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

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

Abstract:

This paper analyzes the effects of short-time work (i.e., government subsidized working time reductions) on unemployment and output fluctuations. The central question is whether the rule based component (i.e., the existence of the institution short-time work) and the discretionary component (i.e., rule changes) stabilize employment over the business cycle. In our baseline scenario the rule based component stabilizes unemployment fluctuations by 15% and output fluctuations by 7%. Given the small share of short-time work expenses in terms of GDP, the stabilization effects are large compared to other instruments such as the income tax system. By contrast, discretionary short-time work interventions do not have any statistically significant effect on unemployment. These effects are based on a structural VAR estimation which is identified using the output elasticity of short-time work estimated from German establishment paneldata. The model shows that non-effects of discretionary interventions may be due to their low persistence.

Keywords: Short-time work, fiscal policy, business cycles, search-and-matching, SVAR

JEL classification: E24, E32, E62, J08, J63

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1 Introduction

Can fiscal policy stabilize output and employment fluctuations? To answer this question, the fiscal policy literature has so far almost exclusively focused on fiscal multipliers of traditional government tax and spending instruments.[1] In this paper, we investigate how short-time work (STW) programs interact with economic fluctuations over the business cycle. STW is meant to reduce employment fluctuations over the business cycle by giving firms in financial difficulties the opportunity to adjust the working time of their employees, while the accompanying reduction in the employees' income is partly compensated by the government. The instrument is heavily used in many countries[2], but so far, there exists only very little research on the effects of this policy over the business cycle. The purpose of this paper is to fill this gap, both from a theoretical and an empirical perspective.

STW affects cyclical job losses in two ways: First, STW is used as a discretionary policy tool over the business cycle (i.e., policy makers facilitate the use of STW in recessions by allowing more workers to be covered by the instrument). Second, STW is not only used in heavy recessions, but many countries have institutions in place such that firms can apply for STW independently of the business cycle stage. Thus, similar to the tax code, STW can act as an automatic stabilizer (i.e., more firms use STW in recessions, although the legal rules are not changed).[3]

Our paper disentangles the rule based and the discretionary component of STW. To address the rule based component, we first estimate the automatic response of STW usage to changes in output from microeconomic firm level data. We then present a DSGE model with frictional unemployment, endogenous firing and STW to assess the automatic stabilization effect of STW and to provide a rationale for how STW affects output and unemployment. In our model, firms in financial difficulties apply for STW at any business cycle stage. STW allows these firms to reduce their production level and thereby losses. Workers that would otherwise have been fired remain employed. Since more firms move into financial difficulties in a recession, more firms will then use STW. Compared to a situation without STW, this direct effect stabilizes firing over the business cycle. In addition, the present value of workers' profits becomes smoother over the business cycle as the drop in profits during recessions is reduced. This indirect effect makes both hiring and firing less volatile over the business cycle. We use the estimated output elasticity to calibrate the model and perform counterfactual simulations for the rule based effects of STW. We find that STW stabilizes output and unemployment fluctuations by 7 and 15 percent, respectively. This is substantial given that the average costs of STW as a share of GDP are a lot less than the respective share of an income tax system which stabilizes output to a similar degree (see Section 3.3 for more details).

To address the discretionary component, we document empirical evidence from a structural VAR with a short-run restriction in the tradition of Blanchard and Perotti (2002).[4] Based on the assumption of an implementation lag of policy to changes in output, we use our estimated elasticity of the rule-based component as a short-run restriction on the contemporaneous variation between STW usage and output. We then use the VAR to estimate the dynamic effects of exogenous (i.e., discretionary) changes in STW policy. We find that STW policy shocks have a very weak stabilizing effect on

[1] 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.

[2] In 2009 between 2 and 5 percent of all employees have been on STW in countries like Germany, Italy, Japan or Turkey (Cahuc and Carcillo, 2011). Krugman (2009) attributes Germany's stable employment in the Great Recession at least partly to STW.

[3] Similarly, the tax bill drops in recessions under a proportional or progressive tax system, without any changes in the tax code. See Mattesini and Rossi (2012) for the role of taxes as automatic stabilizer in a DSGE context.

[4] From Caldara (2010), we know that both the identification of the fiscal policy shocks and the resulting effects on output and hence potentially unemployment are sensitive to the underlying assumptions about the automatic feedback effects.

output, while the effects on unemployment are insignificant. Our model provides an explanation for this result. In a recession, the existing STW rules have already reduced firing. A discretionary intervention allows firms to use STW for more intramarginal workers, i.e., those workers who would not have been fired in the absence of STW. Discretionary interventions can then only have an effect on firing and hiring if they change expectations of future profits, i.e., if firms expect the intervention to have some persistence. Hence, discretionary policy interventions only work through the indirect stabilization effect described above and do not have much of an effect if they are implemented in a very short-lived way.

For all these exercises, we use data for Germany which, due to its very long tradition of STW institutions since the mid 1970's, allows us to observe business cycle characteristics of STW in long time series. In Germany, even in usual times about 200,000 workers are on STW, while the number climbs to roughly 1.5 million in heavy recessions such as the oil price crises or the Great Recession. We document that the number of workers in STW programs as well as the total number of hours worked in these programs varies over time and with the business cycle. Moreover, the more workers are in STW, the less do they reduce the hours that they work compared to their normal working hours. We show that our model can replicate these business cycle facts. Finally, we explore the Institute for Employment Research (IAB) Establishment Panel dataset for the years 2003-2010 to estimate the rule-based component.

A German firm can apply for STW in a fairly simple way. The firm has to announce (on a two page form) to the Federal Employment Agency ("Bundesagentur") that it would like to start using STW within three months. In order to be eligible, it has to prove credibly that it has unavoidable financial difficulties,[5] i.e., that the expected demand for the firm's products is lower than the production potential and it would consequently have to reduce its labor input. If the Federal Employment Agency approves the STW application, it partly compensates workers for their lost income.[6] STW can only be used for a limited period of time (on average about one year). We formulate our baseline model in order to match both the characteristics of the German STW institutions and general characteristics of the German labor market (such as collective bargaining or firing costs).

