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# Counteracting unemployment in crises

## Non-linear effects of short-time work policy

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# Counteracting unemployment in crises: Non-linear effects of short-time work policy

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## Abstract

Short-time work is a labor market policy that subsidizes working time reductions among firms in financial difficulty in order to prevent layoffs and stabilize employment. Many OECD countries have used this policy in the Great Recession, for example. This paper shows that the effects of discretionary short-time work are strongly time dependent and non-linear over the business cycle: it may save up to 0.8 jobs per short-time worker in deep economic crises. In contrast, in normal times and expansions, the effects are smaller and may even turn negative. Our results demonstrate that the policy becomes more efficient as the recession deepens. We disentangle discretionary short-time work from automatic stabilization in German data and estimate time-varying employment effects using a smooth transition VAR.

## Zusammenfassung

Kurzarbeit ermöglicht eine temporäre Reduktion der Arbeitszeit von Arbeitnehmern in Firmen, die einer schwachen Nachfrage gegenüber stehen. Diese soll somit Entlassungen verhindern und die Beschäftigung über den Konjunkturzyklus stabilisieren. Viele OECD Staaten haben dieses Arbeitsmarktinstrument in der Wirtschafts- und Finanzkrise 2008/2009 eingesetzt. In diesem Papier zeigen wir, dass sich die Effekte diskretionärer Kurzarbeit deutlich über den Konjunkturzyklus verändern und in Rezession und Expansion nichtlinear sind. In tiefen Rezessionen kann Kurzarbeit bis zu 0,8 Arbeitsplätze pro Kurzarbeiter erhalten. Im Gegensatz dazu sind die Effekte in Expansionen kleiner und können sogar negativ werden. Wir trennen diskretionäre und regelgebundene Politik in deutschen Daten und schätzen zeit-variierende Beschäftigungseffekte in einem smooth transition VAR.



**JEL classification:** C32, E24, E32, E62

**Keywords:** Short-time work, fiscal policy, labor market, non-linearity, smooth transition VARs, business cycle

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# 1 Introduction

In recessions, a major objective of policy makers is to save jobs. Short-time work (STW) provides wage subsidies to firms that reduce their employees' working time in times of crises instead of firing them. As such, STW is a targeted labor market policy that has been used by most OECD countries in the Great Recession in 2008/2009 (Cahuc and Carcillo, 2011). The discussion on the effectiveness of this policy is, however, still an open question. Burda and Hunt (2011) and Boysen-Hogrefe and Groll (2010) are skeptical, whereas many cross-country studies find positive employment effects of STW during the Great Recession (Cahuc and Carcillo, 2011, Hijzen and Venn, 2011, Hijzen and Martin, 2013).[1] Recently, Balleer et al. (2016) show that STW has two distinct components: an automatic stabilizer that is very effective in terms of stabilizing jobs and a discretionary component for which the effects are less clear. Given that a large share of STW in the Great Recession was implemented in a discretionary fashion, i.e., by governments actively changing existing STW rules, the latter finding calls for a deeper analysis.[2]

The contribution of our paper is threefold. This paper is the first to provide empirical evidence on time-varying effects of a labor market policy in a vector-autoregression (VAR). To do so, we adapt the well-established methodology of state-dependent VARs (see Caggiano et al., 2015 and Auerbach and Gorodnichenko, 2012, among others) towards the identification of discretionary STW policy. The identification relies on microeconomic firm-level data. Our goal is to contribute to the literature on time-varying effects of fiscal and monetary policy by providing an analysis of a labor market policy, filling a research gap. Our second contribution is to allow for an identification of the state-dependent VAR that is regime-specific based on microeconomic firm-level evidence. This approach is new in the application of state-dependent VARs. Third, we contribute to the understanding of STW by documenting large differences in the effectiveness of discretionary STW policy by regime. We calculate maximum employment effects per employee on STW and find that discretionary STW policy may save up to 0.8 jobs per short-time worker in severe economic crises. As a result, the discretionary component of STW can be an effective stabilizer if used in deep recessions. In contrast, the effects of STW in normal times are much less pronounced and may even turn negative.

During the Great Recession, most OECD countries have implemented huge business cycle stimuli to counteract falling labor demand. Besides labor cost reductions and public employment creation schemes, the introduction or expansion of existing STW schemes was popular.[3] The governments increased the generosity of existing schemes either by extending the maximum duration of STW allowances, changing the eligibility criteria or combining STW with training schemes (OECD, 2009). In our analysis, we focus on Germany because the STW take-up rate in 2009 was more than 4 percent of the workforce and the-

[1] Cross-country studies, however, deal with unobserved heterogeneity and the reality that STW institutions are implemented differently across countries.

[2] In the Great Recession, seven OECD countries introduced STW schemes for the first time (Cahuc and Carcillo, 2011). The introduction of a STW scheme can be considered a discretionary policy change.

[3] Out of the (at the time) 33 OECD countries, 25 implemented STW (Cahuc and Carcillo, 2011). In Germany, Italy, and Japan more than 2 percent of the workforce was affected. See OECD (2009) for an overview by country.

reby among the highest across OECD countries during the Great Recession. In addition, Germany has had a long tradition of STW that provides detailed time series and firm-level data. Furthermore, Germany is a typical example for a country with a labor market that is characterized by strong job security regulations and low flexibility. In this environment, STW can be of particular importance to encourage adjustment of labor demand along the intensive rather than the extensive margin.

In Germany, a firm has to apply for STW at the Federal Employment Agency and provide evidence that the expected demand for its goods is temporarily below production potential. If the request is approved, the firm may reduce its employees' working hours and wage payments by up to 100 percent. In 2009, the average working hour reduction due to STW was 28 percent (Source: Statistics of the Federal Employment Agency). The government pays short-time allowance to affected workers and hence partly compensates them for their wage loss.[4] Given that more firms meet the STW eligibility criteria in an economic downturn, this policy acts as an automatic stabilizer that aims to avoid lay-offs by making the intensive margin flexible and reducing labor costs for firms in a temporary slack.

Additionally, the government may adjust certain features of the criteria for STW usage in a discretionary way. These changes may be implemented by law (for example, extensions of the maximum period of eligibility and simplified eligibility criteria) or realized in other ways, such as increasing advertising or interpreting existing criteria in a less stringent way. We refer to these changes as discretionary STW policy. In response to the deteriorating economic conditions in 2009, the German government employed a variety of discretionary STW policy changes. However, discretionary changes have also been applied before the Great Recession and are not necessarily restricted to times of economic crisis. Balleer et al. (2016) are the first to argue that it is important to disentangle the automatic and the discretionary components of STW. In a theoretical labor market model, they show that these distinct components may affect firm behavior and the business cycle very differently. We argue that the effects also interact with the state of the business cycle.

We estimate a smooth-transition VAR (STVAR) on German time series data to assess whether discretionary STW policy has different effects in a recession than in a boom. First, we identify discretionary policy shocks and automatic stabilization in our regime-switching VAR. The rule-based elasticity of STW usage to output serves as a short-run restriction to identify policy shocks in the spirit of Blanchard and Perotti (2002). Balleer et al. (2016) infer this elasticity from microeconomic establishment data for Germany. We extend their approach and further propose to use a regime-specific identification when estimating STVARs. The microeconomic data have information on rule-based elasticity in expansion and recession. We provide a detailed discussion of the nature of STW shocks and when they occur. Next, we follow Koop et al. (1996) and compute generalized impulse response functions (GIRFs), which take into account the full non-linearity of the empirical model by simulating the dynamic model responses to policy shocks conditional on the history and varying by the size and sign of the shock.

[4] The short-time allowance paid by the Federal Employment Agency in Germany amounts to $60$ percent ($67$ percent in case of children in the household) of the net wage loss. For a detailed description of the German STW framework, see Burda and Hunt (2011) or Brenke et al. (2013).

Our paper highlights the following findings. First, we establish large differences in the effectiveness of discretionary STW policy by regime. A linear VAR specification is strongly rejected by the data. Using GIRFs, we find stabilizing employment effects of discretionary STW changes implemented in recessions. However, if used in expansions, employment effects are smaller, and if quarterly GDP growth is above 0.5 percent, they even turn negative. We calculate maximum employment effects per employee on STW and find that discretionary STW policy may save up to 0.8 jobs per short-time worker in severe economic crises. In a normal recession, the maximum employment effect is 0.5 jobs per short-time worker, while in expansions, the effect is zero on impact and -0.2 at maximum. These results are robust to different VAR and regime specifications and across different identification strategies. We conclude that timing is crucial not only for the effectiveness of fiscal and monetary policy but also for labor market policies. Counterfactuals from the VAR show that STW significantly stabilized the labor market in Germany in the Great Recession. In terms of unemployment, we find that the unemployment rate would have increased by $0.2$ percentage points if discretionary STW were not present.

We interpret our finding on the regime-dependent effects of STW as follows. First, in deep recessions, such as the Great Recession, firms face binding credit or liquidity constraints. STW subsidies may help firms to overcome these binding constraints and may thus have more positive effects.[5] In expansions, when these constraints do not bind, a similar effect is absent. We provide evidence from establishment-level data that establishments that used STW in the Great Recession in Germany were indeed more severely affected from binding credit constraints compared to establishments that did not use the policy. Second, we show that establishments that use STW in recessions differ from establishments that do so in expansions. Establishments that use the subsidy in expansions are smaller and less productive on average. As a result, in expansions, the policy supports mainly contracting establishments that are potentially negatively affected by structural change. In contrast, in recessions, the policy benefits establishments that would grow without the recession. These observations are in line with the labor market model of Cooper et al. (2017) with growing and contracting firms. These authors show that in such a setting, STW policy may have negative employment effects if the policy ties workers to contracting firms and thereby makes it more difficult for growing firms to hire.

