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

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Abstract

In the Great Recession most OECD countries used short-time work (publicly subsidized working time reduction) to counteract a steep increase of unemployment. We show that short-time work can actually save jobs. However, there is an important distinction to be made: While the automatic stabilization 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 macro-evidence with macroeconomic modeling in order to identify, quantify and interpret these two components of short-time work.

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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 percent 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 or Boeri and Bruecker, 2011). Yet, our knowledge about the business cycle effects of short-time work (STW henceforth) is limited so far. Using a comprehensive approach including German micro and macro data as well as DSGE-modeling, we show that STW works well as an automatic stabilizer but not when used in a discretionary fashion.

Germany has had a long tradition of STW that goes back to the 1970's and has used STW also outside of recessions.[1] Furthermore, Germany offers rich microeconomic data on the use of STW in establishments. Combining this data with the macroeconomic time-series makes Germany a unique case study in order to evaluate the role of STW as a fiscal stabilizer.[2][3]

We are the first to distinguish between the discretionary and the automatic stabilization component of STW and we show that this distinction is important because the two components can have very different effects. 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") 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.[4] 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 (layoffs).

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. Beyond this, the German government frequently facilitates the use of STW in recessions, i.e., there is also a discretionary component of this policy. Recent articles that have integrated STW into modern macro models (Faia et al., 2013 and Krause and Uhlig, 2011) have only considered STW as a discretionary policy, while we show that the automatic stabilization component is actually more effective.

We use a combination of micro- and macroeconometric empirical evidence as well as macro-modeling to make quantitative statements about the actual effects of the discretionary and the automatic stabilization component of STW and to provide an interpretation for the effects. 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 identify this elasticity based on the cross-sectional

[1] See Figure 1 (solid line) for post-unification Germany and Figure 7 in the Appendix for STW usage in Germany back to 1975.

[2] Recent empirical cross country studies (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 this time-series component. For microeconomic studies with German data see Bellmann et al. (2010), Bellmann and Gerner (2011) and Speckesser (2010).

[3] To address fiscal stabilization, the 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 (2010) use structural VARs for this purpose and Cogan et al. (2010) or Christiano et al. (2011) use dynamic stochastic general equilibrium (DSGE) models.

[4] See Burda and Hunt (2011, p. 297) for an excellent description of German "Kurzarbeit".

dispersion of STW and value added. This microeconomic elasticity is required for two purposes: First, we use the elasticity as a short-run restriction on the contemporaneous variation between STW usage and output for the identification of a structural vectorautoregression (SVAR) in the spirit of Blanchard and Perotti (2002). Second, it imposes discipline on the parametrization of our dynamic stochastic general equilibrium (DSGE) model. While the SVAR allows us to estimate the effects of discretionary policy interventions, the DSGE-model allows us to run a counterfactual analysis of an economy with and without STW and hence, to quantify the automatic stabilization effects. The DSGE-model further provides an intuitive explanation for some stylized facts about STW in the data.

Our SVAR results show that the effect of discretionary STW interventions on employment and unemployment is not statistically significant. However, we document a moderate stabilizing effect on output. While this result sounds a cautionary note on discretionary STW interventions, our counterfactual model analysis shows that STW acts as a fairly strong automatic stabilizer. In our baseline scenario, unemployment fluctuations are reduced by 15 percent and output fluctuations are reduced by 7 percent (compared to the economy without STW).[5]

Our DSGE model provides an explanation for these differences. The model consists of a standard search and matching framework with endogenous separations and firing costs in which STW is the only possibility of labor adjustment along the intensive margin.[6] 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, she is allowed to be sent on STW. She will be sent on STW whenever it is more profitable for the firm 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 (this is exactly the purpose of the policy).

We show that discretionary changes in the eligibility criterion of STW do not lower unemployment if they are not used persistently, and, hence do not affect future expectations. Then, the policy change basically 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 and by reducing aggregate firing costs. Thus, our approach suggests that the distinction between the discretionary and the automatic stabilization component is very important. Both the ineffectiveness result for discretionary interventions and the automatic stabilization are new compared to the existing literature. Thus, at this stage our paper is the most comprehensive approach to quantify the macroeconomic effects of STW.

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, calibrates and simulates the model. Section 6 concludes.

2 Short-time work facts

While STW programs have been implemented in various countries, we focus on German data. As Germany has had a very long tradition of STW institutions, this allows us to calculate business cycle

[5]As laid out in more detail in section 5, the tax system that stabilizes the business cycle 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.

[6]See section 2 and figure 2 for a documentation that this is a plausible assumption.

facts related to STW. Given this, we do not only provide evidence of the effects of STW in the Great Recession, but give a more comprehensive picture.

Even though STW has been used before, the year 1975 marks the beginning of a systematic use of STW schemes in Germany. Certainly being fueled by the oil shocks and the subsequent recession, the German legislature passed a law inscribing the future use of short time work schemes to be targeted explicitly to back employment, not to insure workers against wage cuts. In 1975, the legislator also constituted the reimbursement of workers covered by STW schemes to be 60% of the current wage. This law is still in place today.[7]

The German Federal Employment Agency provides a long time series of the number of short-time workers in Germany at a monthly frequency. The data consists of numbers for West Germany before and West and East Germany after the reunification in 1991. The data for West 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. Here, we exclusively focus on STW schemes that were implemented as fiscal policy related to the business cycle ('konjunkturelle Kurzarbeit'). We further obtain the German GDP from Deutsche Bundesbank and use data for employment and unemployment as reported by the Federal Employment Agency.[8] Data on hours worked is calculated by the Institute for Employment Research (IAB). We consider a post-reunification sample starting in 1993 as our baseline. This avoids any complications in dealing with the German reunification break in the data, the heavy use of STW schemes in the transition period right after the reunification and the use of STW compensation in lockouts until 1986. We use the long sample mainly to perform robustness checks of the results. We take quarterly averages of all monthly series, since not all time series data needed for the subsequent analysis is available at monthly frequency. All series are seasonally adjusted using Census' X12-ARIMA procedure.

Figure 1 depicts the fraction of workers that are covered by STW schemes relative to total employment from 1993 to 2010 (solid line, cp. Figure 7 in the Appendix for the period 1975 to today). STW has been used throughout as it depicts a low, but non-zero average of 0.7% 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). 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. In fact, STW usage is negatively correlated with growth in GDP and employment, hence the business cycle (cp. Figure 8 in the Appendix). The contemporaneous correlations are potentially driven by two effects that are of interest to us: the automatic and the discretionary component of STW.

There are two margins of short-time work: The extensive margin measures the number of workers that are covered by STW programs. The intensive margin measures the reduction in hours worked of those covered by STW programs. Figure 1 shows that these two 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 fall, i.e., the more workers are on STW, the lower is the reduction in hours worked due to STW. The model that we present in the following replicates this pattern over the business cycle. Note that the product of these two series generates a measure of total hours worked reduction due to STW. Figure 2 (dashed line) shows that the resulting series is not constant, but also

[7] See Flechsenhar (1979) and Will (2010).

[8] Nominal data is deflated using the CPI index and as a robustness check also using the GDP deflator provided by the German Federal Statistical Office.

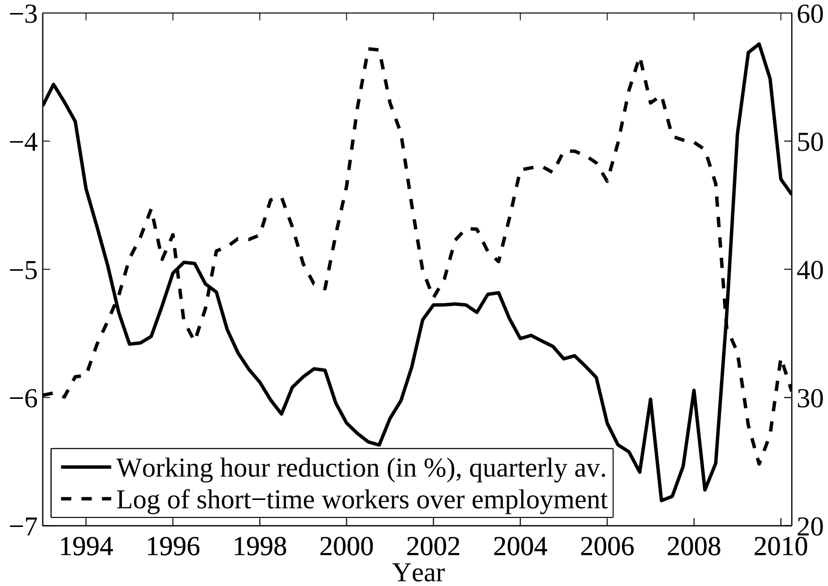

Figure 1: The extensive and the intensive margin of STW 1993-2010. The extensive margin is measured by the log number of short-time workers as a fraction of total employment, the intensive margin is measured by the fraction of hours worked reduced when in STW relative to full-time employment.