Our paper complements an emerging literature on STW. The theoretical literature is relatively scarce and dates back to Burdett and Wright (1989) and Van Audenrode (1994). These theoretical setups rely on an implicit contract model to analyze STW, while they allow for compensation of workers with a reduction in hours worked. In this setting STW may result in an inefficient reduction of hours. Braun et al. (2012) extend this approach in a recent paper. Note, however, that these papers primarily focus on assessing welfare in a static context. This paper does not derive optimal STW policy, but focusses instead on the dynamic interaction of existing STW policy with the business cycle. The few existing examples of a positive analysis of STW in modern business cycle models are Faia et al. (2013) and Krause and Uhlig (2011). Yet, the STW schemes in Faia et al. (2013) and Krause and Uhlig (2011) remain very stylized (e.g. there is no tradeoff between the number of workers in STW, the extensive margin, and the hours reduction per worker, the intensive margin of STW) and may hence be problematic for quantitative analysis.

On the empirical side, the evidence on STW is broader. Abraham and Houseman (1994) show that the STW schemes in European countries in the 1980s are able to compensate for the otherwise inflexible labor markets compared to the US. Most recent empirical studies use cross country estimations (Cahuc and Carcillo, 2011, Arpaia et al., 2010, Hijzen and Venn, 2011, IMF, 2010 and OECD,

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

[6] The compensation is at the same level as the unemployment benefits, which is currently 60% (67%) of the last wage. In particular, if a worker goes on STW for 30%, he would receive 70% of his old wage from the employer plus 30% of 60% of his old wage from the government.

2010). These studies mostly conclude that STW indeed avoids layoffs during recessions, but the cross-country approach suffers from some important limitations. The STW arrangements across different countries rely on very different institutional settings (cp. Hijzen and Venn, 2011 for a comparison of STW legislation across OECD countries) and rule based and discretionary components of STW are not sufficiently separated.

An alternative approach is to evaluate the effects of STW by means of microeconometric studies on the firm level. Examples for this approach are Bellmann et al. (2010), Bellmann and Gerner (2011) and Speckesser (2010) for German data or Calavrezo et al. (2010) for French data. These studies provide some interesting insights into the relationship between STW usage and firm characteristics. They do not directly address the effects of STW policy on unemployment or output. Burda and Hunt (2011) provide a broader perspective. They use a dynamic labor demand estimation to evaluate the role of different institutions and shocks (e.g., working time accounts, the wage moderation or short-time work) in the Great Recession in Germany. Our analysis considers STW over a longer horizon focussing on the interaction of STW and the business cycle, not only recessions. Our methodology is fundamentally different from Burda and Hunt, since we present a formal DSGE model and evidence based on a structural VAR which allows us to disentangle rule-based and discretionary effects.

The rest of the paper is organized as follows. Section 2 documents business cycle facts and microeconometric evidence related to STW for Germany. Section 3 describes, calibrates and simulates the model. Section 4 discusses the evidence from the structural VAR and Section 5 concludes.

2 Short-time work facts

While STW programs have been implemented in various countries, we focus on German data for two reasons: First, Germany has had a very long tradition of STW institutions, which allows us to calculate business cycle 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. Second, we can use German microeconomic survey data in order to estimate the automatic response of STW to changes in output from the cross-section of firms.

2.1 Short-time work over the business cycle

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 legislator 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

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

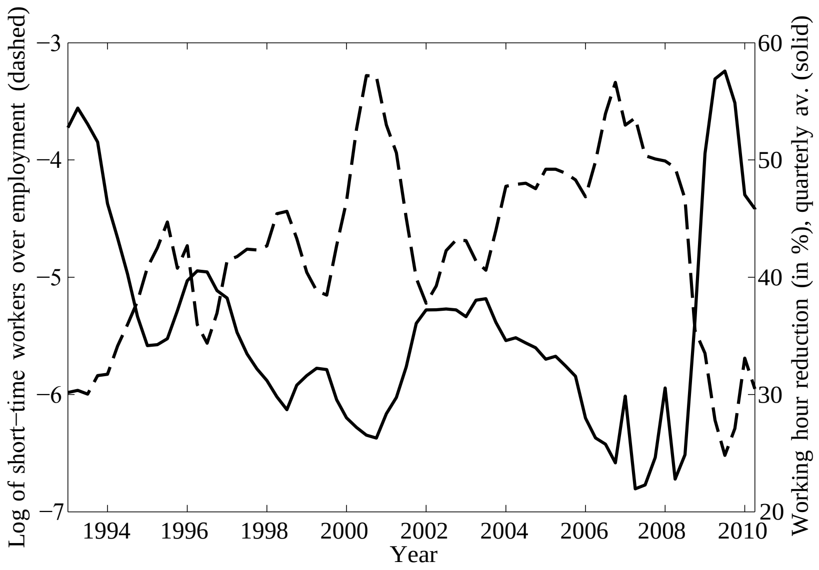

Figure 1: The extensive and the intensive margin of STW 1993-2010. The extensive margin is measured by the log number of short-time workers as a fraction of total employment, the intensive margin is measured by the fraction of hours worked reduced when in STW relative to full-time employment.

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). One can see that 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 rule-based and the discretionary component of STW. This paper uses a calibrated DSGE model as well as a structural VAR to disentangle these two effects.

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

[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.

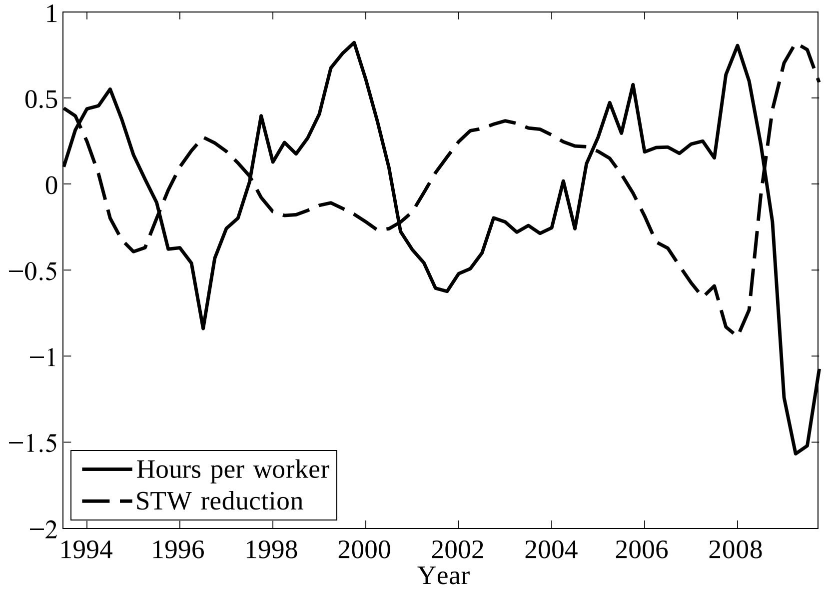

Figure 2: Total hours per worker (solid line) and hours reduction due to STW (dashed line) 1993 to 2010. We consider annual averages to (at least partly) account for the influence of institutional tools to adjust labor input within the year, such as overtime or working time accounts. Both series are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

