND E. PAPPA (2012): "Fiscal Expansions, Unemployment, and Labor Force Participation: Theory and Evidence," *International Economic Review*, 53, 1205–1228.

BUNDESMINISTERIUM FÜR ARBEIT UND SOZIALES (2011): "FAQs zu Kurzarbeit und Qualifizierung," , http://www.bmas.de/portal/49234/property=pdf/2010__11__17__KUG__FAQ__Kurzarbeit__und__Qualifizierung.pdf.

BURDA, M. AND J. HUNT (2011): "What Explains the German Labor Market Miracle in the Great Recession?" *Brookings Papers on Economic Activity*, Spring 2011, 273–319.

CAHUC, P. AND S. CARCILLO (2011): "Is Short-Time Work a Good Method to Keep Unemployment Down?" *Nordic Economic Policy Review*, 1.

CALDARA, D. (2010): "The Analytics of SVARs: A Unified Framework to Measure Fiscal Multipliers," *Mimeo*.

CHRISTIANO, L., M. EICHENBAUM, AND S. REBELO (2011): "When Is the Government Spending Multiplier Large?" *Journal of Political Economy*, 119, 78–121.

CHRISTIANO, L., M. EICHENBAUM, AND M. TRABANDT (2012): "Unemployment and Business Cycles," *Mimeo*.

CHRISTOFFEL, K. AND K. KUESTER (2008): "Resuscitating the Wage Channel in Models with Unemployment Fluctuations," *Journal of Monetary Economics*, 55, 865–887.

CHRISTOFFEL, K., K. KUESTER, AND T. LINZERT (2009): "The Role of Labor Markets for Euro Area Monetary Policy," *European Economic Review*, 53, 908–936.

COGAN, J. F., T. CWIK, J. B. TAYLOR, AND V. WIELAND (2010): "New Keynesian versus Old Keynesian Government Spending Multipliers," *Journal of Economic Dynamics and Control*, 34, 281 – 295.

COSTAIN, J. AND M. REITER (2008): "Business Cycles, Unemployment Insurance, and the Calibration of Matching Models," *Journal of Economic Dynamics and Control*, 32, 1120–1155.

DIAMOND, P. A. (1982): "Aggregate Demand Management in Search Equilibrium," *The Journal of Political Economy*, 90, pp. 881–894.

DUSTMANN, C., J. LUDSTECK, AND U. SCHÖNBERG (2009): "Revisiting the German Wage Structure," *The Quarterly Journal of Economics*, 124, 843–881.

FAIA, E., W. LECHTHALER, AND C. MERKL (2013): "Fiscal Stimulus and Labor Market Policies in Europe," *Journal of Economic Dynamics and Control*, 37, 483–499.

FLECHSENHAR, H.-R. (1979): "Kurzarbeit - Strukturen und Beschäftigungswirkung," *Mitteilungen aus der Arbeitsmarkt- und Berufsforschung*, 12, 362–372.

FUJITA, S. AND G. RAMEY (2009): "The Cyclicality of Separation and Job Finding Rates," *International Economic Review*, 50, 415–430.

HALL, R. E. AND P. R. MILGROM (2007): "The Limited Influence of Unemployment on the Wage Bargain," *American Economic Review*, 98, 1653–1674.

HIJZEN, A. AND D. VENN (2011): "The Role of Short-Time Work Schemes during the 2008-09 Recession," *OECD Social, Employment and Migration Working Papers*.

IMF (2010): *World Economic Outlook - Rebalancing Growth*, International Monetary Fund, Washington D.C.

IN'T VELD, J., M. LARCH, AND M. VANDEWEYER (2012): "Automatic Fiscal Stabilisers: What They Are and What They Do," *Open Economies Review*, 1–17.

KILIAN, L. (1998): "Small-Sample Confidence Intervals for Impulse Response Functions," *The Review of Economics and Statistics*, 80, pp. 218–230.

KRAUSE, M. AND H. UHLIG (2012): "Transitions in the German Labor Market: Structure and Crisis," *Journal of Monetary Economics*, 59, 64–79.

KRAUSE, M. U. AND T. A. LUBIK (2007): "The (Ir)relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions," *Journal of Monetary Economics*, 54, 706 – 727.