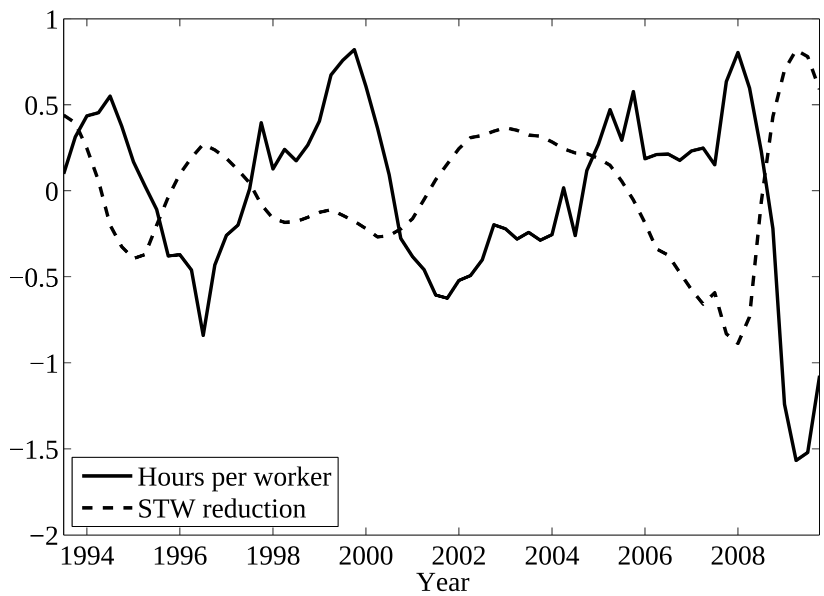

Figure 2: Total hours per worker (solid line) and hours reduction due to STW (dashed line) 1993 to 2010. We consider annual averages to (at least partly) account for the influence of institutional tools to adjust labor input within the year, such as overtime or working time accounts. Both series are HP filtered with $\lambda = 1,600$, the hours per worker cycle is multiplied with 100 for visual reasons.

moves over the business cycle. In fact, it strongly comoves with hours worked per employee in the economy (with a correlation of $-.69$ measured using cyclical deviations from an HP-trend).

For the period that we study, labor input in Germany is adjusted more along the extensive margin than the intensive margin.[9] Outside the large recessions, the extensive margin accounts for about 63% of the overall adjustment of labor input. In contrast to the US, the importance of adjustment along the intensive margin increases in recessions. 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). The negative correlation of hours worked per worker and STW that we document in Figure 2 suggests that STW is an important determinant of labor adjustment along the intensive margin. Here, we look at annual averages at a quarterly basis to (at least partly) wash out the influence of institutional tools to adjust labor input within the year, such as overtime or working time accounts. Complementing our findings, Abraham and Houseman (1994) find that the existence of STW schemes renders the hours adjustment in Germany equally flexible as the US adjustment in a study for the 1970's and 1980's. Burda and Hunt (2011) decompose the hours reduction in the Great Recession into different sources of adjustment and identify STW as the most important source of adjustment. These results reflect 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 ("Arbeitszeitschutzgesetz"). Thus, STW is a measure to loosen these regulations for worker-firm pairs with bad idiosyncratic shocks, particularly in recessions. In our model, we assume for simplicity that STW is the only possibility to adjust labor input along the intensive margin.

3 Estimating the short-time work elasticity using micro data

In our model, the automatic component of STW describes the elasticity of STW usage to changes in the business cycle when policy, e.g., the legal requirements connected to the use of STW, remains unchanged. Put differently, as the business cycle worsens, a larger number of firms becomes eligible to STW programs and may optimally choose to use them. We estimate the elasticity of STW usage to changes in output exploring cross-sectional variation in micro data for recent years. We will use our estimate of this elasticity as an important calibration target in our model and the corresponding stabilization exercise. In order to be able to do this, the micro estimate of the output elasticity of STW should at least be similar to the macro output elasticity of STW that the model describes. In the model that we outline below, the two will be the same. We further need our elasticity estimate to disentangle the automatic and the discretionary component of STW policy in the structural VAR.

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.[10] 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

[9] 57 to 43% if measured using the cyclical component of hours and employment filtered with the HP filter with $\lambda = 1,600$. Reicher (2012) shows that the extensive margin is most important for labor adjustment in most of the continental European countries.

[10] 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 remote data access.

short-time workers in employment can be zero for a given firm. Thus, we include firms without STW into the sample. Firm-level output is measured as the expected revenue in period t measured in period $t-1$. We use this measure for three reasons. First, we argue that this is the relevant measure 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.[11] 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 current revenue or previously expected revenue.

In a linear baseline specification, we explain the fraction of short-time workers in employment y_{it} by expected revenue (in logs) $\mathbf{x}_{it}$ using firm fixed effects

$$y_{it} = \mathbf{x}_{it}\beta_1 + \alpha_i + \gamma_t + \mathbf{z}_{it}\beta_2 + u_{it}. \tag{1}$$

Hence, we only use within-firm variation over time in order to estimate the effects of changes in log revenue on changes in the use of STW. The firm-fixed effects α_i control for time-invariant firm-specific effects in our estimation. STW policy in Germany is typically implemented at the federal level. Hence, STW policy changes affect all firms homogeneously over time. In order to rule out that we pick up policy changes in our estimation, we further include year-specific effects γ_t. The error term u_{it} is white noise. Since time-varying firm-specific effects may also play a role in the estimation, we add the number of employees in the previous year as a measure of time-varying firm size. The term $\mathbf{z}_{it}$ denotes the vector of additional control variables, i.e., the number of employees of the previous year and an industry dummy. Table 1 documents the estimation results. Across linear specifications (1 to 4), the effect of changes in expected revenue on STW use is precisely estimated to range between -2.80 and -3.36.

Our linear specification ignores an important feature in the data. The firm takes two decisions with respect to short-time work: 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. The Tobit model deals with the censored data, but does not model the participation decision. Following Wooldridge (2010, p. 835), we estimate a Tobit model with fixed effects using pooled Tobit and Mundlak terms.[12] We report average censored marginal effects, as these capture the effect of a change in log expected revenue on the actual number of short-time workers in firms using STW and firms not using STW. Our estimate ranges between -2.32 and -2.86 (specifications 5 to 7). Again, we find significant results 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).[13] We use the fraction of firms applying STW in the firm-specific industry sector as the exclusion restriction to

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

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

[13] Estimation is straightforward 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).

	log exp. revenue	derived elasticity	year fixed effects	employees in firm	industry	observations
Linear fixed effects						
(1)	-2.802^{***} [0.306]	-4.003				$39,545$
(2)	-2.968^{***} [0.299]	-4.240	yes			$39,545$
(3)	-3.131^{***} [0.342]	-4.473	yes	yes		$31,824$
(4)	-3.363^{***} [0.382]	-4.804	yes	yes	yes	$28,671$
Fixed effects tobit						
(5)	-2.319^{***} [0.286]	-3.313	yes			$31,824$
(6)	-2.614^{***} [0.311]	-3.734	yes	yes		$31,824$
(7)	-2.856^{***} [0.333]	-4.080	yes	yes	yes	$28,227$
Fixed effects heckman						
(8)	-4.972^{**} [2.57]	-7.103	yes			$31,824$
(9)	-4.87^{*} [2.75]	-6.957	yes	yes		$35,264$
(10)	-5.49^{**} [2.84]	-7.843	yes	yes	yes	$34,642$

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.

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. Across Heckman specifications (8 to 10), our estimates range from -4.97 to -5.49. Our estimates are significant, at least at the 10% level.

Since we have estimated the automatic feedback effects of changes in expected revenue on the use of STW in levels, 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 0.7%. 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 -7.84 at maximum.

4 SVAR evidence

Key to the VAR exercise is to disentangle the effects of business cycle shocks from the effects of discretionary policy changes on the use of STW and other macroeconomic variables such as output and employment. The challenge when identifying these two effects is that we do not explicitly observe exogenous 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 weakly defined and can potentially be interpreted very differently), 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 (e.g., through covering social security contributions of workers in STW, see Bundesministerium für Arbeit und Soziales, 2011 and also the discussion in Section 5. Section 4.1 documents how we identify STW shocks in a structural VAR, Section 4.2 documents and discusses the results. Section 4.3 provides robustness checks.