(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 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.,

[9] 57 to 43% if measured using the cyclical component filtered with the HP filter with $\lambda = 1600$. Reicher (2012) shows that the extensive margin is most important for labor adjustment in most of the continental European countries.

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.

2.2 Estimating the short-time work elasticity using micro data

In our model, the rule-based component of short-time work 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 rule-based 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 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) x_{it} using firm fixed effects

$$y_{it} = x_{it}\beta_1 + \alpha_i + \gamma_t + z_{it}\beta_2 + u_{it}. \tag{1}$$

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,

[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.

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

we add the number of employees in the previous year as a measure of time-varying firm size. The term 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 significantly estimated to range between -2.80 and -3.36.

	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.

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

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

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 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 financial difficulties 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.

3 A labor market model with short-time work

3.1 The model

3.1.1 Model description

The purpose of building a dynamic model is threefold. First, in contrast to the SVAR in section 4, the structural model provides an economic rationale and intuition. Second, in contrast to existing models (Faia et al., 2013, Krause and Uhlig, 2011), our model allows us to distinguish between automatic stabilization and discretionary effects of STW. Thus, we are able to compare the automatic stabilization effects of STW to those of the income tax system (see in't Veld et al., 2012, for a survey). Third, the model provides a prediction for the effects of the discretionary component of STW considering different degrees of persistence of the policy shock. The model allows us to compare these effects to the results of the SVAR and to provide an economic intuition for the latter.

A suitable model for our purpose describes unemployment and labor market flows, i.e., endogenous job findings and separations. Thus, 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.

To model STW, we assume that the government defines an eligibility criterion given by a profitability level), which allows firms to use STW and hence to send workers on governmentally subsidized part-time work. Firms that satisfy this eligibility criterion choose an optimal working time reduction subject to a convex cost function. STW acts as an automatic stabilizer as more firms become eligible for STW as the economy moves into a recession. In addition, the government can

[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).

change the eligibility criterion on a discretionary basis. 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 operating cost shock. Fifth, the wage is determined. Finally, firms make their endogenous separation and STW decisions, based on the idiosyncratic shock realization.

3.1.2 Separation and short-time work decisions

As motivated above, our model is based on a search-and-matching framework with endogenous separations. 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. This 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

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

where a_t is aggregate productivity, w_t is the wage of the worker, c is a fixed cost of production, Λ_{t+1} is the subjective 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.[14]

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:

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

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.[15] This corresponds to the German rule that only firms with "unavoidable financial difficulties" can apply for STW (i.e., the loss needs to be sufficiently large that it would lead to a destruction of the worker-firm pair without using the policy). When quantifying and simulating the model in section 3.3, 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

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

[14] See Costain and Reiter (2008) for a discussion of the limitations of a small-surplus calibration.

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

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.

Given that a worker is eligible for STW, the firm can choose the optimal working time reduction K subject to convex STW costs $C(K(\varepsilon_t))$, with $\frac{\partial C(K(\varepsilon_t))}{\partial K(\varepsilon_t)} > 0$ and $\frac{\partial C(K(\varepsilon_t))^2}{\partial^2 K(\varepsilon_t)} > 0$ to assure interior solutions.[16] There are several reasons to use convex STW costs. First, convex costs are necessary to replicate the empirical finding that the degree of STW usage varies across firms.[17] Second, 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.[18] Third, the implementation of STW must be approved by the workers' council. [19] 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 (see also the household's budget constraint, equation (27)).

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. Imposing a quadratic functional form for the costs of STW

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

gives the optimal degree of STW for a given ε_t:

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

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

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

This defines a firing threshold $v_t^{\mathbf{f}}$ at which the firm is indifferent between firing and retaining a worker:

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

---

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

[17]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).

[18]See Bach et al. (2009) who show that these institutional features generates a convexity in the cost of STW.

[19]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

$$\varphi_t^{\epsilon} = \int_{v_t^{\mathbf{f}}}^{\infty} g\left(\varepsilon_t\right) d\varepsilon_t, \tag{10}$$

and the rate of workers on STW is

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

All the workers above the threshold v_t^k are eligible for STW, but workers above $v_t^{\mathbf{f}}$ are so unproductive that they are fired nevertheless.[20] Note that STW exists in this economy if $v_t^{\mathbf{f}} > v_t^k$. 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: $v_t^{\mathbf{f}} = v_t^k$. 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 in this economy. 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) follows that positive values of K affect the firing cutoff $v_t^{\mathbf{f}}$ 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 $v_{\mathbf{f}}$ 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 $v_{\mathbf{f}} = v_k$.[21]

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 continental European institutions. But even if $\mathbf{f} = c = 0$ and under efficient 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 $C_0 = -\mathbf{f}$ 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 worker. Put differently, the participation constraint of the worker is not violated and he will not quit due to STW.