Our study contributes to two literature strands: the first one is the growing literature that finds non-linearities in policy and/or the labor market itself. Auerbach and Gorodnichenko (2012) and many follow-up papers study non-linearities in fiscal policy, and Weise (1999) is one example of a paper that analyzes a similar non-linearity in monetary policy. Abbritti and Fahr (2013), Michaillat (2012), and Kohlbrecher and Merkl (2016) identify asymmetries in the labor market itself. Gehrke and Weber (2017) show that labor market reforms have asymmetric effects over the business cycle. Cacciatore et al. (2016) make a similar argument based on a theoretical model. In light of these asymmetries in the labor market, a labor market policy such as STW may also have non-linear effects over the business cycle. Using our empirical application for Germany, we show that this is indeed the case. Theoretical arguments for non-linearities in the effects of wage subsidies or public employ-

5 See Canzoneri et al. (2016) for a similar argument in the context of fiscal policy.

ment programs are given by Kohlbrecher and Merkl (2016) and Michaillat (2014). Second, we relate to the literature on the effects of STW. Theoretical contributions include Burdett and Wright (1989), Audenrode (1994), and Braun and Brügemann (2014), among others. Balleer et al. (2016), Cooper et al. (2017), and Tilly and Niedermayer (2017) combine theory and empirics. In addition, there exist several cross-country studies that study STW in the Great Recession, for example, Boeri and Brücker (2011), Cahuc and Carcillo (2011), Hijzen and Venn (2011), Hijzen and Martin (2013) and Brey and Hertweck (2016).

The structure of the paper is the following. The next section briefly describes the background of STW. Section 3 outlines our econometric specification. Section 4 presents our empirical results. In Section 5, we focus on the employment effects of STW in the Great Recession. We perform various robustness checks in Section 6. Section 7 concludes.

## 2 Background

STW allows firms to adjust their labor demand along the intensive (hours) margin rather than the extensive (layoff) margin. Hence, it acts as an instrument that increases the flexibility of a firm's labor input, and the firm is able to temporarily reduce labor costs. However, if demand picks up again, it can increase the volume of hours worked quickly and without additional costs. This policy is of particular relevance in countries with strong labor market frictions, high job security regulations and high hiring and firing costs.[6] We focus on Germany because it is an example of a country with these characteristics, has a long tradition of STW and provides rich data.

Figure 1 illustrates the share of employees covered by STW in Germany relative to total employment since the early 1970s (upper panel). In the middle panel, we show the quarterly real GDP growth rate, and recession periods are shaded. The lower panel of Figure 1 depicts the number of employees and the unemployment rate over time. Clearly, STW is used the most in economic downturns, i.e., when GDP growth is negative. This statement holds when inspecting the absolute number of short-time workers instead of the ratio to employment. The peak STW usage occurred in the Great Recession in 2009 with more than 4 percent of all employees covered by the scheme. Notably, this has been the period with by far the steepest drop in GDP in our sample.[7] Recessionary periods in Germany are accompanied by falling employment and rising unemployment rates. Interestingly, the Great Recession turns out to be an outlier in terms of this pattern. The fall in employment and the rise in unemployment in 2009 was very modest compared to the steep drop of GDP. This

[6] Using a cross-country approach, Cahuc and Carcillo (2011) show that the STW take-up rate correlates positively with the OECD Employment Protection Index. Balleer et al. (2016) develop a labor market model with firms' explicit STW decision and find that the policy is the most effective if the labor market is characterized by strong frictions.

[7] The average reduction of employee hours due to STW between 1993 and 2010 is $30$ percent. There is also some cyclical adjustment along this intensive STW hours margin. In recessions, firms tend to reduce hours by less. Unfortunately, the data on the reduction in hours due to STW is limited (it is available only in broad categories and only from 1993 onward). For this reason, we use the number of employees on STW in the following. Using a measure of the aggregate STW hours from 1993 onward, however, leaves our main conclusions from the SVAR unaffected. In particular, we still find strong non-linearities. One hour of STW was most effective during the Great Recession, which is consistent with results from our baseline specification.

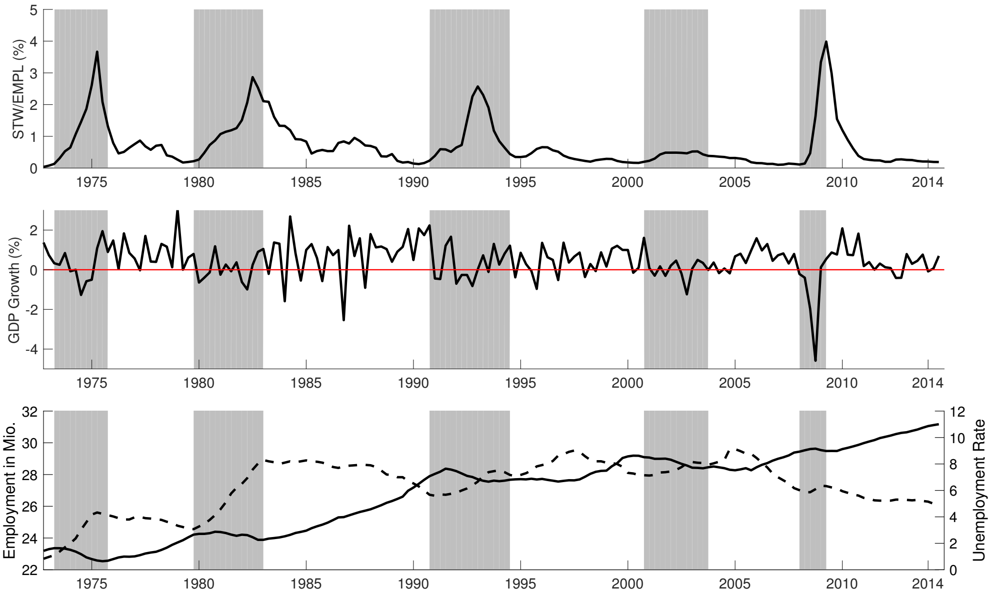



Figure 1: STW and the business cycle. Upper panel: Ratio of STW to total employment (in percentages). West Germany until 1992. Middle panel: Real GDP growth rate and lower panel: Employment in million persons (left axis, solid) and unemployment rate (right axis, dashed). All series are quarterly and seasonally adjusted. Data before 1991 are for West Germany only but adjusted to the German level using a shift dummy if necessary. Shaded areas indicate recession periods as defined by the Economic Cycle Research Institute (ECRI). Appendix A provides information on data sources.

"labor market miracle" has gained a lot of attention in the literature (e.g., Burda and Hunt, 2011). The natural question to ask is how much does STW contribute to this favorable labor market development in the recession. We will give an answer to this question.

STW has also been widely used in earlier recessions in the 1970s, early 1980s, and early 1990s. However, these recessions were not accompanied by similar employment "miracles" as the Great Recession. Based on our results, we will conclude that STW was less effective in these recessions compared to the Great Recession due to the more moderate decline in GDP. Here, the non-linearity in the effects of STW policy will play a large role. STW was used less extensively in the recession of the early 2000s. We attribute this finding to the observation that STW policy usage was less publicly supported in this recession.[8] This implies that discretionary policy, i.e., active changes of STW legislation and rules to promote STW usage, were used less in this recession. In line with Balleer et al. (2016), we argue that the dynamics of STW over the business cycle are triggered by two distinct components: discretion and rule-based behavior.

Rule-based behavior captures firms' STW adjustment to the business cycle subject to the given set of rules. By definition, in a recession, more firms meet the eligibility criterion of facing a temporary lack of demand.[9] These firms thus automatically adjust the number

[8] There were hardly any regulatory changes in STW policy implemented at this point in time (see Table 8 in Appendix B for an overview of STW policy changes implemented by law).
[9] The firm has to prove that it experiences substantial financial difficulties that (a) are due to economic reasons

of short-time workers upwards without the government actively changing the rules. In our VAR, we will pin down this rule-based adjustment to the business cycle by estimating the extent of this rule-based adjustment from firm-level data. However, the rule-based component only partially explains the total increase of STW in recessions. In addition, the government frequently changes the rules of implementing STW. For example, in 2009, the German government extended the period that firms could use STW, made the use of STW cheaper (by additionally covering the social security contributions of short-time workers) and allowed agency workers to be covered by STW. These measures made STW usage more attractive, and firms responded by using the policy more. We refer to these measures as discretionary policy. Some of these discretionary policy measures are observable, e.g., due to explicit changes by law (see Table 8 in Appendix B). However, discretionary policy may also be implemented by interpreting existing rules less strictly. For instance, in the year 2009, the number of rejected STW applications of German firms at the Federal Employment Agency dropped to $0.5$ percent. On average, in the period 2007 to 2016, roughly $3.5$ percent of all applications were rejected (Source: Statistics of the Federal Employment Agency, data are available from 2007 onward).

In this paper, we focus on the interaction of the business cycle with the rule-based and the discretionary STW policy components. Our interest in studying the interaction of STW and the business cycle is motivated by the strong non-linearity of the STW series over the business cycle, as shown in the upper panel of Figure 1. Figure 1 further reveals that there was also a substantial use of STW outside of recessions. For example, in the years 1977/1978, a crisis in the shipyard and steel industry increased the number of short-time workers. In 1989, GDP growth was close to two percent, but the number of short-time workers in the car manufacturing industry rose substantially. In September 2010, when the German economy recovered after the Great Recession, several simplified eligibility criteria introduced during the preceding recession were explicitly extended until the end of March 2012.