4.1 Identifying short-time work shocks in a structural VAR

To identify business cycle and discretionary STW policy shocks in the data, we estimate a structural VAR with a short-run restriction in the fiscal VAR tradition of Blanchard and Perotti (2002). The general VAR setup is based on a reduced-form estimation of

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

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 u_t, which are assumed to be independent and identically distributed with mean zero and covariance Σ_u. We now seek to identify the underlying structural shocks e_t from transforming the reduced-form innovations u_t using a transformation matrix A such that

$$Au_t = e_t.$$

The structural innovations e_t are assumed to be orthogonal with Σ_e diagonal and hence allow for an economic interpretation. Without loss of generality, we normalize the diagonal elements of Σ_e 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.

Blanchard and Perotti (2002) seek to identify the effects of a shock in fiscal policy on output, hence the output multiplier. The main difficulty is then to disentangle the co-movement in the policy variable (government spending or tax revenue) and output that is due to business cycle shocks from the one that is due to discretionary policy shocks. Key to the identification is the assumption that policy reacts with an implementation lag to changes in output which seems a reasonable assumption in quarterly data. All contemporaneous covariation of the policy variable and output can then be interpreted as the automatic feedback effect of the policy variable to the business cycle. We call this the output elasticity of the policy variable. The baseline estimation in Blanchard and Perotti (2002) assumes this elasticity to be zero. This appears to be a reasonable assumption in the case of government spending. In the case of tax revenue, in contrast, there may be automatic feedback effects from the business cycle to the policy variable. As pointed out by Caldara (2010), given the estimated parameters of the VAR, the value of this output elasticity of the policy variable is an important determinant of the identification and hence the output multiplier itself. We look at the effects of different values of this elasticity below.

In the tradition of Blanchard and Perotti (2002), we measure business cycle shocks as shocks to output. These shocks could then be interpreted both as supply or demand shocks driving the business cycle corresponding to the formulation in the model presented in section 5. We then use a short-run restriction in order to disentangle the dynamic effects of business cycle shocks from STW policy changes on the use of STW, output and employment. In line with our model, positive STW policy shocks can be interpreted as exogenous, unexpected changes along various dimensions of STW policy, such as enhanced eligibility to use STW or a reduction in the costs associated with STW usage. To identify these shocks in the data, we replace the policy variable in the setting of Blanchard and Perotti (2002) with our measure of the fraction of short-time workers in employment over time. As the series plotted in Figure 7 suggests and the model in Section 5 rationalizes , STW institutions are always in place and we should hence expect automatic feedback effects from a business cycle shock to STW even when policy has not changed. This means that the elasticity of STW usage to output is potentially non-zero.

Given that we know the value of this elasticity, how does the short-run restriction work? As discussed above, STW and GDP are negatively correlated. The identification now decomposes this negative correlation, or more precisely the estimated covariance of the two variables in the VAR, into two components, the business cycle and the policy component. Intuitively, if the imposed automatic feedback effect from the business cycle onto STW is 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, the effect of policy shocks on output becomes positive on impact. We show below that this is indeed the case in our baseline specification.

4.2 Results

In our baseline estimation of the effects of business cycle shocks and exogenous 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.[14] In addition, we use GDP growth as measuring the business cycle component of this variable, hence something that we can compare to the output of a model with a constant steady state as the one in Section 5. 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 the policy variable and the coefficients in the matrix A derived by Caldara (2010) in order to implement the short-run restrictions. Note that we have estimated the automatic feedback effects of the business cycle on the use of STW in levels rather than logs in the micro data. Hence, we need to transform this estimate into an elasticity by dividing it by the average STW usage in the sample of interest. For our baseline sample of 1993Q1-2010Q4 this elasticity corresponds to -3.31.

Figure 3 shows the quarterly responses of output, STW usage and unemployment to positive one-standard-deviation shocks in output and policy.[15] Note that the output response is plotted in growth rates, not in levels. 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 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

[14] 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.

[15] Figure 10 in the Appendix plots the estimated shock series over time.

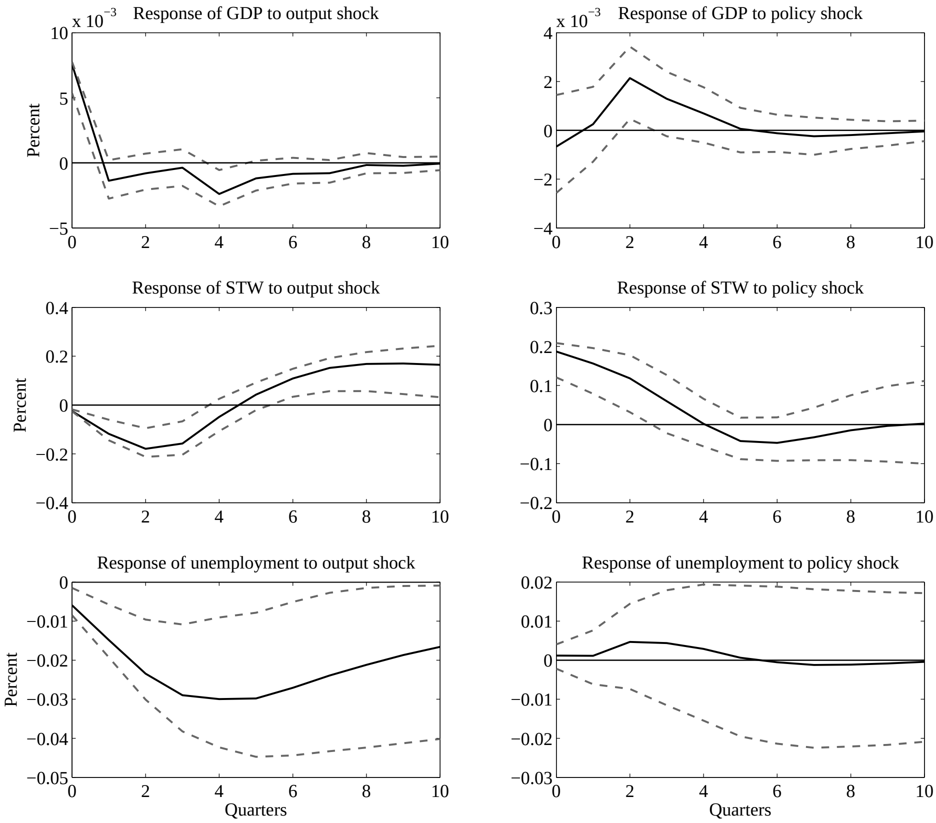

Figure 3: Impulse responses to output and STW policy shocks. SVAR estimated with log STW per employed workers, GDP growth and the log unemployment rate for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped bands with 10,000 draws.

that it is in fact positive. Output does not show any significant impact response to a policy shock, only after two quarters we observe a slight increase.

Strikingly, the unemployment rate does not significantly react to a STW policy shock. This is a surprising result, as a discretionary fiscal policy that is officially aimed at supporting employment does not seem to have a significant effect on this variable. Statistically, this result reflects the fact that business cycle shocks do not explain enough of the negative covariation of unemployment with output and the positive covariation of unemployment with STW usage. As a consequence, policy shocks do not have any significant effect on unemployment which contrasts the explicitly stated goal of this policy. Our model in Section 5 provides an interpretation of this result: temporary discretionary changes in STW policy do not affect future expectations and therefore hiring and firing decisions in a significant way. We document robustness of this result below.

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[16]. 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. 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 very strong positive elasticities, these effects are all insignificant. 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.

4.3 Robustness

We address the robustness of our results along various dimensions. Table 4 in the Appendix summarizes the results of our robustness checks.[17] Most importantly, we consider if the two recessions 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.[18] This does not affect the results 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

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

[17]More detailed results are available upon request.

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

to Blanchard and Perotti (2002) who incorporate a dummy for particularly large tax reforms into their fiscal VAR. Table 4 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 4 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 provided by the German Statistical Office 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.[19] As 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 climate index published monthly by the ifo Institute for Economic Research) 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 these shocks, we further include the interest rate as measured by the 3-months money market rate from Deutsche Bundesbank into the specification. Table 4 shows that including the interest rate into our specification does not change our baseline results.

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 eastern Germany directly after reunification for reasons not related to the business cycle, we only use STW data for West Germany.[20] Since the mean STW usage in the long sample is higher than in the short sample (0.83%), we correct our elasticity estimate down to -2.79. Note that our elasticity estimate stems from micro 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 4 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, even though mostly insignificantly. This documents that when taking into account early recessions, discretionary STW policy has on average not been very successful in stabilizing employment or output in recessions.

[19] The series for total hours worked is provided by the German Statistical Office.