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

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

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

$$
\begin{aligned}
J_{t+1} \;=\;& (1-\varphi^{x}) \int_{-\infty}^{v^{k}_{t+1}} (a_{t+1} - w_{t+1} - \varepsilon_{t+1})\, g(\varepsilon_{t+1}) d\varepsilon_{t+1} \\
&+ (1-\varphi^{x}) \int_{v^{k}_{t+1}}^{v^{f}_{t+1}} [(a_{t+1} - w_{t+1} - \varepsilon_{t+1})\,(1 - K(\varepsilon_{t+1})) - C(K(\varepsilon_{t+1}))]\, g(\varepsilon_{t+1})\, d\varepsilon_{t+1} \\
&- (1-\varphi_{t+1})\, c - (1-\varphi^{x})\, \varphi^{e}_{t+1} f + (1-\varphi_{t+1})\, E_{t+1} \Lambda_{t+2} J_{t+2}. \qquad (12)
\end{aligned}
$$

Here,

$$\varphi_{t+1} = \varphi^{x} + (1-\varphi^{x})\, \varphi^{e}_{t+1}, \qquad (13)$$

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}.

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.

3.1.3 Some thoughts on welfare

Can STW improve welfare? In practice, economies with STW schemes (e.g., in continental Europe) have a lot smaller labor market flows and potentially more labor hoarding than Anglo-Saxon type labor markets. These economies are characterized by heavy regulations such as large firing costs and constraints on working time adjustments. Thus, STW may be an instrument to circumvent the losses associated with these regulations, particularly in recessions.

Labor hoarding may either by driven by a low matching efficiency and/or high firing costs. When it is difficult to find a new worker or expensive to fire a worker, firms may be willing to retain workers with a negative $a_t - \varepsilon_t$, i.e., workers that reduce the value added in an economy. Without restrictions on the working time, firms would use the intensive margin and reduce the working time for these workers. However, as section 2 discusses in detail, the intensive margin is not important in normal times in most OECD countries. We conclude from this that working time regulations make it very costly for worker-firm pairs to implement privately efficient working time reductions. Within our model context, we therefore assume that STW is the only possibility to increase flexibility along the intensive margin. The partial unemployment benefit payments for workers ensure that workers do not violate their participation constraints (i.e., they do not quit their job). This leads to a large number of sustained matches, which has the additional beneficial effect that firing costs are saved.

Obviously, to the extent that firing costs and working time regulations are not a primitive of the economy but due to regulations, the government could simply remove them and thereby shift the economy closer towards the first best outcome. Although this goes beyond the scope of the paper, let us briefly point out why governments may prefer STW vis-à-vis removing firing cost or working time regulations. First, there may be political economy reasons against removing these instruments. While STW may be a perfectly accepted instrument among voters, a reduction of firing costs may for example be opposed by insiders. Second, there may be other considerations (outside our model) to maintain firing costs or working time regulations. Firing costs may for example exist due to a lack of consumption insurance for risk averse agents (see, e.g., Bertola (2004)).

3.1.4 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

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

where Λ_{t+1} is the stochastic discount factor ($\Lambda_{t+1} = \beta C_{t+1}^{-\sigma}/C_t^{-\sigma}$), J_t is the value of a job and κ are the vacancy posting costs. Free entry implies $V_t = 0 \;\forall\; t$ which simplifies the above equation to

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

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.

3.1.5 Employment evolution

The evolution of the employment rate n_t in this economy is described by

$$n_t = (1-\varphi_t)\,n_{t-1} + \eta_t(1-\varphi_t)(1-n_{t-1}). \tag{19}$$

Note that workers on STW are treated as employed, corresponding to the official German employment statistics (although they only work part-time).

3.1.6 Wage bargaining

Finally, we specify wage formation. Here 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. Hence, wages are set collectively and not individually for each ε_t. The median firms' profit[22] (with operating costs zero) of a match is

$$F_t = a_t - w_t - c + E_t\Lambda_{t+1}(1-\varphi_{t+1})J_{t+1}. \tag{20}$$

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

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

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 disagreement. Thus, the fall-back option of the firm is

$$\tilde{F}_t = -c + E_t\Lambda_{t+1}(1-\varphi_{t+1})J_{t+1}. \tag{21}$$

The median workers' surplus W_t from a match is

$$W_t = w_t + E_t\Lambda_{t+1}(1-\varphi_{t+1})W_{t+1} + E_t\Lambda_{t+1}\varphi_{t+1}U_{t+1} \tag{22}$$

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

$$\tilde{W}_t = b + E_t\Lambda_{t+1}(1-\varphi_{t+1})W_{t+1} + E_t\Lambda_{t+1}\varphi_{t+1}U_{t+1}. \tag{23}$$

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:

$$w_t = \gamma a_t + (1-\gamma)b. \tag{24}$$

Finally, the average compensation of a worker on STW is given by

$$w_t^{stw} = \int_{v_t^k}^{v_t^f} \frac{(1-K(\varepsilon_t))w_t + bK(\varepsilon_t)\,g(\varepsilon_t)}{\chi_t} d\varepsilon_t. \tag{25}$$

Here, depending on the realization of ε_t the worker is sent on STW for a share of $K(\varepsilon_t)$ of her working time. For that fraction she only receives unemployment benefits. For the remainder she receives the collectively bargained wage. Since being on STW is a convex combination of full employment and unemployment, workers always prefer STW to being laid-off.

3.1.7 Households' consumption decisions

We assume that households have a standard utility function of the form:

$$U_t = E_t \sum_{j=t}^{\infty} \beta^{j-t} \frac{C_j^{1-\sigma}}{1-\sigma}, \tag{26}$$

where β is the household's discount factor, σ is the elasticity of intertemporal substitution, and C is aggregate consumption.

As is common in the literature, we assume that each household consists of a large number of individuals, each individual supplies one unit of labor inelastically and shares all income with the other household members (see Merz, 1995 or Andolfatto, 1996). This implies that consumption does not depend on a worker's employment status. Thus, the representative household maximizes its utility subject to the budget constraint:

$$B_t + C_t = w_t n_t(1-\chi_t) + n_t\chi_t w_t^{stw} + bu_t + (1+i_{t-1})B_{t-1} + \Pi_t - T_t. \tag{27}$$

Here, B are nominal bond holdings, T are lump-sum taxes, i is the nominal interest rate and Π are aggregate profits which are transferred in lump-sum manner, w is the regular wage under full time work, χ is the share of workers who are on STW, w^{stw} is the average compensation for a worker who is on short-time work[23], n is the employment rate, b the income of unemployed workers and u the unemployment rate. The intertemporal utility maximization yields the standard consumption Euler equation

$$C_t = \beta E_t C_{t+1} (1 + i_t)^{-\frac{1}{\sigma}}. \tag{28}$$

3.1.8 Government budget constraint

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

$$b n_t \int_{v_t^k}^{v_t^f} K(\varepsilon_t)\, g(\varepsilon) d\varepsilon_t + b u_t = T_t. \tag{29}$$