## 3 Econometric specification

We study time-varying effects of STW policy in a logistic smooth transition VAR (STVAR) model.[10] The model allows us to study time-varying effects in distinct regimes: recession and expansion. The advantage of the smooth transition approach is that the model smoothly evolves between recessionary and expansionary states (in contrast to abrupt switches from one quarter to the next) and allows us to make statements about the severity of the distinct regimes. Compared to estimating a structural VAR for each regime, a STVAR has the advantage that it uses the entire set of observations and therefore provides more

or due to an unavoidable event, (b) are only temporarily, (c) are unavoidable and (d) affect at least one-third of the company's workforce with a wage loss of more than $10\%$ of their monthly gross income.

[10] See Auerbach and Gorodnichenko (2012), among others. Granger and Teräsvirta (1993) introduced the univariate smooth transition model. The STVAR of Auerbach and Gorodnichenko (2012) has recently been criticized with respect to the calculation of impulse responses (Ramey and Zubairy, Forthcoming). We account for this criticism in our analysis (details follow in Section 4).

reliable estimates.[11] Our baseline VAR specification in reduced form is

$$X_t = \big(1 - F(z_{t-1})\big)\Pi_E(L)X_{t-1} + F(z_{t-1})\Pi_R(L)X_{t-1} + u_t \tag{1}$$

$$u_t \sim N(0, \Omega_t) \tag{2}$$

$$\Omega_t = \Omega_E\big(1 - F(z_{t-1})\big) + \Omega_R F(z_{t-1}) \tag{3}$$

We define $X_t = [Y_t, STW_t, N_t]'$ where $Y_t$ is the log of real GDP, $STW_t$ is the log of the aggregate number of workers on STW and $N_t$ is the log of employment. The model allows for different effects in recessions and expansions by defining a distinct set of coefficients in each regime. The coefficients in expansions are given by $\Pi_E(L)$, whereas $\Pi_R(L)$ denotes the coefficients in recessions. Similarly, the variance-covariance matrix of the mean zero, normally distributed reduced-form innovations $u_t$ is regime-specific with $\Omega_E$ in expansions and $\Omega_R$ in recessions. The time-varying nature, i.e., the weight on the parameters in recessions and expansions, is governed by the probability of being in a recession $F(z_t)$

$$F(z_t) = \frac{\exp\big(-\gamma(z_t - c)\big)}{1 + \exp\big(-\gamma(z_t - c)\big)}, \quad \gamma > 0,\ var(z_t) = 1, E(z_t) = 0 \tag{4}$$

where the parameter $\gamma$ determines the speed of transition between states, $z_t$ is a switching variable that is normalized to have a zero mean and unit variance and $c$ indicates the threshold at which transitions from one state to another occur.

For the choice of the switching variable $z_t$, we follow Auerbach and Gorodnichenko (2012) and Caggiano et al. (2015) and use a standardized moving average of GDP growth.[12] The speed of transition parameter $\gamma$ is calibrated to match the number of recession periods in Germany as defined by the Economic Cycle Research Institute (ECRI), which amounts to approximately 31$\%$ of the time. Given this observation, we define a recession if $F(z_t) > 0.69 = 1 - 0.31$. The parameter $\gamma$ is calibrated to match $Pr(F(z_t)) \geq 0.69 \approx 0.31$, which implies $\gamma = 1.79$. This choice is in line with the results of a grid search using the Bayesian Information Criterion for possible values of $\gamma$. Note that a threshold VAR model is a special case of a STVAR model if $\gamma \to \infty$. Hence, a value of $\gamma = 1.79$ indicates a rather low speed of switching from one regime to another. A STVAR turns out to be the better model choice compared to a threshold VAR. Figure 2 depicts the probability of being in a recession $F(z_t)$ and hence the corresponding weight on the recessionary parameters, along with ECRI recession periods. High realizations of $F(z_t)$ are associated with ECRI recessions.

Our baseline sample ranges from 1973Q1 to 2014Q4. Data on GDP and employment are provided in the German National Accounts, and data on the number of short-time workers are given by the German Federal Employment Agency ('Bundesagentur für Arbeit').

[11] Dividing the sample into recessionary and expansionary periods would lead to a sample size of approximately $n = 50$ for the recession, which may lead to unstable parameter estimates.

[12] Similar to Auerbach and Gorodnichenko (2012), we calculate a centered five-quarter moving average. A centered moving average is our preferred specification because it allows the most timely recession date, in contrast to a backward-looking moving average. For example, if we estimate simple two-state Markov switching model on German GDP growth rates, the filtered probability of recession has a correlation of 0.79 with the centered moving average. The backward-looking moving average considerably lags the filtered recession periods and has a correlation of 0.5 only.

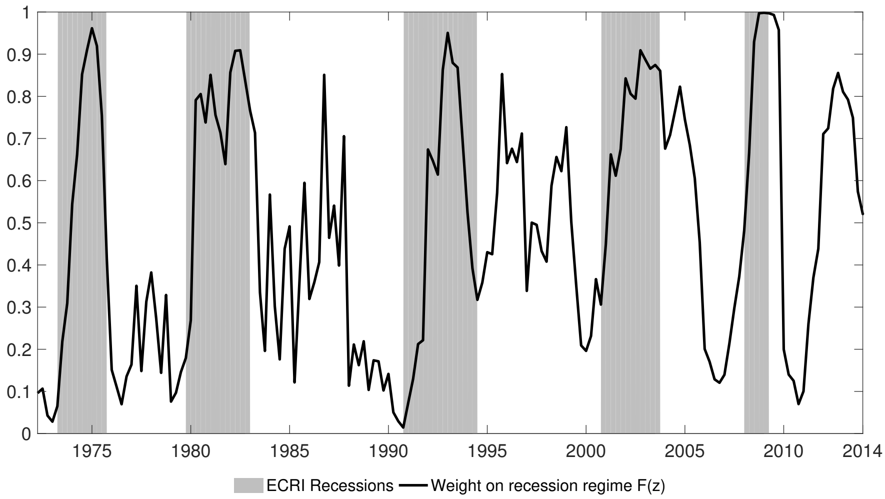



Figure 2: Weight on recession regimes. The business cycle indicator $z_t$ is set to a five-quarter moving average of the output growth rate and normalized, $\gamma = 1.79$. The economy spends approximately 20 percent of the time in a recession. Source: Own calculations.

Appendix A provides details on our data. We express all variables in levels in our baseline estimation.[13] The baseline specification includes two lags of endogenous variables, a regime-specific trend and a regime-specific intercept. In addition, we include a shift dummy for the reunification of West and East Germany in 1991Q1 and the switching variable $z_t$ from one up to four lags as exogenous regressors. This choice of model specification is based on the Bayesian Information Criterion (BIC). In line with Auerbach and Gorodnichenko (2012), we estimate the STVAR model with Markov Chain Monte Carlo (MCMC) methods, as proposed by Chernozhukov and Hong (2003). These methods are well suited to deal with the non-linearity in the model.

As a first test, we check whether the data necessitate a non-linear VAR model or whether a linear VAR would also meet the data requirements. The LM-type linearity test proposed by Weise (1999) and Granger and Teräsvirta (1993) tests the null hypothesis $H_0 : \gamma = 0$ against the alternative hypothesis $H_1 : \gamma > 0$.[14] The test strongly rejects the null of linearity. This test result is a first indication that the non-linearity matters for the analysis of STW.

## Identification of STW policy shocks

Our identification of STW policy shocks in the SVAR follows Balleer et al. (2016). As well-established in the fiscal policy literature (Blanchard and Perotti, 2002), we disentangle movements in policy due to exogenous discretionary shocks from movements in policy due to the endogenous responses to non-policy shocks with a short-run restriction in the VAR. Under the assumption that discretionary policy reacts to non-policy shocks only with an im-

[13] Our results are robust to an alternative specification with growth rates; see Section 6. We demean and normalize the data prior to estimation.

[14] The test statistic is given by $LR = (T - k)(\log|\Omega_0| - \log|\Omega_1|) \sim \chi^2(pk^2)$ where $\Omega_0$ is the covariance of the residuals of a linear model and $\Omega_1$ is the covariance of the residuals of a non-linear model, $T$ denotes the sample size and $k$ the number of estimated parameters in the model. We consider the degrees of freedom correction for small samples proposed by Sims (1980). For a detailed description on the linearity test, see Weise (1999).

plementation lag of at least one quarter, the only contemporaneous response to non-policy shocks is given by the endogenous response of STW.[15] This response is the automatic or rule-based response (see the discussion in Section 2). Given that external information on this rule-based response exists, this information can be used as a short-run restriction to identify STW policy in the VAR.[16]

In a linear framework, Balleer et al. (2016) estimate this rule-based response from German establishment-level data and find an elasticity of STW to output of $-3.31$. The estimated coefficient implies that a one-percent drop in output increases STW by $3.31$ percent. The advantage of the estimation on the microeconomic level is that all firms are subject to the same rules at a given point in time. Changes in the rules are controlled for by time fixed effects. In our context of a regime-switching VAR, the elasticity from microeconomic data provides a clean way to derive regime-specific short-run restrictions to identify our empirical model.