[20] 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.

5 A labor market model with short-time work

5.1 The model

5.1.1 Model description

Our paper aims at quantifying the effects of the automatic stabilization and the discretionary component of STW. While the SVAR has shown the non-effects of discretionary policy changes on (un)employment, it is silent about the underyling economic rationale and the automatic stabilization effects of STW. Thus, we need a model that integrates important institutional features of the German economy (firing costs and collective bargaining) to deliver credible results and a model that is rich enough for quantitative analysis (calibration to microeconomic evidence). To keep the model tractable, we need to make some simplifying assumptions.

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 (see Section 2), while in deep recessions, STW plays a very important role in flexibilizing the intensive margin. See Burda and Hunt (2011) for a decomposition of labor input adjustments for the Great Recession. However, we leave the role of other instruments to flexibilize the intensive margin (e.g. working time account) for future research. This issue would be worrisome if we calibrated our model such that STW is responsible for the entire intensive margin adjustment in deep recessions. However, we use micro-data to calibrate our model based on the cross-sectional elasticity of STW with respect to output.

Second, the data shows that only a small share of firms uses STW to reduce the working time by 100 percent (most reduce hours by a lot less). To replicate this feature, we assume that firms are subject to convex costs of reducing the working time and provide some institutional underpinnings. But we do not provide any deeper microfoundation 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). Our choice is inherently model consistent. But in reality there may be interesting decision processes at the firm level of how STW affects bilateral surpluses and how these surpluses are shared.

For normative work, it is certainly crucial to have better microfoundations for the last two components. However, we consider these limitations as being of second order for our purposes, namely the quantification of the automatic stabilization component and a possible interpretation of the SVAR results. We are not only able to calibrate our model to the elasticity estimated in Section 3. The model does also a very good job in replicating the business cycle features of the extensive and intensive margin of STW. In addition, it offers a plausible explanation for the SVAR results.

Some more words on the rest of the model are in order: We use the search and matching framework of Diamond (1982) and Mortensen and Pissarides (1994) to model job findings and endogenous job separations assuming that worker-firm pairs are subject to idiosyncratic shocks. We integrate two institutional features into our model that are prevalent in countries with STW. First, we assume that wages are bargained collectively. Second, we assume linear firing costs. We check for the robustness of our results, by changing the bargaining rule and by 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.

5.1.2 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_t. We assume that the idiosyncratic component is additive and has the interpretation of a cost-shock. Additivity has the advantage that there are worker-firm pairs that may generate negative contemporaneous profits, even with a zero wage (i.e., it allows to model extreme idiosyncratic shocks). %textbfCM: Just a try: But I am not sure if we should advertise this that openly? CM WL stellt sich 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 in this economy because the latter depends on the former.

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

$$J(\varepsilon_t) = a_t - w_t - \varepsilon_t - c + \beta E_t J_{t+1}, \tag{2}$$

where a_t is aggregate productivity, w_t is the wage of the worker, c 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 (12) for the definition). The fixed cost of production c was introduced by Christoffel and Kuester (2008) as a way to generate the large volatility of unemployment over the business cycle found in the data, without resorting to wage rigidity or using a small-surplus calibration.[21]

We assume that the government defines an eligibility criterion C_0 for STW such that only workers whose value is below that threshold are allowed to be sent on STW. With this modeling choice we try to replicate the German rule that says that any firm that is in "financial difficulties" can apply for STW. We define financial difficulty as an expected loss **above** a certain threshold.

$$a_t - w_t - \varepsilon_t + \beta E_t J_{t+1} - c < C_0. \tag{3}$$

We interpret C_0 as a policy instrument. By lowering C_0, the government makes the eligibility criterion more stringent and, thus, directly reduces the number of workers on STW. In our benchmark calibration, we assume $C_0 = -f$, where f is the cost of firing a worker. This assures that only those workers are allowed to be sent on STW that would otherwise have been fired.[22] When quantifying and simulating the model in section 5.3, we show the effects of loosening the eligibility criterion, i.e., of increasing C_0.

Based on equation (3) we can define a threshold-level for the idiosyncratic component ε_t

$$v_t^k = a_t - w_t + \beta E_t J_{t+1} - c - C_0, \tag{4}$$

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.

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, in the German case a 100% working time reduction is extremely rare.[23] 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

[21] See Costain and Reiter (2008) for a discussion.

[22] Note that for $C_0 = -f$, equation (3) coincides with the firing condition of an equivalent model without STW.

[23] 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).

$\frac{\partial C(K(\varepsilon_t))}{\partial K(\varepsilon_t)} > 0$ and $\frac{\partial C(K(\varepsilon_t))^2}{\partial^2 K(\varepsilon_t)} > 0$, which assures interior solutions.[24] 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.[25] Second, the implementation of STW must be approved by the workers' council.[26] 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 obviously 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). Focusing on just one of those factors and thus microfounding it further may lead to overly simplistic outcomes. We defend our short-cut based on its empirical performance. We will show in 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.

Thus, the firm chooses the optimal level of K by maximizing the contemporaneous profit of a worker on STW:

$$\max_{K(\varepsilon_t)} \pi_t = (a_t - w_t - \varepsilon_t)(1 - K(\varepsilon_t)) - c - C(K(\varepsilon_t)). \tag{5}$$

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 which is independent of the production level. We impose a quadratic functional form for the costs of STW

$$C(K(\varepsilon_t)) = c_K \frac{1}{2} K(\varepsilon_t)^2. \tag{6}$$

This implies that the optimal degree of STW for a given ε_t is:

$$K^*(\varepsilon_t) = -\frac{a_t - w_t - \varepsilon_t}{c_K}. \tag{7}$$

Naturally, the lower the profitability of a worker, i.e., the higher the realization of ε_t, 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:

$$(a_t - w_t - \varepsilon_t)(1 - K(\varepsilon_t)) - C(K(\varepsilon_t)) - c + \beta E_t J_{t+1} < -f. \tag{8}$$

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

$$v_t^f = a_t - w_t - c + \frac{E_t \Lambda_{t+1} J_{t+1}}{1 - K\left(v_t^f\right)} + \frac{f}{1 - K\left(v_t^f\right)} - \frac{C\left(K(v_t^f)\right)}{1 - K\left(v_t^f\right)}. \tag{9}$$

[24]Assuming a linear cost function would imply corner solutions, i.e. workers either work full time or reduce hours by 100%.

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

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

Thus, the endogenous separation rate is

$$\phi_t^e = \int_{v_t^f}^{\infty} g(\varepsilon_t)\, d\varepsilon_t, \tag{10}$$

and the rate of workers on STW is

$$\chi_t = \int_{v_t^k}^{v_t^f} g(\varepsilon_t)\, d\varepsilon_t. \tag{11}$$

All the workers above the threshold v_t^k are eligible for STW, but workers above v_t^f are so unproductive that they are fired despite the possibility to send them on STW.[27] 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 c_K approaches infinity, then from equation 7 it follows that $K = 0$, i.e., firms do not use STW. In this case the STW cutoff and the firing cutoff are identical: $v_t^f = v_t^k$. This limiting case provides us with the model that we use for 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 one.

From equation (9) it follows that positive values of K affect the firing cutoff v_t^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 in which $v_f = v_k$.[28]

It should be noted 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 micro-elasticity of STW with respect to output. And we add firing costs and collective bargaining to replicate realistic European institutions. But even if $f = c = 0$ and under efficient individualistic bargaining, some workers exist who would generate contemporaneous losses, but who would not be fired because the losses they generate are not greater than the future value of a worker (which 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. The firm is free to choose the optimal working time reduction, i.e., it will only use a positive level of STW if this increases profits. Although workers have no choice in our model, they gain from the use of STW as well. Under the condition $C_0 = -f$ only workers who would otherwise have lost their job go on STW. Consider a worker with operating costs slightly above the firing threshold in the model without STW. With STW her income is $bK + (1 - K)w$, while without STW her income is simply b due to unemployment. Thus, a worker on STW earns at least as much as an unemployed worker (since wages are larger than unemployment benefits). Furthermore, the worker on STW has the continuation value of an employed worker, while the fired worker has the continuation value of an unemployed worker which is unambiguously lower. Thus, STW improves the flow value of the

[27] See Figure 9 in the Appendix for a graphical illustration of the distribution of the idiosyncratic shock and both threshold values.

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

worker. Put differently, the participation constraint of the worker is not violated and he will not quit due to STW.