3.1.9 Equilibrium and aggregation

The general equilibrium is defined by the bond market equilibrium (equation (28)), the labor market equilibrium (equations (10), (8), (4), (9), (10), (11), (19) and (24)) and the product market equilibrium. The latter requires that consumption equals production minus frictional costs, i.e.

$$\begin{aligned} C_t \;=\; & (1-\varphi^x) \left(n_t^B \int_{-\infty}^{v_t^k} (a_t - \varepsilon_t)\, g(\varepsilon_t)\, d\varepsilon + n_t^B \int_{v_t^k}^{v_t^f} (1 - K(\varepsilon_t))(a_t - \varepsilon_t)\, g(\varepsilon_t)\, d\varepsilon \right) \\ & - n_t^B (1-\varphi_t)\, c - (1-\varphi^x)\, n_t^B \varphi_t^e \mathbf{f} - v_t \kappa. \end{aligned} \tag{30}$$

with $n_t^B = n_{t-1} + \eta_t (1 - n_{t-1})$. Aggregate consumption equals production minus resource costs.

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, fixed costs of production and STW costs.

3.2 Calibration

To illustrate the properties of our model, we parameterize 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 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 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

[23]Note that this compensation consists of the wage paid by the employer for the remaining working time and the compensation by the government for the STW part. For analytical convenience (since the full expression contains several integrals and since some variables will be defined latter), we summarize these elements as w^{stw}.

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
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 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.

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.

We introduce fixed costs of production to generate stronger amplification effects (i.e., responses of labor market variables to aggregate productivity shocks)[24] 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 the output elasticity of STW of -3.3%.

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.

[24] 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).

3.3 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.

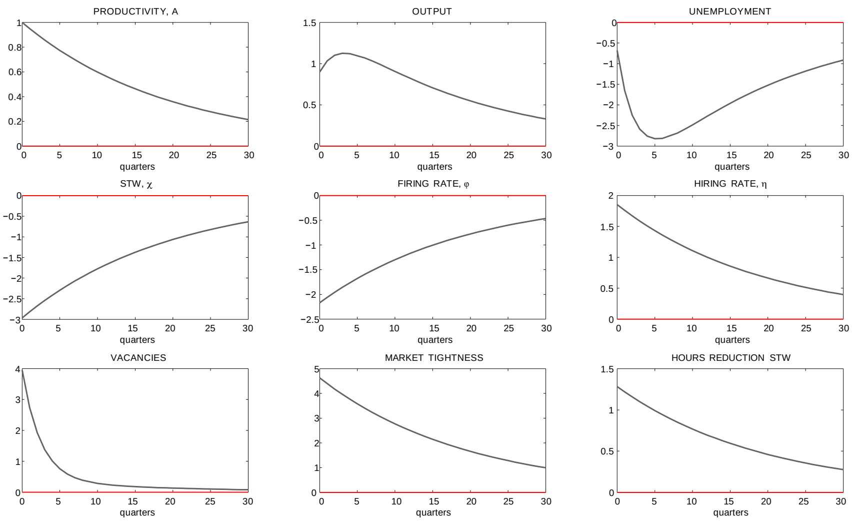

Figure 3: Impulse responses of a positive shock to aggregate productivity. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive increase in aggregate productivity.

3.3.1 Automatic stabilizers

The impulse responses of a positive, one standard deviation shock to productivity a, with autocorrelation 0.95, are given in Figure 3. 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, 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. 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.

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 3, 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.

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 $\lambda = 1,600$).

In order to assess the role of STW as an automatic stabilizer on the labor market and the macroeconomy, we compare the business cycle statistics of an economy with and without STW. Table 3 shows business cycle statistics for an economy with STW and for an economy without STW. 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). Taking into account the low expenses for STW, the automatic stabilization effects of STW are large compared to the effects of the income 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). These stabilization predictions have to be put in perspective to the size of the instrument. On average only 0.7% of all workers are on STW. Between 1998 and 2011 the average costs of STW accounted for just 0.03% of GDP.[25] By contrast, the income tax system accounts for more than 10% of GDP in most OECD countries.

In a first robustness check, we reduce firing costs 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.[26] 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

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

[26]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.

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 STW is a fairly cost-efficient policy and thus the extra costs in a recession due to the automatic reaction are small.

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.

3.3.2 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 4 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).

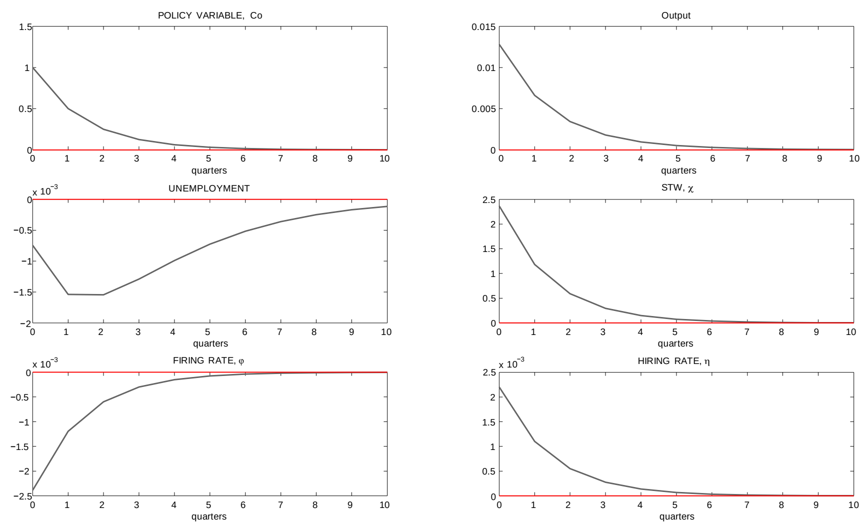

Figure 4: Impulse responses of a negative shock to C_0. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive decrease in the costs of STW.