KRUGMAN, P. (2009): "Free to Lose," *OP-ED Column in New York Times of November 12th, 2009*.

LECHTHALER, W., C. MERKL, AND D. J. SNOWER (2010): "Monetary Persistence and the Labor Market: A New Perspective," *Journal of Economic Dynamics and Control*, 34, 968–983.

LJUNGQVIST, L. AND T. SARGENT (2007): "Understanding European Unemployment with Matching and Search-Island Models," *Journal of Monetary Economics*, 54, 2139–2179.

MÖLLER, J. (2010): "The German Labor Market Response in the World Recession – De-mystifying a Miracle," *Zeitschrift für ArbeitsmarktForschung*, 42, 325–336.

MORTENSEN, D. T. AND C. A. PISSARIDES (1994): "Job Creation and Job Destruction in the Theory of Unemployment," *The Review of Economic Studies*, 61, 397–415.

MOUNTFORD, A. AND H. UHLIG (2009): "What are the Effects of Fiscal Policy Shocks?" *Journal of Applied Econometrics*, 24, 960–992.

MUNDLAK, Y. (1978): "On the Pooling of Time Series and Cross Section Data," *Econometrica*, 46, pp. 69–85.

OECD (2010): *OECD Employment Outlook 2010 - Moving Beyond the Jobs Crisis*, Organization for Economic Cooperation and Development, Paris.

——— (2012a): *OECD Employment Outlook 2012*, Organization for Economic Cooperation and Development, Paris.

——— (2012b): *Revenue Statistics 2012*.

REICHER, C. (2012): "A Simple Decomposition of the Variance of Output Growth Across Countries," *Applied Economics Letters*, 19, 869–872.

SHIMER, R. (2005): "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, 95, pp. 25–49.

SPECKESSER, S. (2010): "Employment Retention in the Recession: Microeconomic Effects of the Short-time Work Programme in Germany," *Mimeo*.

WILL, H. (2010): "Short Time Compensation - Macroeconom(etr)ic Insight," *IMK Working Paper*, 1/2011.

WOOLDRIDGE, J. (2010): *Econometric Analysis of Cross Section and Panel Data*, MIT press.

WOOLDRIDGE, J. M. (1995): "Selection Corrections for Panel Data Models under Conditional Mean Independence Assumptions," *Journal of Econometrics*, 68, 115–132.

Appendix

Variable	Source
Short-time workers	German Federal Employment Agency
Employment	German Federal Employment Agency
Unemployment rate	German Federal Employment Agency
Hours worked	Institute for Employment Research
GDP	Deutsche Bundesbank
GDP deflator	German Federal Statistical Office
CPI	German Federal Statistical Office
ifo business climate index	ifo Institute for Economic Research
3-month money market rate	Deutsche Bundesbank
Consumption	German Federal Statistical Office
Gross investment	German Federal Statistical Office

Table 5: Data sources. We take quarterly averages of all monthly series, since not all data is available at monthly frequency. All series are seasonally adjusted using Census' X12-ARIMA procedure.

	All	2003	2006	2009	2010
Observations	64,056	16,067	15,912	15,909	16,168
Firms using STW	4202	622	231	1648	1701
Mean of STW/EMP, in %	3.34	2.03	0.74	5.63	4.93
Mean of STW/EMP, in %, only STW firms	50.90	52.41	51.55	54.37	46.90

Table 6: Descriptives on STW data in IAB establishment panel

	Response in output			Response in unemployment		
	Sign	(qrt.)	Significant in qrt.	Sign	(qrt.)	Significant in qrt.
Baseline (1993-2010)						
baseline	-	(1)	none	+		none
	+	(2-)	2			
with recession dummies	-	(0)	none	+		none
	+	(1-)	2			
with legal change dummies	-	(0-1)	none	+		none
	+	(2-)	2			
with labor productivity instead of output	-	(0)	none	+		none
	+	(1-)	2			
with GDP deflator	-	(0-1)	none	-	(0-5)	none
	+	(2-)	2	+	(6-)	none
with employment instead of unemployment	-	(0-1)	none	+	(0-1)	none
	+	(2-)	none	-	(2-)	none
with total hours instead of unemployment	-	(0-1)	none	-	(0-5)	none
	+	(2-)	none	+	(6-)	none
with ifo index as control	-	(0)	none	+		none
	+	(1-)	none			
with interest rate as control	-	(0)	none	+		none
	+	(1-)	2			
with consumption growth as control	-	(0)	none	+		none
	+	(1-)	none			
with investment growth as control	-	(0)	none	+		none
	+	(1-)	2			
Long sample (1975-2010)						
baseline	-	(0-1)	1	+		none
	+	(2-)	none			
with recession dummies	-	(0-1)	none	+		none
	+	(2-)	none			