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

$$\begin{aligned} J_{t+1} &= (1-\phi^x)\int_{-\infty}^{v_{t+1}^k}(a_{t+1}-w_{t+1}-\varepsilon_{t+1})\,g(\varepsilon_{t+1})d\varepsilon_{t+1} \\ &+ (1-\phi^x)\int_{v_{t+1}^k}^{v_{t+1}^f}\left[(a_{t+1}-w_{t+1}-\varepsilon_{t+1})\,(1-K(\varepsilon_{t+1}))-C\left(K(\varepsilon_{t+1})\right)\right]g(\varepsilon_{t+1})\,d\varepsilon_{t+1} \\ &\quad -(1-\phi_{t+1})\,c-(1-\phi^x)\,\phi_{t+1}^e f+(1-\phi_{t+1})\,E_{t+1}\Lambda_{t+2}J_{t+2}. \end{aligned} \tag{12}$$

Here,

$$\phi_{t+1}=\phi^x+(1-\phi^x)\,\phi_{t+1}^e, \tag{13}$$

is the overall rate of job destruction, which depends on the endogenous rate of job destruction defined in (10) and on the exogenous rate of job destruction ϕ^x (due to quits).

The first integral in equation (12) 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.

5.1.3 Matching on the labor market

While we have focused on the firing and STW decision of the firm so far, we now establish the market driven variables. Matches m_t are determined by a Cobb-Douglas matching function

$$m_t=\mu u_t^{\alpha}v_t^{1-\alpha}, \tag{14}$$

where u_t is unemployment, v_t 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_t (i.e., the probability of a firm to fill a vacancy) is

$$q_t=\mu\theta_t^{-\alpha}, \tag{15}$$

where $\theta_t=v_t/u_t$ is the labor market-tightness. Consequently, the job-finding rate η_t (i.e., the probability of an unemployed worker to find a job) is

$$\eta_t=\mu\theta_t^{1-\alpha}. \tag{16}$$

The present value of a vacancy is defined as

$$V_t=-\kappa+\beta E_t q_t J_{t+1}+E_t\Lambda_{t+1}(1-q_t)\,V_{t+1} \tag{17}$$

where J_t 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

$$\kappa=\beta E_t q_t J_{t+1}. \tag{18}$$

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.[29]

[29]Note that we have assumed that new matches are also subject to idiosyncratic shock and thus the the separation risk. This is already incorporated in the defintion of J.

5.1.4 Employment evolution

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

$$n_t = (1 - \phi_t) n_{t-1} + \eta_t (1 - \phi_t)(1 - n_{t-1}). \quad (19)$$

Thus, the employment rate in the current period includes workers of the previous period who did not get fired and unemployed workers who got newly matched. Note that also new matches are subject to the separation risk. Workers on STW are treated as employed, corresponding to the official German employment statistics (although they only work part-time).

5.1.5 Wage bargaining

Finally, we specify wage formation. We assume that the wage is bargained between the firm and the incumbent worker for whom the realization of the operating costs equals its expectation of zero. The foundations of our median bargaining model are similar to those of a median voting model (with unions and employers' association who are the major players of German wage negotiations).[30] Hence, wages are set collectively, and not individually for each ε_t. The median firms' profit[31] (with operating costs zero) of a match is

$$F_t = a_t - w_t - c + \beta E_t (1 - \phi_{t+1}) J_{t+1}. \quad (20)$$

In case of disagreement, production will come to a halt, and bargaining will resume in the next period. This 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

$$\tilde{F}_t = -c + \beta E_t (1 - \phi_{t+1}) J_{t+1}. \quad (21)$$

The median workers' surplus W_t from a match is

$$W_t = w_t + \beta E_t (1 - \phi_{t+1}) W_{t+1} + \beta E_t \phi_{t+1} U_{t+1} \quad (22)$$

where U_t is the value of unemployment. The workers' fall-back option under disagreement is then

$$\tilde{W}_t = b + \beta E_t (1 - \phi_{t+1}) W_{t+1} + \beta E_t \phi_{t+1} U_{t+1}. \quad (23)$$

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:[32]

$$w_t = \gamma a_t + (1 - \gamma) b. \quad (24)$$

In the numerical section, we will check for the robustness of our results by using a wage rule which includes the market tightness in the wage.

[30] According to OECD (2012), the collective bargaining coverage in Germany was 72 percent in 1990 and 62 percent in 2009.

[31] Note that the median firm does not use STW (empirically, only 0.7% of German firms use STW on average).

[32] When we use a (distortionary) proportional income taxes in a robustness check, the tax shows up in the bargaining equation.

5.1.6 Government budget constraint

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

$$bn_t \int_{v_t^k}^{v_t^f} K(\varepsilon_t)\, g(\varepsilon) d\varepsilon_t + bu_t = T_t. \tag{25}$$

5.1.7 Equilibrium and aggregation

The labor market equilibrium is defined by equations (4), (8), (9), (10), (10), (11), (19) and (24). Aggregate output (Y) in our model is defined as

$$\begin{aligned} Y_t &= (1-\phi^x)\left[n_t^B \int_{-\infty}^{v_t^k} (a_t - \varepsilon_t)\, g(\varepsilon_t)\, d\varepsilon + n_t^B \int_{v_t^k}^{v_t^f} (1 - K(\varepsilon_t))\,(a_t - \varepsilon_t)\, g(\varepsilon_t)\, d\varepsilon \right] \\ &\quad - n_t^B (1-\phi_t)\, c - (1-\phi^x)\, n_t^B \phi_t^e f - v_t \kappa. \end{aligned} \tag{26}$$

with $n_t^B = n_{t-1} + \eta_t (1 - n_{t-1})$. Aggregate output equals production minus resource costs. Since our model does not contain any other aggregate demand components, aggregate output equals aggregate consumption in our model.

When determining production we need to take account of the reduction in working time of workers on STW and the idiosyncratic shock. The resource costs include vacancy posting costs, firing costs and fixed costs of production.

5.2 Calibration

We calibrate the 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%. We assume logarithmic utility in consumption **(**$\sigma = 1$**).** 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 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 cost shock follows a logistic distribution which we normalize to have an unconditional mean of zero. To achieve our calibration target, we set the scale parameter 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 for 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 large, but in the aggregate the convex STW costs amount to only 0.3% of output.

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

Table 2: Calibration.

We introduce fixed costs of production to generate stronger amplification effects (i.e., responses of labor market variables to aggregate productivity shocks)[33] and to target the estimated contemporaneous elasticity of the extensive margin of STW with respect output changes. We set the fixed costs of production c to 0.23 to match the lower bound of our microeconometric estimates for the output elasticity of STW, -3.3% (compare output and STW in Figure 4).

It is well known that micro-elasticities may be unequal to macro-elasticities. Two things are worth noting: First, with the bargaining game in our baseline model (which does not contain any market tightness variable due to the assumed bargaining game), the macro elasticity exactly corresponds to the micro-elasticity. Thus, the calibration strategy is certainly consistent with our model. Second, in order to check for the robustness of results, we also perform a simulation exercise with the market tightness in the bargaining equation and obtain similar (albeit somewhat lower) stabilization results.

In our counterfactual exercise, the autocorrelation of the aggregate productivity shock is set to 0.95. The shock size is normalized to 1.

5.3 Simulation results

Our model allows for two types of shocks: a business-cycle shock and a discretionary change in government policy concerning short-time work. In the first subsection, we analyze how large the automatic stabilizing effects of STW are. In the second subsection, we analyze the effects of a policy shock and thereby establish a reference point for the SVAR results.

[33]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). 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 estimates of STW).

5.3.1 Automatic stabilizers

The impulse responses to a positive, one standard deviation shock to productivity a, with autocorrelation 0.95, are given in Figure 4. 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 has a positive effect on the firing cutoff v_t^f, thus 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 to a decline in unemployment. Overall, due to our assumption of fixed costs of production, our model can replicate the two main stylized facts of the business cycle. First, our model shows a Beveridge curve, i.e., a negative correlation between unemployment and vacancies of -0.49. Second, labor market variables are more volatile than productivity and output. The standard deviation of unemployment in our simulation is 2.5 times larger than the standard deviation of the underlying productivity shock.[34]

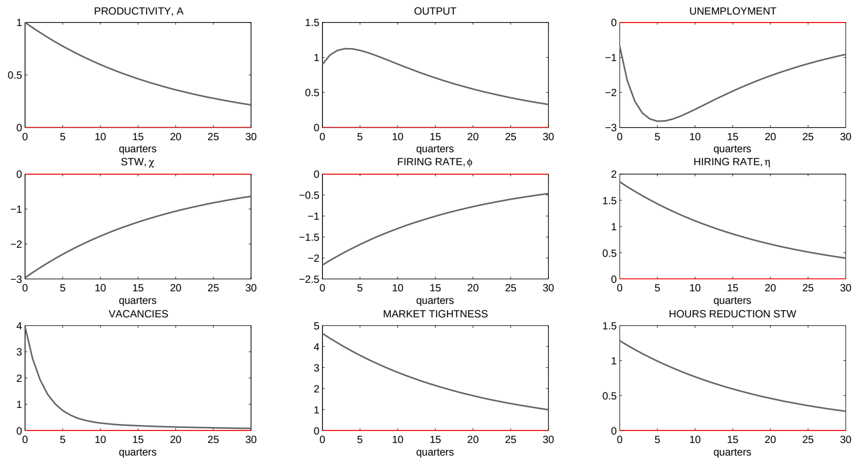

Figure 4: Impulse responses of a positive shock to aggregate productivity. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive increase in aggregate productivity.