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 5. Note, however, that the positive effects on output remain. The reason is that the policy allows unproductive matches to reduce their working time without the need to incur the firing cost.

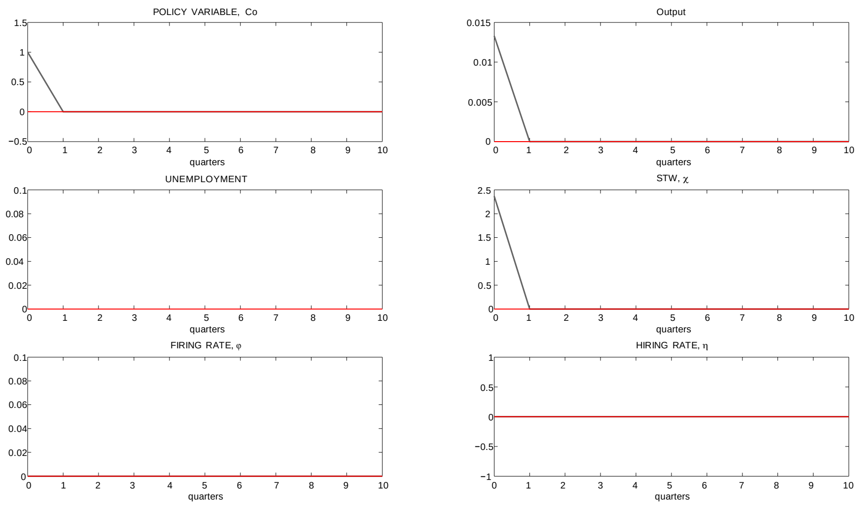

Figure 5: Impulse responses of a negative shock to C_0. Impulse responses are given in percentage deviations from steady state. The shock is implemented as a temporary autoregressive decrease in the costs of STW.

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.

4 Empirical 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 3. 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 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 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 3. 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 3 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.[27] 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 3. 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 6 shows the quarterly responses of output, STW usage and unemployment to positive one-standard-deviation shocks in output and policy.[28] 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 6 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 6 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 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 3 provides an interpretation of this result: temporary discretionary

[27] 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.

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

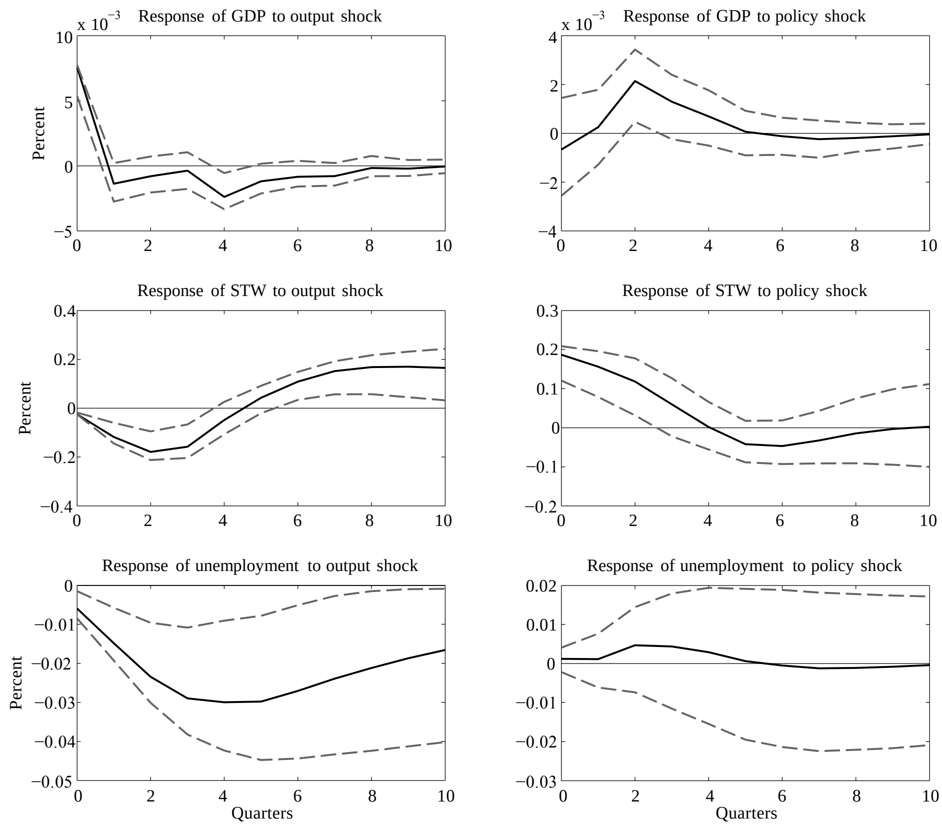

Figure 6: Impulse responses to output and STW policy shocks. SVAR estimated with log STW per employed workers, GDP growth and the log unemployment rate for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped bands with 10,000 draws.

changes in STW policy do not affect future expectations and therefore hiring and firing 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[29]. 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.[30] 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.[31] 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 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

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

[30]More detailed results are available upon request.

[31]We measure recessions, also in the long sample, as peak to trough of the GDP series that is HP-filtered with $\lambda = 1600$.

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.[32] 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.[33] 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.

5 Conclusion and outlook

In the baseline calibration of our DSGE model, the rule based component of short-time work stabilizes unemployment fluctuations by 15% and output fluctuations by 7%. These numbers are large given that STW expenses are a very small fraction of GDP in most countries. According to our SVAR-results, discretionary short-time work interventions do not have any statistically significant effect on unemployment. According to our model, this is due to interventions with little persistence. To generate positive employment effects, discretionary changes in STW need to have an impact on the expectations of future profits. Interventions that do not last for a long time barely affect the future present value of workers and thereby generate a larger deadweight effect.

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

[33] 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.

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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.