Table 7: Summary of robustness checks. The table reports the sign and significance of the responses in output and unemployment to a STW policy shock. Significance is based on 90% bootstrapped confidence bands. Each row reports the sign of the response, the corresponding horizon (in quarters) in which the sign occurs, and whether the response is significant or not. When the sign of the respective impulse-response changes, the next row indicates this change, the corresponding horizon and the significance.

Parameter		Value	
		German type economy	US type economy
β	discount factor	0.99	
κ	cost of posting a vacancy	1.21	0.34
α	matching elasticity w.r.t unemployment	0.60	
μ	matching efficiency	0.43	0.77
b/w	replacement rate	0.65	0.4
f	linear firing costs	2.40	0
s	scale parameter of profitability distribution	1.03	0.32 (0.34)
c_K	shift parameter in STW cost function	20.22	20.22 (3.50)
a	productivity	1	
c_f	fixed cost of production	0.23	
Steady state targets		**Value**	
q	worker finding rate	0.70	
ϕ	overall job destruction rate endogenous 1/3, exogenous 2/3	0.03	0.1
η	job finding rate	0.31	0.81
u	unemployment rate	0.09	0.12
χ	short-time work rate	0.007	not targeted (0.007)

Table 8: Calibration of US type economy.

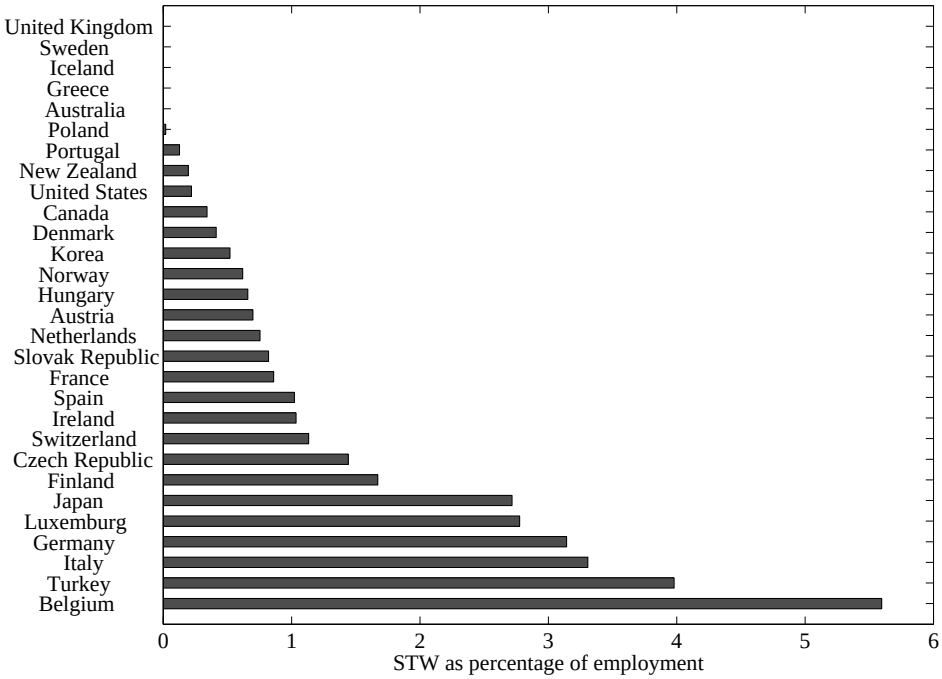

Figure 7: STW as a percentage of total employment across OECD countries in 2009 (Cahuc and Carcillo, 2011). We thank Pierre Cahuc for providing the data set.