What happens to STW? Remember the two 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. As demonstrated by Figure 4, our model replicates both stylized facts. Output and the share of workers on STW have a correlation of -0.99. Output and the average reduction of working hours have a correlation of 0.99. If productivity increases, firms become more profitable and so fewer workers are sent on STW. However, this decreases the average quality of workers on STW, i.e., only those workers with relatively high idiosyncratic cost shocks are sent on STW and therefore the average reduction of working hours increases.

In order to assess the role of STW as an automatic stabilizer of the labor market and the macroeconomy, we compare the business cycle statistics of an economy with and without STW. Table 3

[34]Note that we have used the fixed costs of production to match the elasticity of STW with respect to output, and not to match the volatility of unemployment. Therefore, the volatility of unemployment is still somewhat lower than found in the data.

Stabilization in $\%$	baseline	$f = 1.2$	$f = 0$	θ in bargaining	distortionary taxation
Output y	-6.8	-5.7	-3.9	-5.5	-6.8
Unemployment u	-14.9	-10.8	-5.4	-11.4	-14.6

Table 3: Reduction of the standard deviation in percent of the cyclical component of different variables in the model with STW compared to the model without STW. Cyclical components are defined as the log-deviations from the Hodrick-Prescott filter (smoothing parameter $\lambda = 1,600$).

shows the corresponding business cycle statistics. In the economy without STW, we change the standard deviation of the idiosyncratic shock and the vacancy posting cost to obtain the same steady state values for the labor market flow variables (i.e., the job-finding, job-separation rate and worker finding rate). This makes the log-deviations comparable (since the levels are unaffected). All other parameters remain unchanged compared to the baseline calibration.

The presence of STW reduces business cycle fluctuations, measured by the standard deviation of the cyclical component of output, by roughly 7% and reduces unemployment fluctuations by roughly 15% (see Table 3).

In a first robustness check, we reduce firing costs from 60% of annual productivity to 30% and 0% of GDP, respectively. The latter case is analyzed to illustrate that STW may also stabilize an economy without firing costs, but it certainly does not correspond to German institutions. Additionally, we change the scale parameter of the idiosyncratic cost distribution and the vacancy posting costs to obtain the same steady state for the labor market flows. This prevents that different log-deviations are driven by steady state shifts. 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, i.e., the latter has a somewhat lower value than in the baseline calibration.[35] Thus, in our exercise we inquire how the automatic stabilizers change in an economy with lower firing costs (but the same steady states). Interestingly, they drop because an economy with lower firing costs has smaller fluctuations of frictional costs, which reduces the possibility of STW to stabilize them.

In a second robustness check, we change the bargaining equation in the following way $w_t = \gamma(a_t + \kappa\theta_t) + (1-\gamma)b$. This means that, in contrast to Hall and Milgrom (2007), we assume that the fall-back option in the bargaining game is the outside option, hence unemployment. Given that the market tightness in the bargaining equation increases the wage volatility, there is less room for STW to stabilize and thus the stabilization effects are somewhat smaller than in the baseline scenario. Note, however, that the difference is very small.

Finally, we assume that additional expenses due to the cyclical variation in STW are financed by an immediate increase in a distortionary proportional income tax (i.e., we assume a balanced budget and the bargaining outcome is directly affected by these tax increases). As expected, such a distortionary financing of STW reduces its stabilization effects. The reduction is surprisingly small, however. The reason is that the defined STW rule is very cost-efficient and thus the extra costs in a recession due to the automatic reaction are small.

Is a stabilization of 5 to 7% of GDP fluctuations and 10 to 15% of unemployment fluctuations a lot? To evaluate the cost-effectiveness of the automatic stabilization, we have to put the stabilization effects in relation 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 0.03% of GDP.[36] How does this compare to

[35] In a further robustness check, we also adjusted the fixed costs to obtain the same elasticity of STW with respect to output. The results are qualitatively the same, quantitatively similar and are available on request.

[36] At the peak in 2009 it was 0.13% of GDP.

other automatic stabilizers such as the tax system? The estimated size of 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). However, the income tax system accounts for more than 10% of GDP in most OECD countries. Thus the stabilzation through STW appears to be large relative to the costs.

Overall, our baseline calibration and robustness checks predict sizeable stabilization effects of STW despite the relatively small size of the STW system compared to the income tax system. It has to be emphasized that we used the lower bound of our estimated elasticities for the model calibration. Thus, our predicted stabilization effects can be expected to be conservative.

5.3.2 Policy shock

Next, 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 C_0. We consider a policy that increases the number of workers on STW on impact by 1 percent and then slowly converges back to the steady state with a coefficient of autocorrelation of 0.5. Figure 5 shows the impulse responses of such an increase in C_0. The direct effect of an increase in C_0 is to decrease the STW threshold v_t^k (see equation 4), which implies that more workers are sent on STW. Note, however, that there are also indirect effects through an increase in the profitability of firms. Reducing C_0 allows firms to send more workers on STW in the future reducing the losses generated by these workers. Consequently, the value of job J goes up, firing goes down and vacancy posting goes up (see equations 17 and 9).

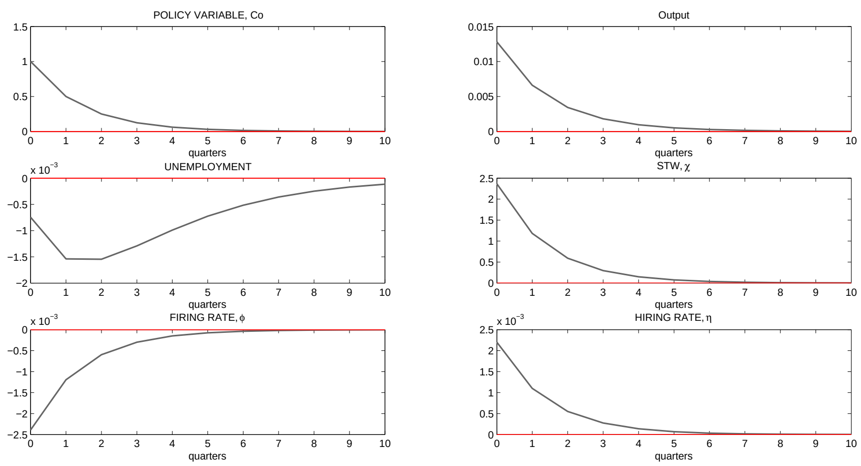

Figure 5: Impulse responses of a negative shock to C_0. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive decrease in the costs of STW.

Both the decrease in firing and the increase in vacancy posting tend to decrease unemployment, while output goes up. Note, however, that the decrease in unemployment hinges on the indirect effect just described. This indirect effect in turn depends crucially on the expectations about the future value of a job (vacancy creation and firings depend only on J_{t+1} and not on J_t). If the policy change is expected to not last long (i.e., if the coefficient of autocorrelation is low), then the impact on expected future profits will be low and the effects on unemployment will be low, too. In the extreme case of an uncorrelated shock the effects on unemployment vanish altogether, as demonstrated by Figure 6. Note, however, that the positive effects on output remain. Although employment remains unaffected, worker-firm pairs with a large positive idiosyncratic operating cost shock reduce their working time. Thus, there are two countervailing effects. On the one hand, aggregate production is reduced and on the other hand operating costs (which are part of the aggregate resource constraint) are reduced. In our calibration, the second effect dominates and aggregate output increases. Since our SVAR yields the same qualitative results, the reduction of resource costs due to discretionary STW interventions seems to be important in reality.