To do so, we extend the establishment-level estimation of Balleer et al. (2016) to a non-linear regime-specific setting using the same establishment-level data. Based on the establishment panel data, we can estimate elasticity in recessions and expansions. In the VAR as specified in Equation (1), we can then apply a regime-specific identifying elasticity in the matrix of contemporaneous relations. Then, we allow for time-varying rule-based reactions of STW in response to an output shock. Step by step, we show results based on a constant identifying elasticity, in line with Balleer et al. (2016) first. The extension in Section 4.3.1 discusses the results that we obtain with regime-specific elasticities in more detail. However, our overall findings remain similar.

The short-run restriction on the STW response to output shocks determines the contemporaneous correlation of output and STW due to output movements, whereas the remaining correlation will be interpreted as discretionary policy shocks. Technically, we recover the structural form of the VAR in Equation (1) by restricting the matrix of contemporaneous relations $A_0$ with $A_0^{-1}A_0^{-1} = \Omega_t$ and $a_0[1,2] = -3.31$. Then, the structural shocks $\epsilon_t \sim N(0, I)$ are related to the reduced-form residuals by $\epsilon_t = A_0 u_t$. Generally, our $N$-variable STVAR is identified if we impose $N(N-1)/2$ restrictions. Hence, we require three restrictions in our baseline with $N = 3$. The remaining two are implemented as a Cholesky identification for the last shock in the VAR.[17]

[15] Balleer et al. (2016) discuss that the implementation lag assumption is justified in quarterly STW data. We checked this assumption using a VAR with monthly data that implies that the implementation lag has to hold for only one month. Our main finding on the non-linearity in the employment response to STW shocks is robust in this VAR.

[16] In the SVAR literature on fiscal policy, different identification strategies are commonly used. One well-known alternative to the Blanchard and Perotti (2002) identification is the narrative approach of Ramey (2011). For STW policy, however, the narrative identification approach is not suitable. Certain policy changes are directly observable in German legislation (see Appendix B), but the set of discretionary measures is much broader (e.g., via a less stringent implementation of existing rules). Creating a measure of the use of the word "STW" in newspapers as commonly done in the uncertainty context (Baker et al., 2016) does not help, either, as we have to disentangle exogenous and endogenous, i.e., rule-based, STW movements.

[17] These restrictions imply that a shock in employment does not have a contemporaneous effect on output and STW. However, we do not interpret this shock.

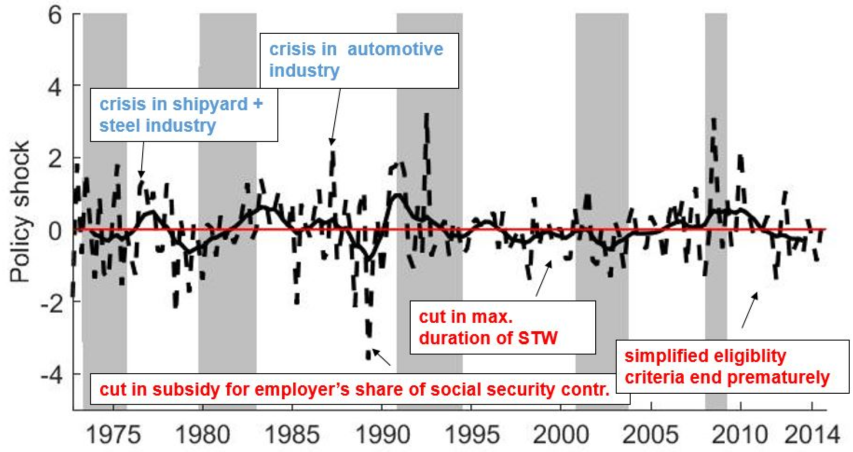



Figure 3: Structural STW policy shocks as identified in SVAR. The dashed line shows the shock series, the solid line represents a five-quarter moving average of the structural policy shocks. Gray shaded areas represent recession periods according to the ECRI definition. Source: Own calculations.

### Identified structural STW shocks

To stress the implications of our identification strategy, we analyze the structural policy shocks that we obtain from our baseline STVAR estimation. Figure 3 illustrates the identified policy shocks (dashed line) and a five-quarter moving average of the shocks (solid line). Given that the VAR controls for the rule-based component of STW via the short-run restriction, the shocks capture remaining discretionary policy changes. Indeed, the identified discretionary policy shocks coincide with periods when substantial changes to STW policy were implemented in the German economy (see also the discussion in Section 2). For example, there were substantial positive discretionary amendments during the Great Recession in 2009. The STVAR clearly identifies these changes as positive discretionary policy shocks around this period. In addition, the increase of STW allowances in 1975 is visible (compare Appendix B). Nonetheless, there are positive discretionary shocks not only in recessions but also in expansions. Examples are the period after the Great Recession in 2010, the crisis in the shipyard and steel industry in 1977/78 and the crisis in the car manufacturing industry in 1987 that was alleviated via STW. Furthermore, several negative discretionary STW policy shocks in expansions are visible in our series of structural shocks: a cut in the subsidy for the employer's share of social security contributions in late 1989, the decrease in the maximum duration of STW in 2000 and the cutback of several simplified eligibility criteria in 2011. Further note that not all recessionary periods are accompanied by expansionary STW policy shocks. For example, the moving average of the shock series for the recession from 2001 to 2003 is negative. This fact captures that STW was used less than expected in this recession. Overall, the timing of the identified policy shocks makes us confident that the STVAR indeed identifies the effects in which we are interested.

# 4 Results

In this section, we report estimated impulse response functions to a STW policy shock by regime and the severity of the regime.[18] For the computation of impulse responses, we follow Koop et al. (1996) and Caggiano et al. (2015) and compute generalized impulse response functions (GIRFs) that take into account the history up to time $t-1$ and may vary by the size and sign of the shock. As shown by Koop et al. (1996), GIRFs depend on initial conditions. We control for that by randomizing over all possible histories.

The main idea of GIRFs is to draw a history $t$, simulate the paths of the endogenous variables with and without a shock for the impulse response horizon $h$, compute the difference and repeat the process many times. We take 500 random draws from our MCMC parameter draws and simulate for each draw 500 histories. Appendix D provides a detailed description of the GIRF algorithm. This methodology allows for a dynamic feedback mechanism between recession and expansion: Since our switching variable $z_t$ is a moving average of GDP growth, we simulate the GDP path and can update the switching variable at every step of the simulation.[19] Hence, the probability of being in a recession $F(z)$ is endogenized. In addition, a shock may drive the economy out of or into recession. For illustration purposes, we normalize the size of the STW shock to one in each regime.

## 4.1 Recession

First, we will consider the effects of a discretionary STW policy shock in a recession. Note that the model is in a recession if the probability of being in a recession $F(z_t)$ exceeds $0.69$ according to our baseline calibration of the switching process. We classify 31 percent of the periods in our sample as recessions.

### 4.1.1 Normal recession

Figure 4 shows the GIRFs for a policy shock, i.e., a discretionary expansion of STW policy, in a normal recession. In these and all subsequent figures, the straight red line indicates the median responses in recessions. The shaded error bands denote 68 percent confidence intervals.

Expansionary discretionary STW policy induces firms to increase the number of short-time workers. This positive STW effect persists for approximately three years before returning to zero with a peak after one quarter. Most interestingly, the employment response to a STW shock in a recession is significant and positive. This finding implies that discretionary STW stabilizes the labor market in a recession. This finding is in line with the notion of falling employment in a recession. A recession is triggered by a negative GDP shock that has a strong negative effect on employment. As such, discretionary STW policy counteracts the

[18] We illustrate impulse responses of a linear SVAR model in comparison to the non-linear GIRFs from our baseline model in Figure 14 in Appendix F. In the linear model, employment and GDP fall in response to a STW shock.

[19] To compute the centered moving average, we use VAR forecasts of our endogenous GDP series.

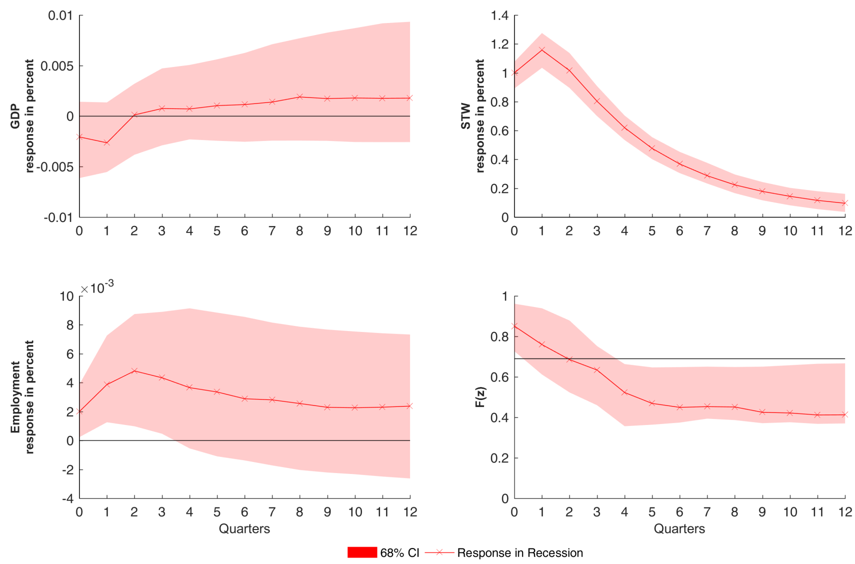



Figure 4: Median responses to a STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

overall trend of falling employment in recessions. A STW shock that increases the number of short-time workers by 100 percent or 250,000 workers, which amounts to roughly one standard deviation across the STW time series, increases employment by 0.2 percent or approximately 42,000 employees. The GDP response is insignificant and slightly negative in the first two quarters.