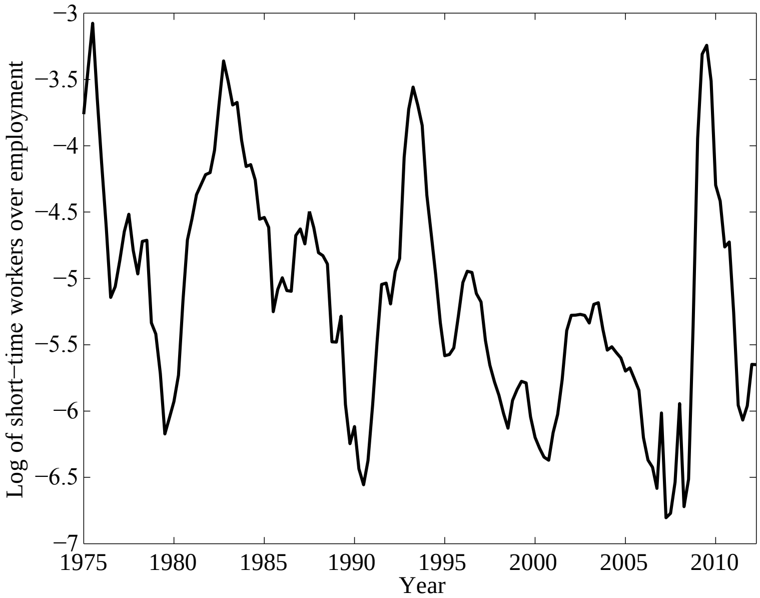

Figure 7: Short-time work in Germany 1975-2012. The series depicts the log of the number of short-time workers as a fraction of total employment.

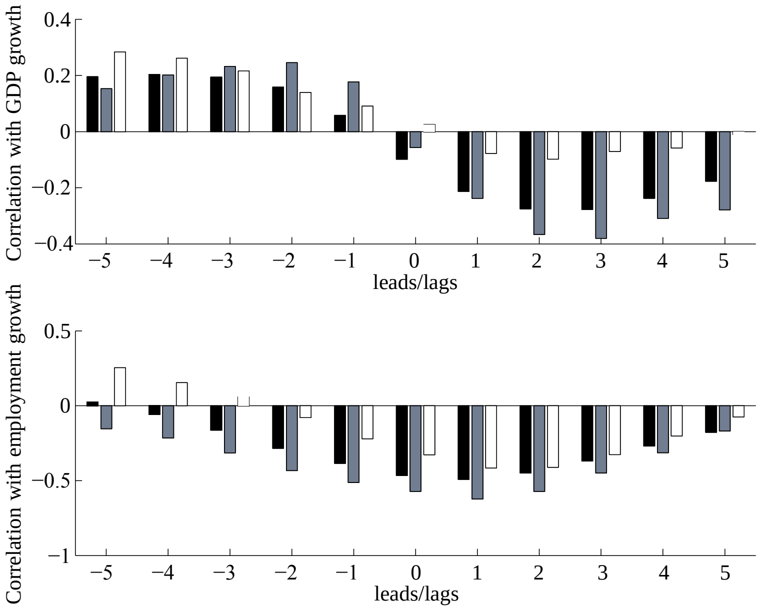

Figure 8: Correlation of number of short-time workers as a fraction of employment with GDP and employment. Leads/lags depict the correlation of STW/EMP in period t with GDP or employment in period $t + i$ / $t - i$. Black bars show correlations over the long sample corresponding to 1975 to 2010, gray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

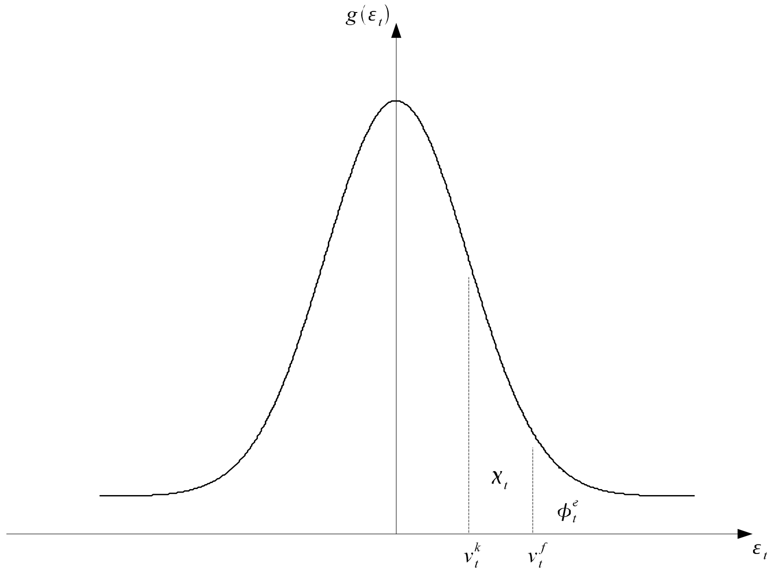

Figure 9: Illustration of the distribution of idiosyncratic shocks to the worker-firm pair and firing threshold v_t^f and STW threshold v_t^f.

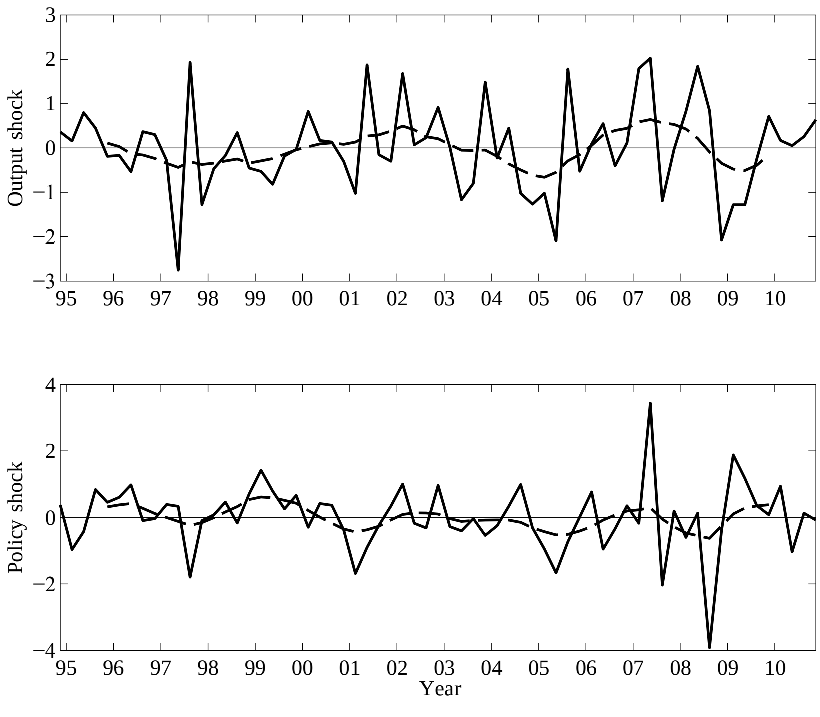

Figure 10: Estimated output and STW shocks from baseline VAR. The solid series shows the actual shock, the dashed series is smoothed with a centered moving average with four leads and lags and triangularly declining weights. SVAR estimated with STW per employed workers, GDP growth and unemployment (all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