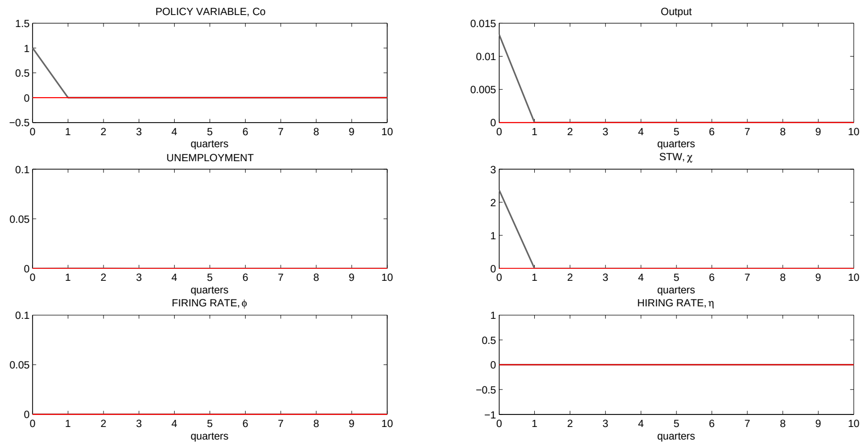

Figure 6: Impulse responses of a negative shock to C_0. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive decrease in the costs of STW.

Overall, our model suggests that discretionary STW policies only have an effect on unemployment if they affect future expectations. In the extreme, a policy change that just lasts for one period creates a deadweight effect of 100%, i.e., all additional workers that go on STW due to loosening the eligibility criterion would not have been fired in the absence of rule changes. The reason is that more intramarginal workers go on STW, while the firing cutoff point remains unaffected.

6 Lessons and Outlook

This paper combines microeconomic and macroeconomic evidence as well as macro-modeling in a novel way in order to separately investigate the rule-based and the discretionary effects of STW policy in Germany. Based on the estimated microeconomic elasticity, we have shown that the discretionary component of STW is ineffective (i.e., it does not save jobs), while the automatic stabilization component shows a substantial stabilization effect (i.e., it saves jobs). The reason is that transitory interventions may lead to substantial deadweight effects , while rules affect future expectations and thus exert an effect on firms' hiring and firing decisions.

Under the existence of a STW system, transitory interventions make it easier for firms to use STW. However, they subsidize worker-firm pairs that would not have been destroyed in the absence of the intervention. Thus, no additional jobs are saved.

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 the rule-based component may stabilize the economy. Not differentiating these two different cases may lead to biases when estimating the effects of STW on the macroeconomic level.

Does our analysis suggest that Paul Krugman (2009) is right that STW was an important job saver in the Great Recession? And, if yes, was that driven by the rule-based or the discretionary component of STW? Regarding the latter, note that it is impossible to run a SVAR just for the crisis. Hence, we have to rely on the SVAR-results for the longer sample. 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 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 percent decline of GDP, equivalent to the 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.[37] 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 size leads to an increase of unemployment of 5.66 percentage points. Thus, our counterfactual analysis predicts that the automatic component of STW has prevented an increase of unemployment of 0.84 percentage points, i.e. it saved roughly 300,000 jobs in the Great Recession.

Thus, Krugman is right that STW has indeed contributed to the German labor market miracle. But our back-of-the-envelope calculation suggests that additional forces were 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 a further flexibilization of the intensive margin 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.

What are the lessons for other countries? First, rules are better than discretion.Our paper suggests that a well-designed STW system may provide a fair amount of stabilization at low fiscal costs (e.g., compared to the income tax system). It is certainly an interesting question for future research whether STW systems in other countries provide more or less automatic stabilization than in Germany and why.

Second, our paper has shown that the stabilization effects depend on the institutional settings. According to the model simulations, economies with larger firing costs and less flexible wages can expect stronger stabilization effects due to STW. Larger firing costs make it particularly 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 in in the aggregate. More flexible wages act as an automatic stabilizer (when wages adjust more along the cycle, quantities move by less). Thus, our model suggests that there is more room for STW as an automatic stabilizer when wages are less volatile along the business cycle. While we are unaware of any cross-country studies that compare the degree of wage rigidity and the use of STW, Cahuc and Carcillo (2011) show that there is indeed a positive cross-country correlation between the average

[37] Note that a simple estimated Okun's law relationship would lead to numbers in a similar order of magnitude. Obviously, we observe GDP and unemployment numbers where the automatic stabilization effects are already at work. Taking this into account would change the results of our back-of-the-envelope calculation only slightly and make it less intuitive.

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 with large firing costs. It remains for future research whether these cross-country differences are driven by different discretionary interventions in the Great Recession or different institutional settings.

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Appendix

	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			
Long sample (1975-2010)						
baseline	-	(0-1)	1	+		none
	+	(2-)	none			
with recession dummies	-	(0-1)	none	+		none
	+	(2-)	none			

Table 4: Summary of robustness checks. The table reports the sign of the responses in output and unemployment to a STW policy shock. Significance is based on 90% bootstrapped confidence bands.

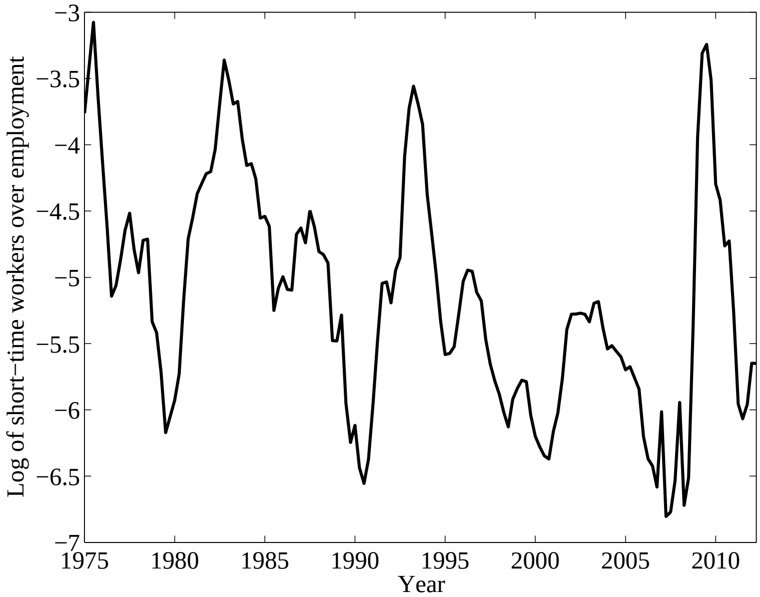

Figure 7: Short-time work in Germany 1975-2012. The series depicts the log of the number of short-time workers as a fraction of total employment.

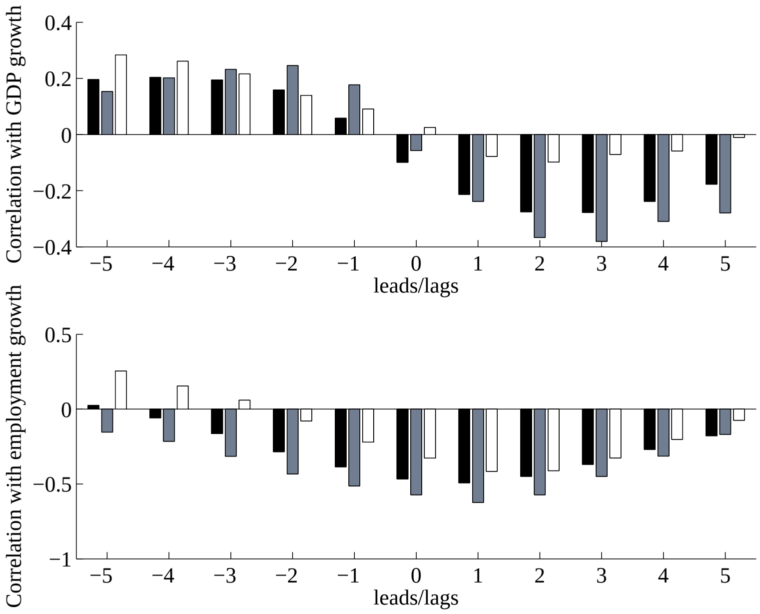

Figure 8: Correlation of number of short-time workers as a fraction of employment with GDP and employment. Leads/lags depict the correlation of STW/EMP in period t with GDP or employment in period $t+i$ / $t-i$. Black bars show correlations over the long sample corresponding to 1975 to 2010, gray bars 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.