To further illustrate the quantitative dimension of the STW effects according to the GIRFs, we define the employment effect of one short-time worker as the number of jobs saved per additional discretionary short-time worker. We explore the time-varying nature of discretionary STW policy by computing the GIRF of employment to a one-percent STW shock in every quarter from 1973Q1 to 2014Q4. We relate the (cumulated) employment response to the (cumulated) STW response after the policy shock. In particular, we define impact, short-run, medium-run and long-run effects as $\sum_{h=0...H} \beta^h N_h / \sum_{h=0...H} \beta^h STW_h$ for $H = 0, 4$ and $8$, and maximum effects as $\max_{h=0...H} \beta^h N_h / \max_{h=0...H} \beta^h STW_h$. We discount the effects by a factor $\beta = 0.99$. Table 1 gives an overview of the average employment effects per discretionary short-time worker for recessions. On impact, the employment effect of one short-time worker amounts to $0.19$ jobs saved in recessions. The effect grows larger over time and reaches $0.51$ at maximum.

The lower right panel of Figure 4 depicts the evolution of the probability of being in a recession after a discretionary STW policy shock. This plot shows how the GIRFs capture the endogenous regime changes after a shock. Two quarters after the shock, the median recession weight is already below our threshold of $0.69$ and further decreases to $0.5$.

| | | Recession | Deep Recession | Great Recession |
|---|---|---|---|---|
| Impact | | 0.19 | 0.21 | 0.30 |
| Cumulated | 4Q | 0.43 | 0.48 | 0.72 |
| | 8Q | 0.60 | 0.70 | 1.10 |
| Maximum | | 0.51 | 0.58 | 0.83 |

Table 1: Employment effects per discretionary short-time worker in recessions defined as (cumulated) employment response relative to the (cumulated) STW response after a policy shock ($\sum_{h=0...H} \beta^h N_h / \sum_{h=0...H} \beta^h STW_h$ for $H = 0, 4$ and $8$ and $\max_{h=0...H} \beta^h N_h / \max_{h=0...H} \beta^h STW_h$). Deep recessions are defined as periods in which the switching variable $z_t < -1$. The Great Recession covers the periods from 2008Q3 to 2009Q2. Source: Own calculations.

#### 4.1.2 Deep recessions and the Great Recession

Next, we analyze the responses of a discretionary STW policy shock in deep recessions only. Due to the non-linearity in the STVAR, the model responses may differ by regime severity. As a first step, we analyze differences between our baseline and more extreme events by considering periods when the switching variable $z_t$ is below $1$ standard deviation, hence $z_t < 1$.[20] In this scenario, we isolate 15% of our observations as deep recessionary periods, hence $F(z_t) > 0.85$. The effect of a discretionary STW policy shock on employment in this case is illustrated in panel (a) of Figure **??**. The overall shape of the response is very similar to the one in normal recessions (Figure 4); however, the effects are more pronounced. As illustrated in Table 1, the maximum employment effect per discretionary short-time worker in deep recessions is 0.58 jobs saved and hence slightly higher compared to the 0.51 saved in mild recessions.

Second, we isolate the Great Recession in Germany (2008Q3-2009Q2) as an example of a very deep recession. The Great Recession period corresponds to periods where the switching variable $z_t$ is below 2 standard deviations of the switching variable $z_t$ and $F(z_t) > 0.98$.[21] The corresponding GIRFs are illustrated in panel (b) of Figure **??**. Interestingly, during the Great Recession, the positive employment effect in response to a discretionary STW shock becomes even larger and more persistent. A 100 percent STW policy shock during the Great Recession, stabilized employment by approximately 210,000 jobs at the peak.[22] Table 1 illustrates that the maximum employment effect of one additional discretionary short-time worker rises to $0.83$ in the Great Recession. This is the peak effect in our sample. It stands out that the more severe a recession, the greater the effects of discretionary STW on employment. In Section 5, we will provide a detailed analysis of the employment effects of STW policy in the Great Recession. We will further investigate the effects of the discretionary and rule-based components of STW separately.

[20] In a baseline recession, we enter a recession if $z_t < -0.46$.

[21] For a graphical illustration of the periods isolated as extreme events, see Figure 20 in Appendix F.

[22] The employment response on impact in the Great Recession period is 0.0024 percent and peaks after three quarters at 0.009 percent. In mild recessions, the employment response was 0.0017 percent on impact and peaked at 0.004 percent.

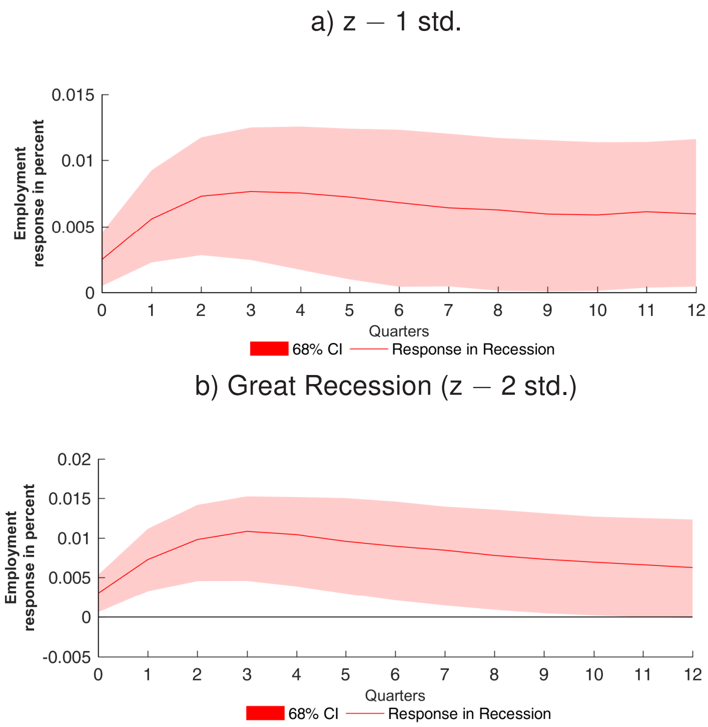



Figure 5: Deep recessions and the Great Recession. Median employment responses to a STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

#### 4.1.3 Mechanism in recessions

Our results show that the employment effect of an expansionary discretionary STW policy shock in recessions is positive. Further, it holds that as the recession gets deeper, the positive employment effects become more pronounced. Next, we want to explore the underlying reasons for these results. Why does employment rise after a STW shock? One way to think about this question is in terms of rigid labor markets with long-term employer-employee relationships. Then, hiring and firing workers is costly, e.g., due to search frictions in the spirit of Diamond (1982) and Mortensen and Pissarides (1994) and/or hiring and firing costs.[23] As a result, firms will not adjust the labor input fully flexibly and keep workers even if they are temporarily unproductive. This mechanism is known as labor hoarding. STW subsidies reduce the costs of labor hoarding. Consequently, STW will induce firms to use even more labor hoarding and reduce separations. If separations drop, unemployment falls and employment rises. This mechanism is supported by VAR responses that we obtain from augmented VARs with data on separations or that we estimate with unemployment instead of employment (see Figure 19 in Section F).

A further interpretation explaining the long-run positive effects of STW on employment is that STW prevents hysteresis effects, i.e., structural unemployment rising due to cyclical unemployment (Blanchard and Summers, 1986). Given that STW keeps employees in the firms, the typical channels that may lead to hysteresis such as skill loss, stimatization,

[23] See Balleer et al. (2016) for a model-based analysis of STW in a search and matching labor market. An alternative motive is to keep firm-specific human capital in the firm. See Tilly and Niedermayer (2017) for a recent contribution along this dimension.

| | Credit constraint establishments | Non-credit constraint establishments |
|---|---|---|
| STW usage (in % of total employment) | 5.64 | 2.05 |

Table 2: STW usage of credit constraint and non-credit constraint establishments. We count a firm as credit constrained if the firm reports difficulty in getting access to credit. Source: IAB Establishment Panel (year 2009).

demotivation and high re-entry barriers are eliminated. For Germany, Klinger and Weber (2016) show that hysteresis effects matter particularly in recessions.

What can explain why the stabilizing effects of STW are stronger as GDP growth decreases? Notably, our deepest recession in the sample, the Great Recession, was accompanied by a deep financial crisis. Thus, a hypothesis is that financial frictions interact with our effect in deep recessions. STW allows firms to considerably reduce their labor costs in times of financial difficulty. Thus, it may particularly assist credit constraint firms during recessions. Given that these firms have no other means of financing their operating costs (rent, interest, liquidity, etc.), the STW subsidy to labor costs gives these firms some financial scope without having to lay off employees. We find some indicative evidence for this hypothesis in the IAB establishment panel. The IAB establishment panel is a yearly survey of approximately 16,000 German establishments. In 2009 only, establishments were asked whether they experienced difficulties in getting access to credit. As shown in Table 2, establishments that report such credit constraints in the year 2009 have a substantially higher STW usage (relative to total employment) compared to firms that do not face similar credit constraints. The STW share of total employment in credit constraint firms is with $5.64$ percent more than double the share in non-credit constraint firms ($2.05$ percent).[24] We interpret this finding as anecdotal evidence that STW is more attractive for firms that face explicit financial frictions.