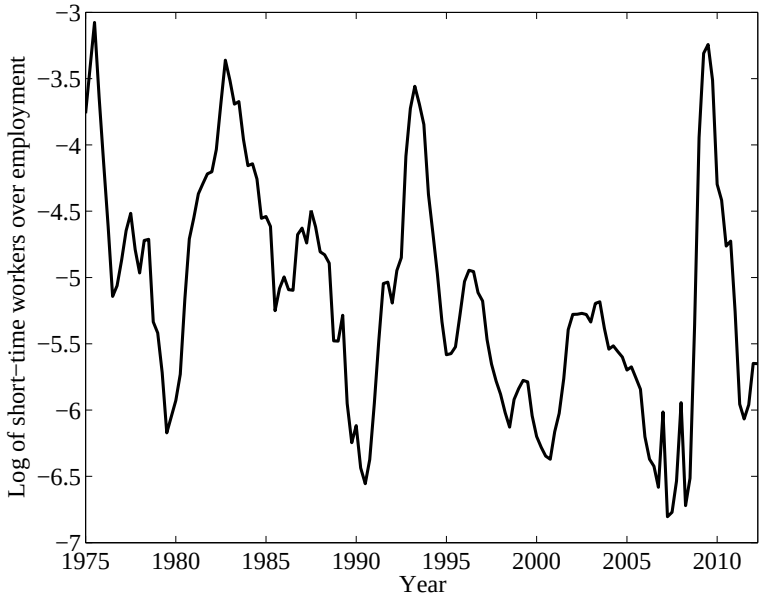

Figure 8: Short-time work in Germany 1975-2012. The series depicts the log of the number of short-time workers as a fraction of total employment.

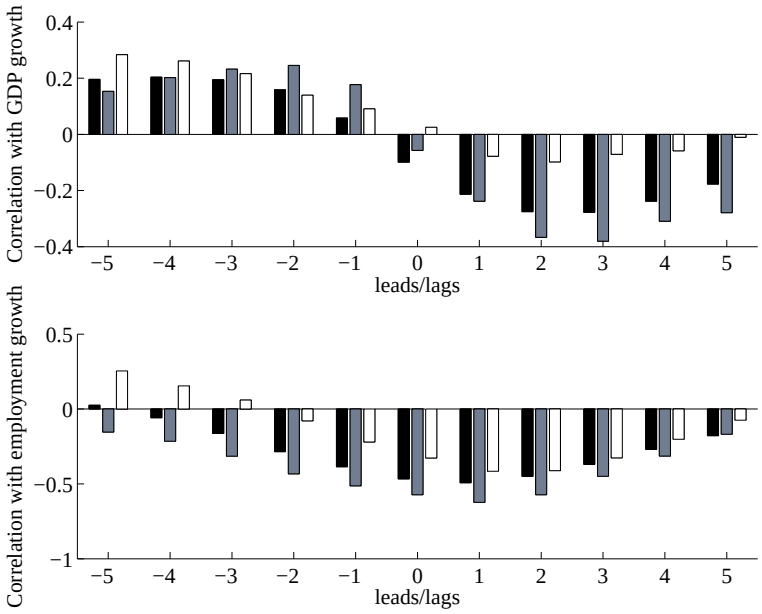

Figure 9: Correlation of number of short-time workers as a fraction of employment with GDP and employment. Leads/lags depict the correlation of STW/EMP in period t with GDP or employment in period $t + i$ / $t - i$. Black bars show correlations over the long sample corresponding to 1975 to 2010, gray bars show the short post-reunification sample corresponding to 1993-2010. White bars show correlations over the long sample without STW peaks in the 4 recessions.