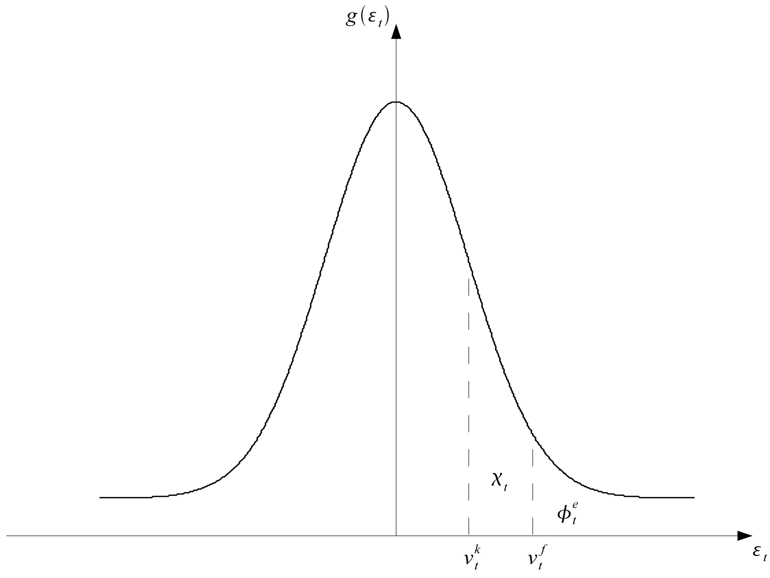

Figure 9: Illustration of the distribution of idiosyncratic shocks to the worker-firm pair and firing threshold v_t^f and STW threshold v_t^f.

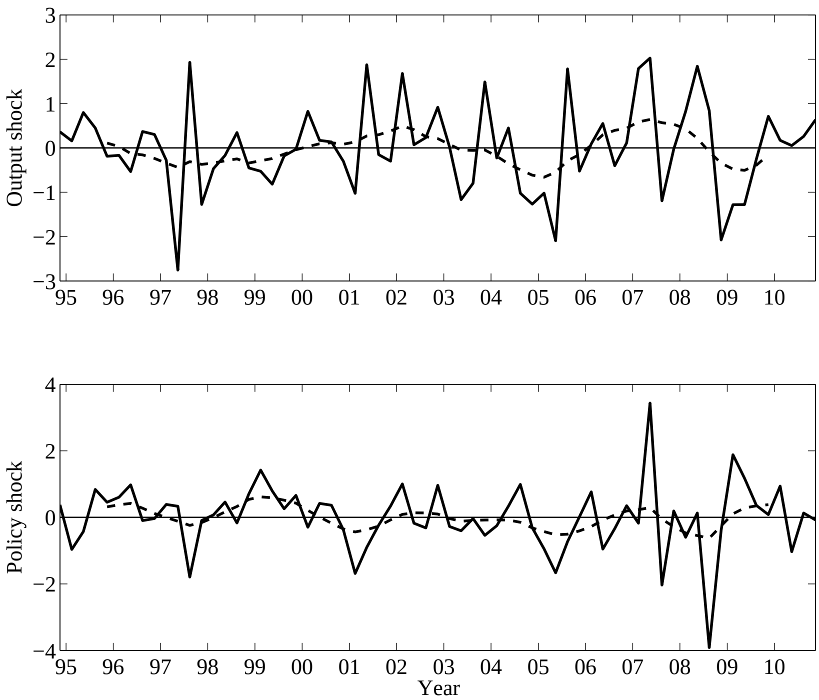

Figure 10: Estimated output and STW shocks from baseline VAR. The solid series shows the actual shock, the dashed series is smoothed with a centered moving average with four leads and lags and triangularly declining weights. SVAR estimated with STW per employed workers, GDP growth and unemployment (all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

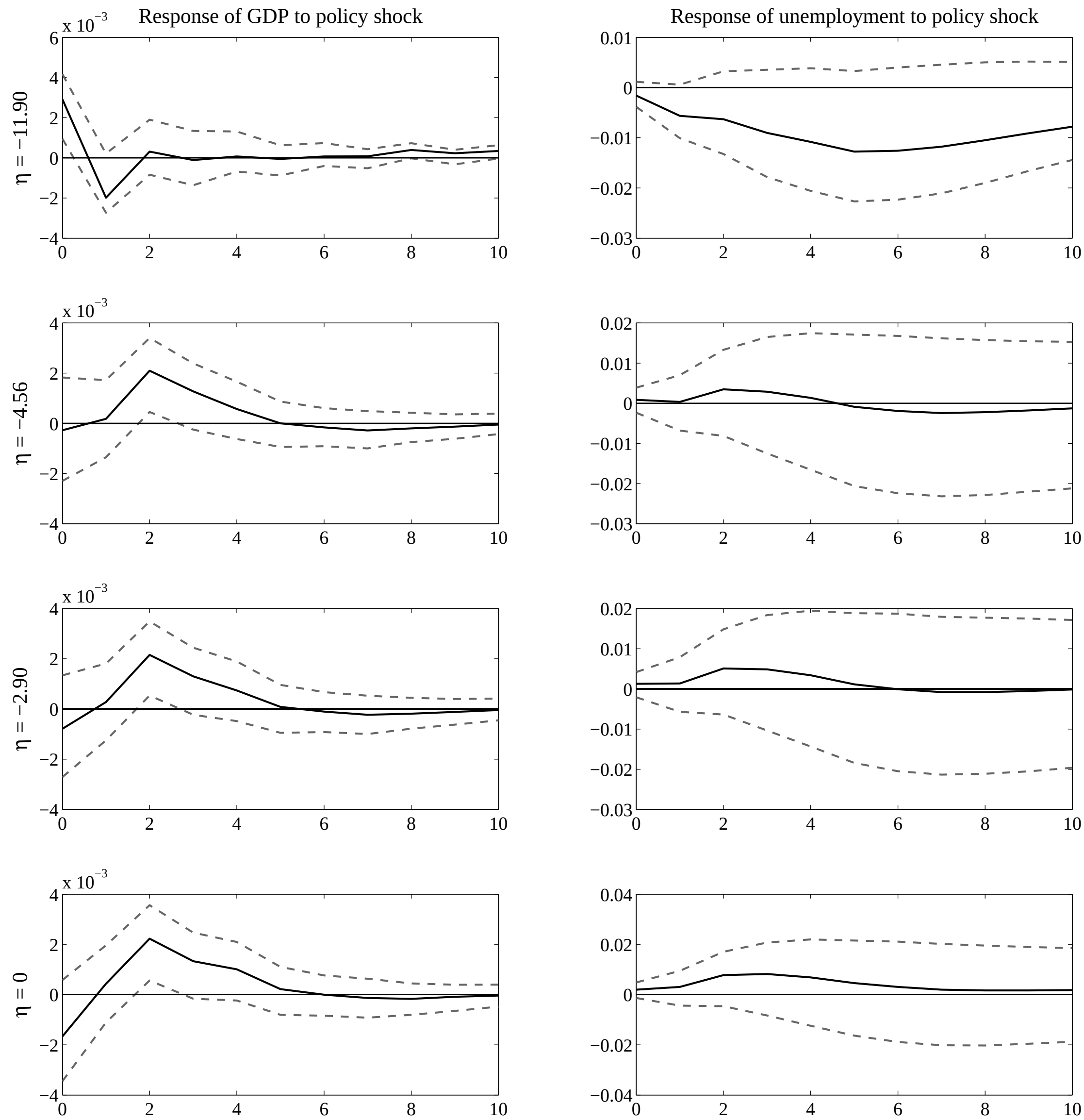

Figure 11: Impulse responses to policy shocks for different output elasticities of STW η. SVAR estimated with STW per employed workers, GDP growth and unemployment (all in logs) for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped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

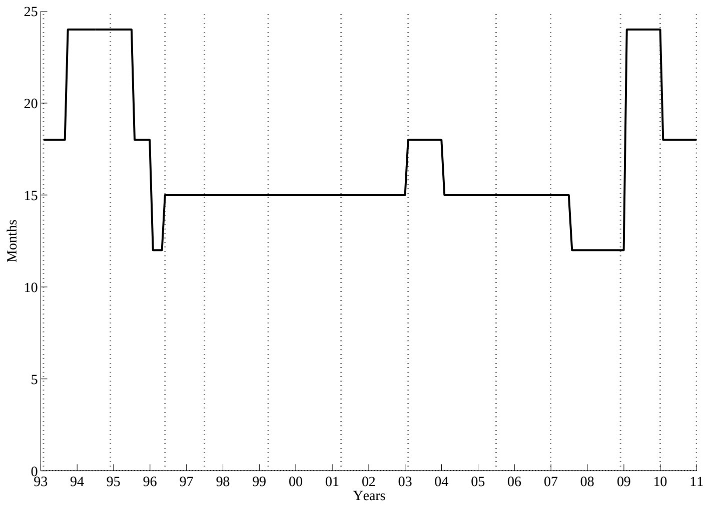

Figure 12: Legal changes in duration of eligibility of short-time work. The series describes legal maximum period of eligibility of a worker under short-time work scheme. Vertical lines show the timing of the corresponding legislation.