In the context of fiscal policy, a similar argument has been made by Canzoneri et al. (2016), who show in a theoretical model that financial frictions in the spirit of Curdia and Woodford (2010) play an important role for the effectiveness of fiscal policy. These frictions, i.e., a spread between the bank deposit rate and the bank loan rate for savers and borrowers can explain asymmetries in policy effectiveness in recession and expansion. A fiscal impulse in a recession reduces the financial friction and creates a financial accelerator. The same mechanism is present during expansions; however, since the friction is smaller to begin with, the reaction of the financial accelerator is weaker. We argue that a similar mechanism could be at work in the case of STW subsidies in recessions. STW subsidies reduce firms' cost of production. In the model of Canzoneri et al. (2016), this process reduces prices and stabilizes demand. In a deep recession, the financial friction is stronger, and thus, the

[24] In a simple regression, a dummy for credit constraint also significantly affects STW usage when controlling for additional firm characteristics, including demand. In particular, we control for important variables that influence STW usage, such as firm size, revenue, sector, and workforce characteristics. Unfortunately, we cannot make any causal statements here because the survey data have information on credit constraint establishments only in the year 2009.

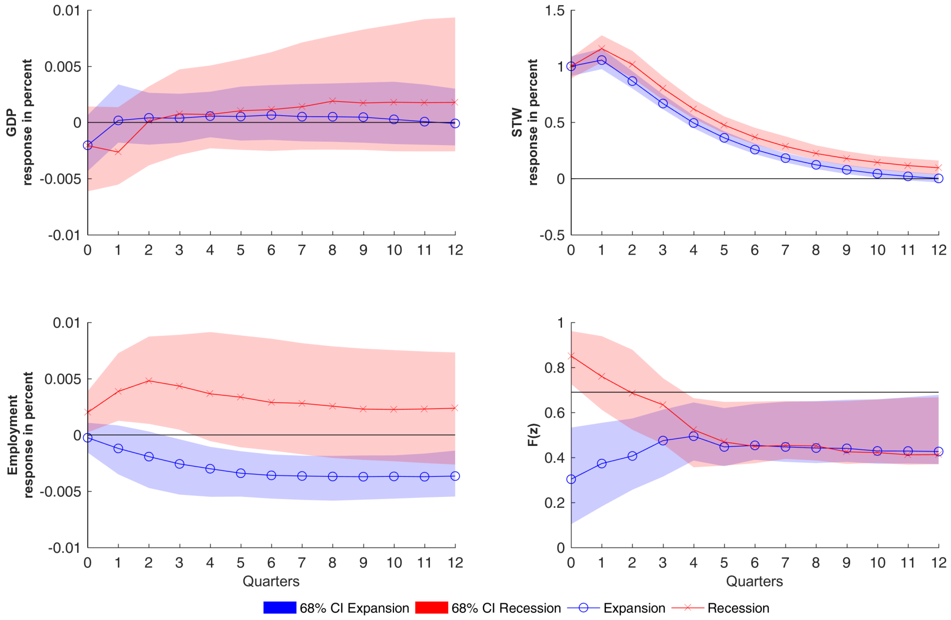



Figure 6: Median responses to a STW policy shock in expansion and recession (normalized to one). Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

stabilizing effect is, as in the case of fiscal policy, more pronounced.

## 4.2 Expansion

### 4.2.1 Normal expansion

Next, we illustrate the economy's responses to a positive STW policy shock in a normal expansion. The probability of being in a recession is below $69$ percent. The corresponding GIRFs in expansion (and recession for comparison) are illustrated in Figure 6. Similar to recessions, STW's response to the expansionary shock itself persists for approximately three years, peaking after one quarter.[25] In an economic upswing, the effects of a discretionary STW policy shock on employment, however, are remarkably different from the effects in a recession. The employment response is close to zero and insignificant with a negative sign (from quarter one onward). In recessions, we documented a positive employment response. The impact response of GDP is slightly negative but zero in the subsequent quarter. Furthermore, the economy stays in an expansion, as illustrated by the response of the probability of being in a recession in the lower-right panel. Quantitatively, as illustrated in Table 3, the employment effect per discretionary short-time worker in expansions is positive (but very small) on impact and becomes negative in the medium run (-0.28 after two years). Discretionary STW policy has negative effects in the long-run if implemented in expansions. We give an explanation for these negative effects in the following. Before, however, we document the effects in strong recessions only.

[25] We illustrate non-normalized GIRFs in expansion and recession in Figure 15 in Appendix F. In an expansion, the STW series responds slightly more strongly to a shock of similar size. The overall conclusions are not altered by inspecting non-normalized GIRFs.

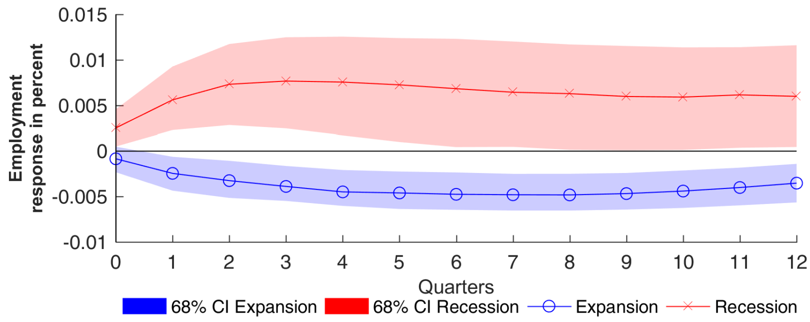



Figure 7: Median responses to a STW policy shock normalized to one in strong expansions. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

#### 4.2.2 Strong expansions

Consistent with strong recessions, we define strong expansions as histories when the switching variable $z_t$ is above 1 standard deviation ($F(z_t) < 0.15$). Figure 7 shows the corresponding GIRFs for employment. We see that in strong economic upswings, the employment effects are significantly negative after approximately one year and slowly return to zero afterwards. In general, as the expansion becomes stronger, the effects become more pronounced. Table 3 shows that the employment effect per discretionary short-time worker in expansions is already slightly negative in strong expansions (-0.04). The cumulated effects show that these negative effects become even stronger over time (up to almost -0.7 after two years).

| | | Expansion | Strong Expansion | Recession | Deep Recession | Great Recession |
|---|---|---|---|---|---|---|
| Impact | | 0.03 | -0.04 | 0.19 | 0.21 | 0.30 |
| Cumulated | 4Q | -0.03 | -0.26 | 0.43 | 0.48 | 0.72 |
| | 8Q | -0.28 | -0.69 | 0.60 | 0.70 | 1.10 |
| Maximum | | -0.16 | -0.47 | 0.51 | 0.58 | 0.83 |

Table 3: Employment effects per discretionary short-time worker over the business cycle (see Table 1 for details). Deep recessions/strong expansions are defined as periods in which the switching variable is $z_t < -1/ > +1$. Source: Own calculations.

To sum up and to provide a general view of the time-dependency of STW policy, we present the historical number of jobs saved as a result of discretionary STW policy over time. Figure 8 depicts the employment effects of one discretionary short-time worker. For illustrative purposes, we show results for the impact response of employment to STW shocks only. In line with the insights from the GIRFs in the previous subsection, the size of the employment effects varies considerably over time and is much higher in recessions than in expansions.

Based on these considerations, we quantify the cut-off between positive and negative employment effects. The recession probability that corresponds to an impact employment response of exactly zero implies an associated value of the quarterly moving average (MA) of GDP growth of $0.47$ percent. If quarterly GDP growth is above 0.5 percent (in terms of a five-quarter MA), the employment effects in response to a discretionary STW policy

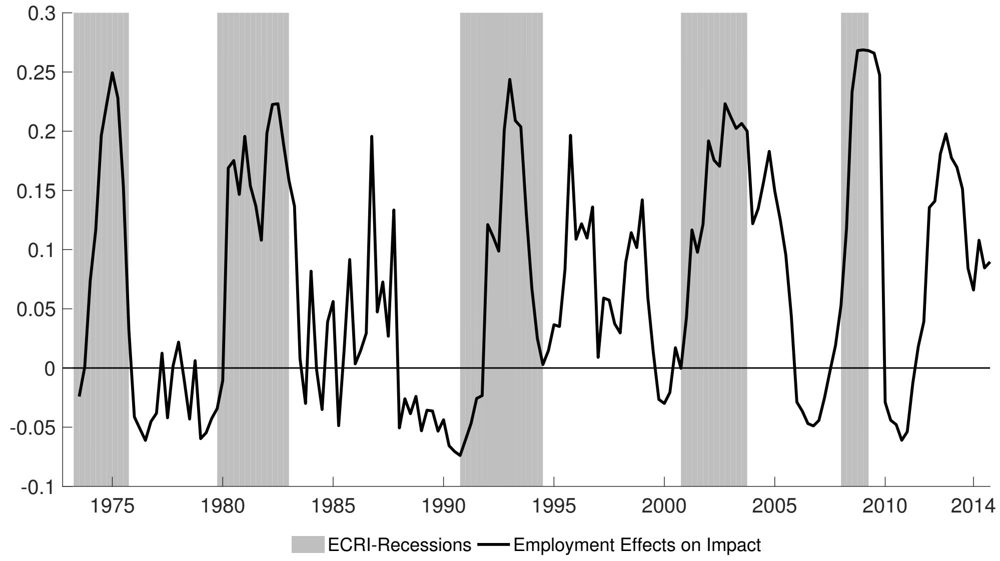



Figure 8: Historical employment effects per short-time worker. Shaded regions denote ECRI recession periods. The solid black line illustrates employment effects on impact, while the blue dashed line shows cumulated effects over 4 quarters. Source: Own calculations.

shock turn negative. For GDP growth rates below 0.5 percent, discretionary STW policy has positive effects on employment.