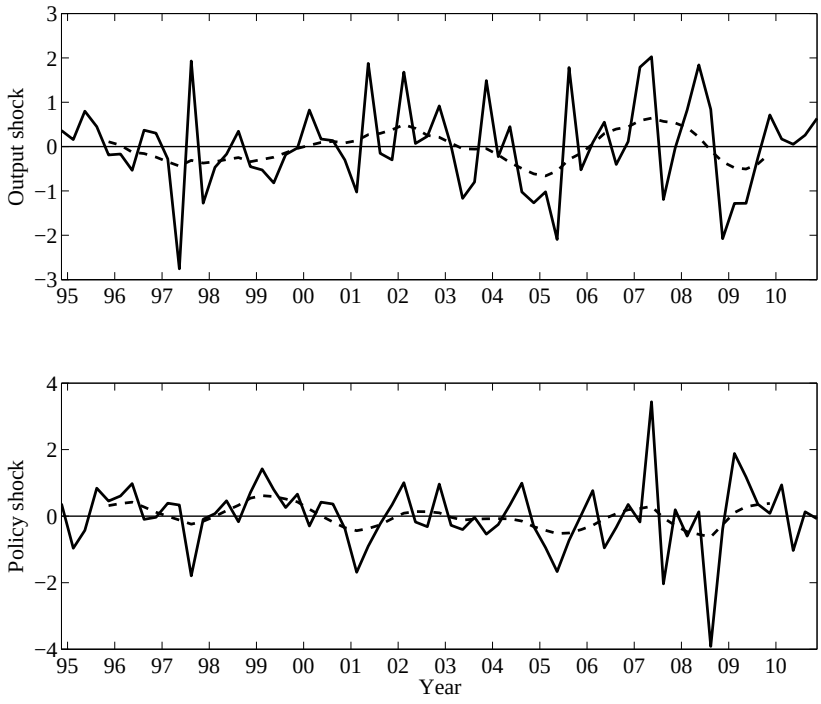

Figure 10: Estimated output and STW shocks from baseline VAR. The solid series shows the actual shock, the dashed series is smoothed with a centered moving average with four leads and lags and triangularly declining weights. SVAR estimated with STW per employed workers, GDP growth and unemployment (all in logs) for 1993Q1 to 2010Q4.