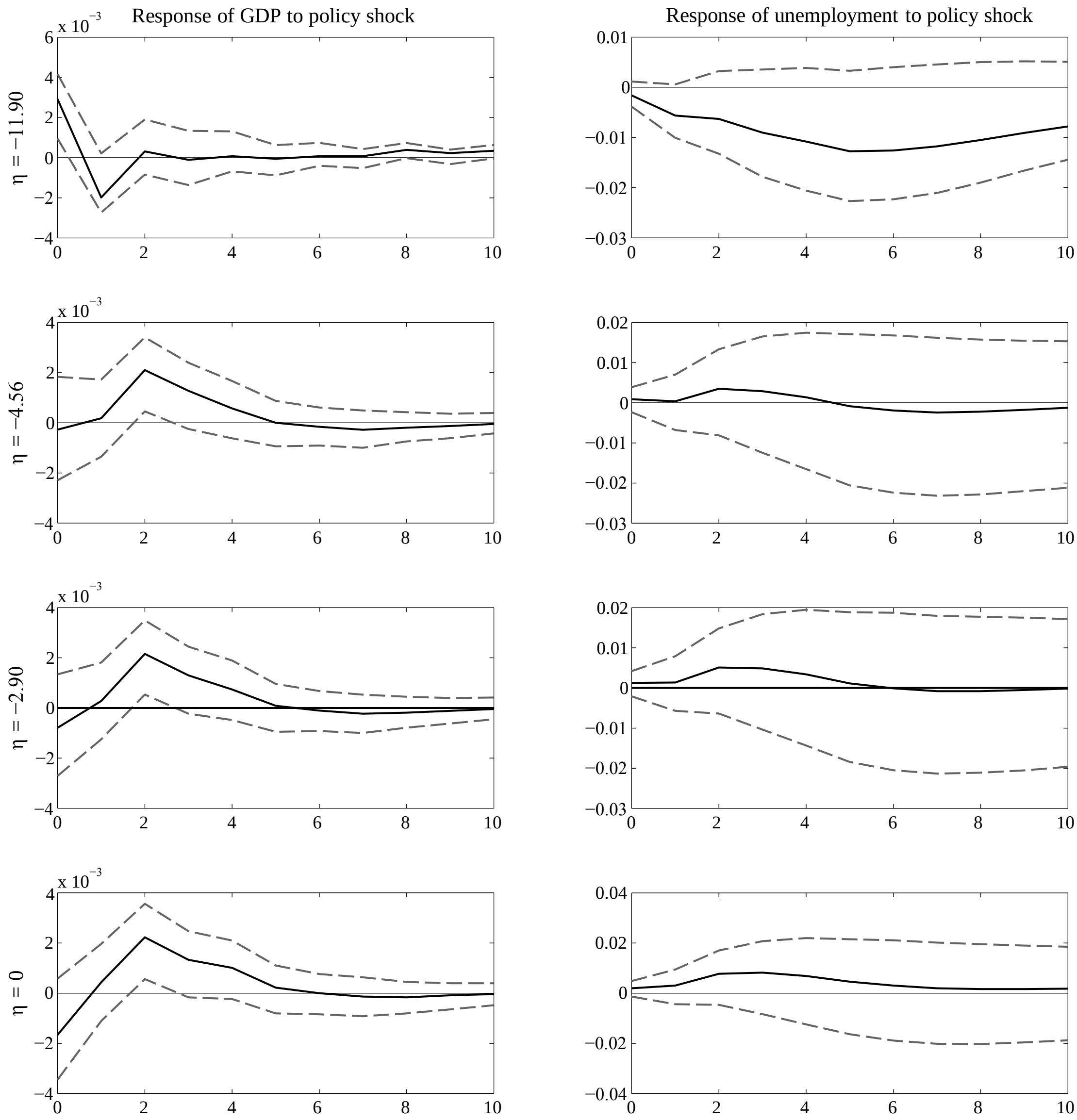

Figure 11: Impulse responses to policy shocks for different output elasticities of STW η. SVAR estimated with STW per employed workers, GDP growth and unemployment (all in logs) for 1993Q1 to 2010Q4. Quarterly responses to a positive one-standard deviation shock. Confidence intervals are 90% bootstrapped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

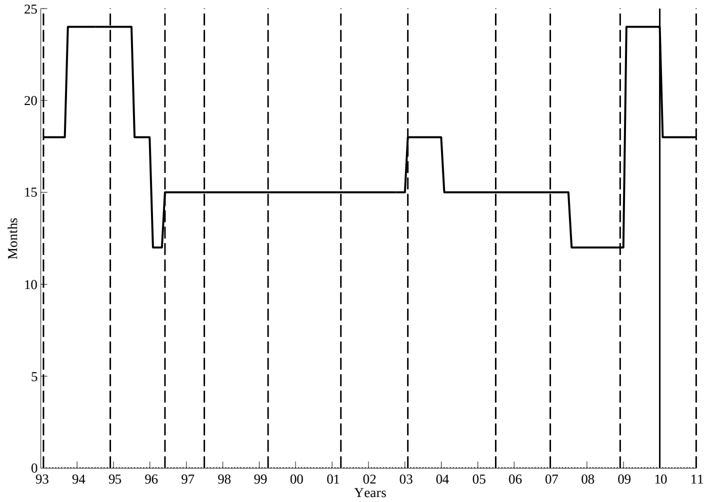

Figure 12: Legal changes in duration of eligibility of short-time work. The series describes legal maximum period of eligibility of a worker under short-time work scheme. Vertical lines show the timing of the corresponding legislation.