### 4.2.3 Mechanism in expansions

Why does the long-run effect of STW on employment turn negative in (strong) expansions? We argued before that in deep recessions and financial crises, financial frictions can explain more positive effects of STW in recessions. However, this mechanism does not explain why STW can have negative effects in expansions.

To shed some light on this finding, we check for differences between firms that use STW in expansion vis-à-vis recession. The IAB establishment panel has information on establishments' STW usage in both business cycle phases.[26] The descriptive statistics in Table 4 show that establishments using STW are generally larger (in terms of employees and revenue), more export-oriented and older than establishments that do not use STW. Interestingly, however, the characteristics of STW establishments differ depending on whether they implement STW in recessions or expansions. In recessions, STW establishments tend to be larger, more productive and more export-oriented than establishments that use STW in expansions. These descriptive results suggest that establishments using STW in expansions are a negative selection of all establishments. These may be contracting firms

[26] To differentiate the effect of the recession on the establishment and the general establishment characteristics, we investigate the number of short-time workers in the first half of the current year, whereas revenue and employment characteristics refer to the previous year. The characteristics of establishments using STW have been analyzed by various previous studies. Among others, Crimmann et al. (2012) show based on the same establishment-level data that (mostly large) German establishments use STW to keep their core employees and hence firm-specific human capital in the establishment during crises.

| | STW estab. | | Non-STW estab. | |
|---|---|---|---|---|
| | Recession | Expansion | Recession | Expansion |
| Employees | 50.21 | 38.63 | 13.68 | 14.64 |
| Revenue | 7.95 mio. | 5.46 mio. | 2.11 mio. | 2.16 mio. |
| Productivity (Revenue/employees) | 112,281 | 106,284 | 119,672 | 111,260 |
| Export share (%) | 8.91 | 7.32 | 2.55 | 2.56 |
| Share of firms older than 10 years | 79.68 | 74.77 | 72.79 | 72.55 |

Table 4: Comparison of establishment characteristics. Data are from the IAB establishment panel for the years 2003, 2006, 2009 and 2010; hence, we cover two recessions (2003=mild recession and 2009=deep recession). The data are weighted with sample weights and thus are representative of the population of German establishments. Productivity, revenue and employees refer to the previous year.

that are negatively affected by structural change, for example. STW may thus prevent a reallocation of resources to expanding firms.

Another look at the series of structural STW shocks in Figure 3 corroborates this suggestion: most positive expansionary shocks took place in response to specific crises in the shipyard, steel and car manufacturing industry during the first half of the sample and during the German reunification. STW that used to alleviate the impact of non-business-cycle-related crises may have long-run negative effects on the labor market. We further provide evidence that the use of STW in this regard in Germany stopped after the reunification period. In a SVAR for the period after the German reunification (1993 onward, monthly data), the persistent negative employment response after an expansionary STW policy shock in expansions is absent (see Figure 25 in Appendix F). The positive effect of STW on employment in recessions remains.

In a recent paper, Cooper et al. (2017) develop a theoretical model that rationalizes potential negative effects of STW on employment. In a similar vein to our descriptive evidence above, Cooper et al. (2017) stress the difference of the effectiveness of STW policy conditional on the decomposition of the economy across expanding and contracting firms. If the share of expanding firms is greater than the share of contracting firms, overall employment effects of STW may become negative. In general, there are more expanding firms in an expansion than in a recession. The use of STW in contracting firms in expansions makes hiring for growing firms more costly (because STW decreases the pool of unemployed workers). In other words, STW in expansions keeps contracting firms alive and binds resources to these firms. Discretionary STW policy during expansions may cause an inefficient allocation of labor. This general point has previously been made in the literature: STW should not be used to alleviate the transitions triggered by structural change.[27]

[27] Boeri and Brücker (2011), Cahuc and Carcillo (2011), Arpaia et al. (2010), Brenke et al. (2013) and Hijzen and Martin (2013) stress the importance of a proper design of STW schemes and warn of negative effects if they are used in times of recovery. They argue that these effects can be caused by inefficient reductions in working hours (Cahuc and Carcillo, 2011) or by tying workers to unproductive firms and hence preventing productivity gains (Boeri and Brücker, 2011). Boeri and Brücker (2011) argue that STW may act as a distortionary subsidy and prevent structural adjustments in the long-run. This may counteract the 'cleansing effect' of recessions.

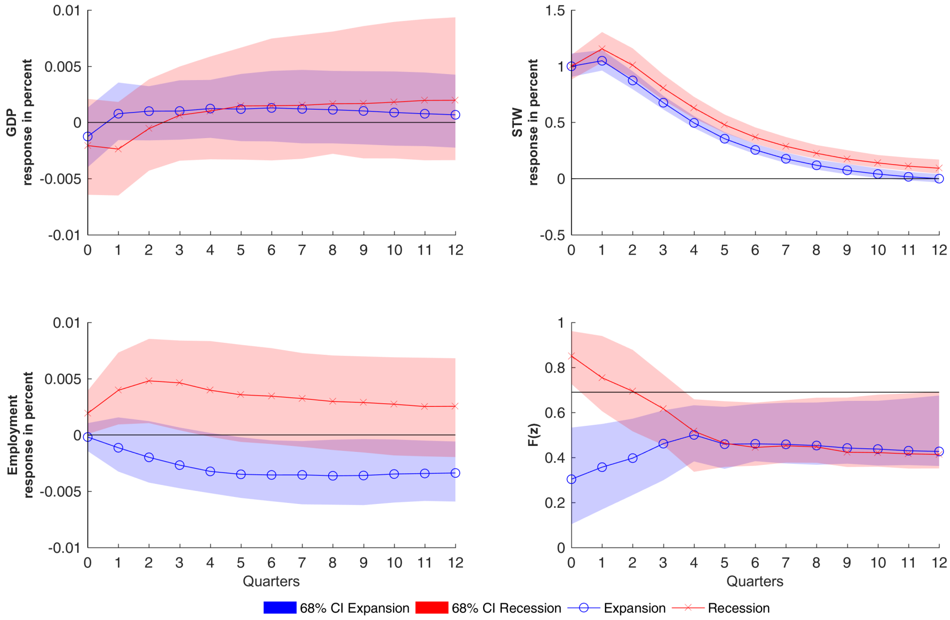



Figure 9: Median responses to a STW policy shock in expansion and recession (normalized to one) with regime-specific identification. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

## 4.3 Extensions

### 4.3.1 Regime-specific identification strategy

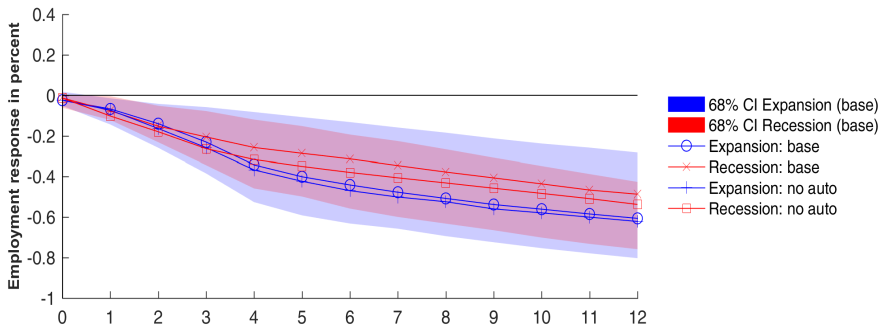
Our short-run identifying restriction that we derive from microeconomic firm-level data allows us to implement a regime-specific identification of our STVAR. Then, we relax the assumption that firms' rule-based STW response to output shocks is the same in expansions and recessions. We estimate regime-specific STW elasticities by applying the same estimation procedure as Balleer et al. (2016), except for adding an interaction term of output and recessionary years (see Appendix E for details). We find a significant difference in the STW responses to output shocks between expansions and recessions. The STW elasticity to changes in firms' expected revenue in expansions is $-4.76$, whereas it is significantly lower in recessions, with a value of $-3.44$. At first glance, it may seem surprising that the rule-based component is (in absolute value) higher in expansions than in recessions. However, this observation is actually much in line with our finding of STW firms in expansions being a negative selection of all firms (see Section 4.2.3); these firms use STW more. See Balleer et al. (2016) for a similar argument. Figure 9 shows the GIRFs for a STW policy shock that we obtain if we use regime-specific short-run restrictions, in line with the numbers above. Most importantly, our main result remains robust: STW policy shocks have a positive effect on employment in recessions, whereas they have a zero and long-run negative effect in expansions. Additionally, the multipliers (not shown here) are very similar to the estimation with a constant elasticity.