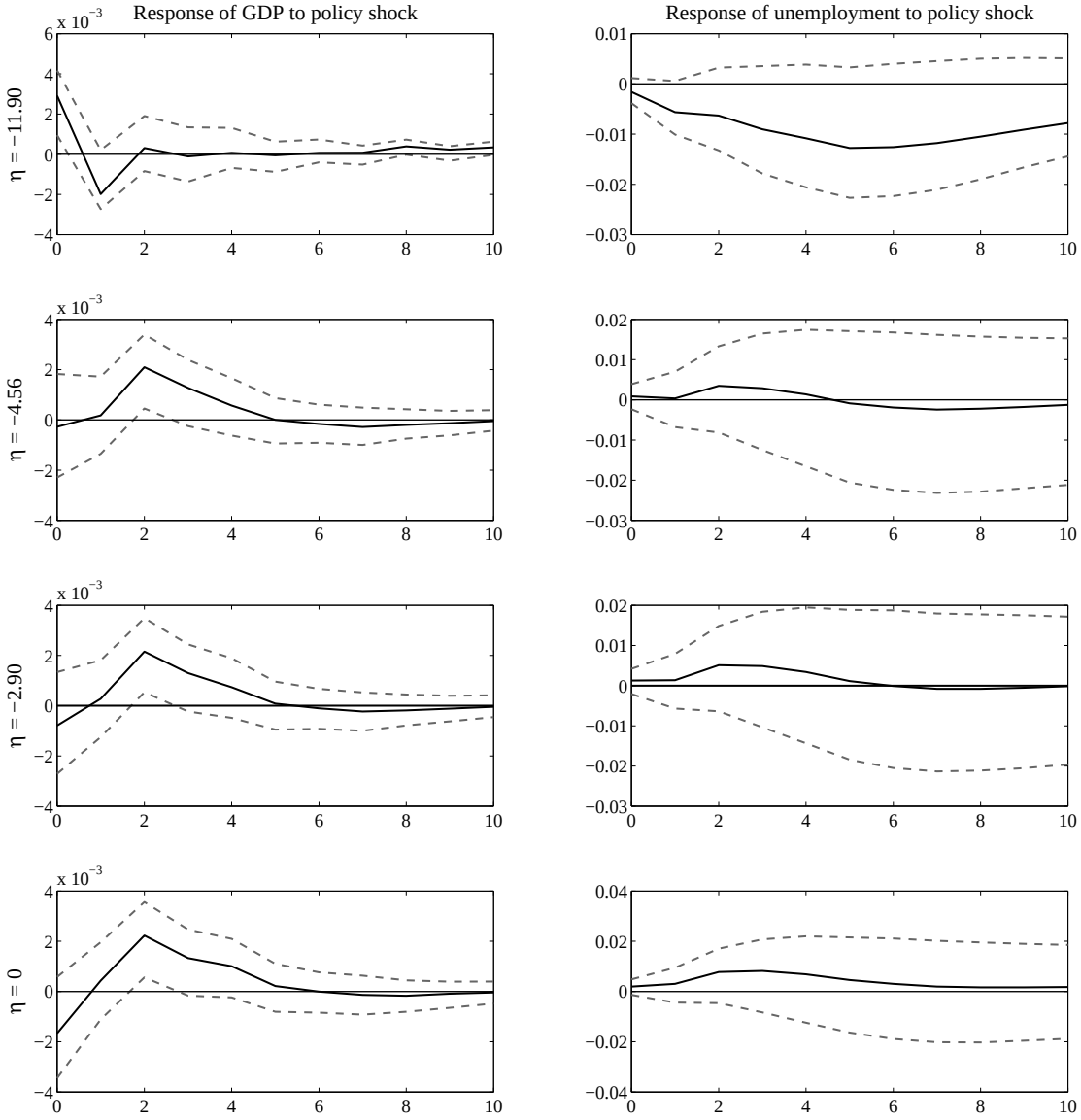

Figure 11: Impulse responses to policy shocks for different output elasticities of STW η. SVAR estimated with STW per employed workers, GDP growth and unemployment (all in logs) for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped bands with 10,000 draws.

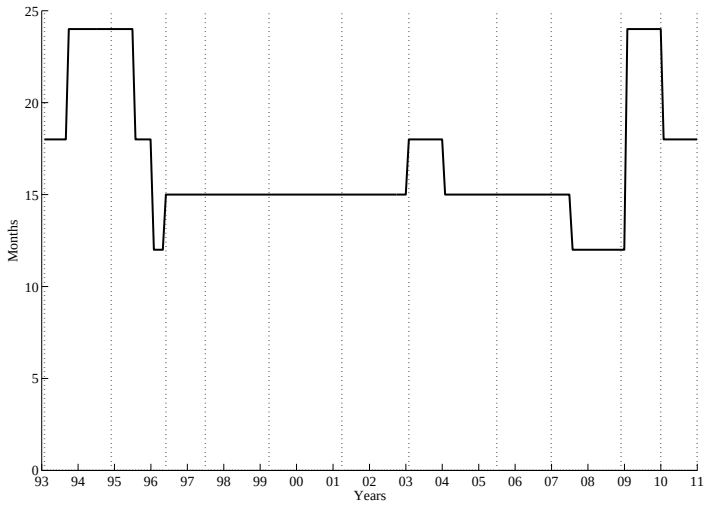

Figure 12: Legal changes in duration of eligibility of short-time work. The series describes legal maximum period of eligibility of a worker under short-time work scheme. Vertical lines show the timing of the corresponding legislation.

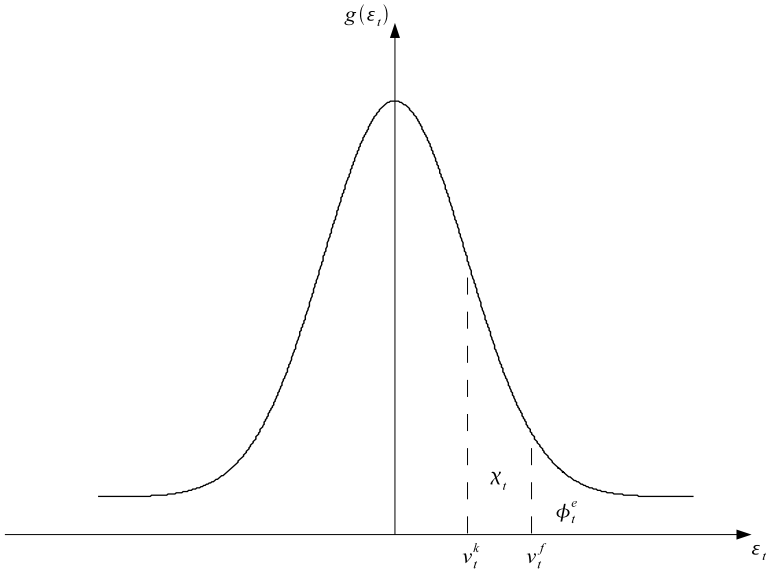

Figure 13: Illustration of the distribution of idiosyncratic shocks to the worker-firm pair and firing threshold v_t^f and STW threshold v_t^f.