### 4.3.2 The role of the rule-based component in the Great Recession

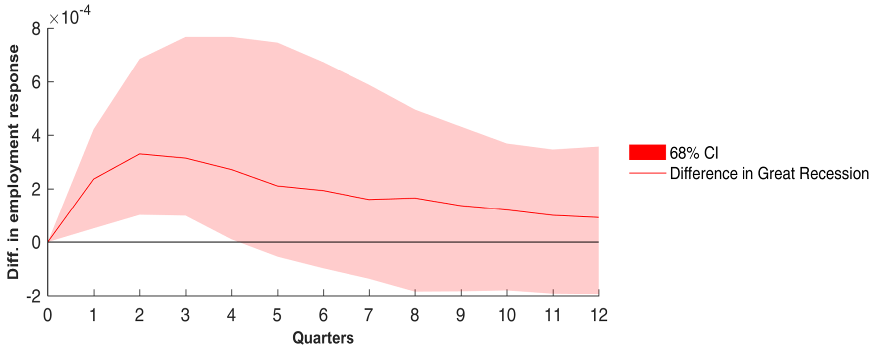
This paper established that discretionary STW policy is more effective during recessions than in expansions. The critical reader may wonder whether this is also the case for the rule-based policy component. We use our STVAR to provide a tentative answer regarding the effects of the rule-based component in the Great Recession. Naturally, the data in the STVAR do not have information on an economy without the rule-based policy component. However, we can turn off the stabilizing reaction of this component to non-policy shocks by zeroing the STW coefficients in $\Pi_E$ and $\Pi_R$ and the STW entries of the $A_0-$ matrix (compare Equation (4), see Caggiano et al. (2017), Sims and Zha (2006), or Primiceri (2005) for a similar approach in the context of monetary policy). The responses in this modified VAR are equal to the responses in an economy without the rule-based STW policy stabilization if we assume that all the other parameters remain unchanged in spite of switching off the rule-based component, i.e., in spite of the policy change. Based on this hypothetical economy without the rule-based component, we then compare the employment responses to an output shock without the rule-based stabilization to the employment response in the original VAR where STW adjusts in the rule-based fashion.

Figure 10 shows the drop in employment after a negative output shock in the baseline STVAR with and without the rule-based STW adjustment (upper panel). Notably, employment responds more strongly to an output shock if we shut off the systematic response of the rule-based STW component. Interestingly, however, the stabilization due to the rule-based component is very similar across the different regimes. The confidence bands largely overlap each other. Hence, we conclude that the effectiveness of the rule-based component of STW policy is largely time-invariant. This result confirms our focus on the non-linearity in the effects of the discretionary policy component.

Furthermore, we isolate the stabilizing effect of the rule-based component in the Great Recession (lower panel of Figure 10), which allows us to quantify the automatic stabilizing effects of the rule-based component in the Great Recession. Jointly with the stabilization due to the discretionary STW component, this number allows us to make a statement on the total stabilizing effects of STW in Germany in the Great Recession. Quantitatively, the rule-based component of STW as triggered by a drop in GDP growth from peak to trough (2008Q1 to 2009Q3) of almost 7 percent amounts to a cumulated employment effect over the first year of 350,000 jobs. This number is similar to the findings of Balleer et al. (2016), who make a similar argument based on a search and matching labor market model with STW. The number of Balleer et al. (2016) is even larger, making our number a more conservative estimate. Given the overall similar order of magnitude, we are confident that our assumption of the VAR responses' invariance to the switching off of the rule-based response is justified in our context .




(a) Employment responses to output shock




(b) Differences in responses: Great Recession

Figure 10: Upper panel: Median employment response to a negative output shock with and without the rule-based component of STW policy. Lower panel: Differences of the employment response in the Great Recession with and without the rule-based STW stabilization in response to a negative output shock. Source: Own calculations.

# 5 Employment effects in the Great Recession

In this section, we use the STVAR to investigate the role of STW in Germany in the Great Recession. To do so, we simulate the dynamics of the variables in the STVAR conditional on the output shocks that occurred from period 2008Q3 onward (period of the first negative output shock in the Great Recession) to 2011Q2.[28] We further switch on and off the discretionary STW policy shocks that took place in this period, resulting in a hypothetical employment series under the scenario that there would not have been any discretionary changes to STW policy in the Great Recession. This procedure also allows us to decompose the series of short-time workers into those triggered by discretionary short-time policy and those due to rule-based adjustments. In a second step, we additionally turn off the rule-based component of STW as described in the previous Section 4.3.2. For this exercise, the caveat from the previous section applies again: we have to assume that this does not affect the other parameters in the STVAR. Then, the result is a hypothetical employment series in the Great Recession if STW would not have existed at all. The results of these exercises for the number of short-time workers and the different (hypothetical) employment responses are depicted in Figure 11.

The decomposition of the STW series reveals that approximately $40$ percent of all short-time workers during the Great Recession were on STW due to discretionary changes, whereas the automatic stabilizing effect explains the remaining $60$ percent of all short-time workers (upper panel of Figure 11).

The lower panel of Figure 11 shows once again that employment remained relatively stable during the Great Recession in Germany (solid line) in spite of the huge GDP drop triggered by the negative output shocks. However, our results clearly show that without a discretionary STW intervention, employment would have dropped by more in the years 2009 and 2010 (triangular marking). We find that discretionary STW policy saved 100,000 jobs per quarter on average in this period. If we simulate employment under the assumption that STW would not have existed at all (in absence of both the rule-based and the discretionary component of STW), there would have been an even more pronounced drop in employment (dashed line). On average, without any STW, employment would have dropped by 140,000 more persons per quarter, amounting to 0.4 jobs saved per short-time worker in this period on average. In sum, STW saved approximately 540,000 jobs during the first year of the Great Recession.[29] In terms of unemployment, this number translates to a potential rise of the unemployment rate of $0.3$ percentage points that was prevented due to STW. Of these $0.3$ percentage points, approximately $0.2$ percentage points are due to discretionary policy intervention.

The magnitude of our results is in line with existing (mostly cross-sectional) studies on the employment effects of STW in the Great Recession. Cahuc and Carcillo (2011) find significant positive employment effects of STW during the Great Recession and Hijzen and Martin (2013: p. 23) estimate the number of saved jobs in Germany at 580,000, while

[28] The simulation is based on the median parameter estimates.

[29] This refers to the cumulated employment effects of both discretionary and rule-based STW between 2008Q3 and 2009Q3.

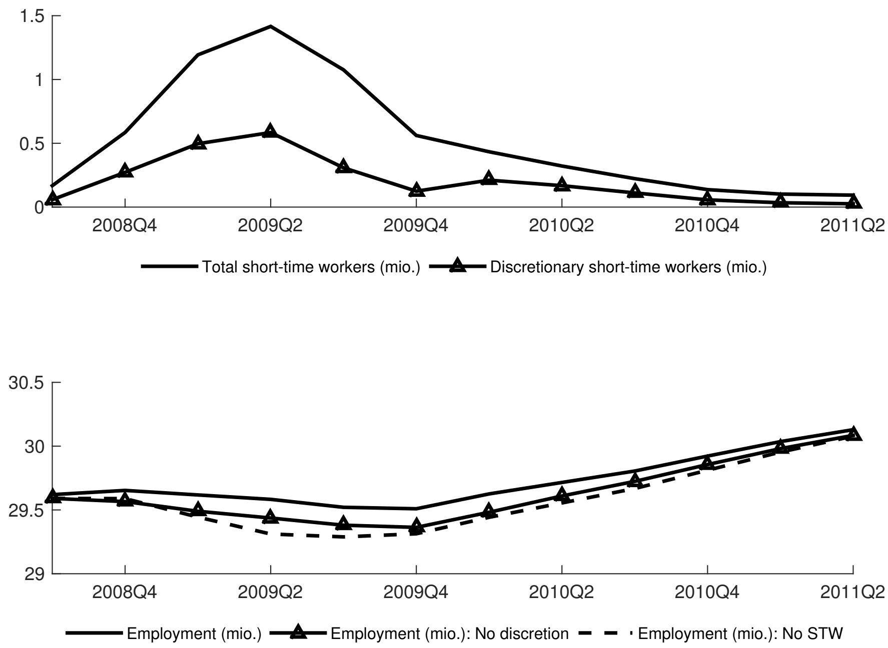



Figure 11: Upper panel: Decomposition of short-time workers in the Great Recession in discretionary short-time workers and rule-based short-time workers. Total short-time workers are the sum of rule-based short-time workers and discretionary short-time workers. Lower panel: Counterfactual employment series without the discretionary component of STW and without STW at all (i.e., neither discretion nor rule-based component). Simulation period: 2008Q3-2011Q2. Source: Own calculations.

calculations of Crimmann et al. (2010: p. 38) suggest that approximately 300,000 jobs were preserved due to STW and Balleer et al. (2016) quantify the automatic stabilizing effect of STW to 466,000 saved jobs. Estimates of Boeri and Brücker (2011) indicate that the number of jobs saved was 435,000. Our estimate of a total of roughly 540,000 jobs saved - of which 390,000 jobs were kept due to the discretionary component of STW and another 150,000 due to the rule-based component - are hence at the upper end of existing estimates. This finding is unsurprising, given that we are the first to fully account for the non-linearity of discretionary STW policy from a time series perspective.

# 6 Robustness

In this section, we conduct a variety of robustness checks to analyze the sensitivity of the time-varying response of employment to a STW policy shock. In particular, we check the robustness of our results with respect to identification, potential anticipation of policy, regime calibrations and larger VAR with additional control variables. All the results are summarized in Appendix F.

## 6.1 Identification and anticipation

To check the sensitivity of our results to the identification strategy, we vary the identifying elasticity and thus the short-run restriction in the VAR and explore alternative identification schemes.

First, we estimate our non-linear VAR for different identifying elasticities. In the baseline, we impose the elasticity of $-3.31$ as estimated by Balleer et al. (2016). Now, we use the estimated elasticity $\pm$ 2 standard deviations of the estimate, i.e., an elasticity of -4.13 and -2.5 respectively, and a zero elasticity, i.e., shutting off the rule-based policy component. The results are summarized in Figure 21 in Appendix F and reveal that the effects are hardly sensitive to the exact value of the short-run elasticity. In particular, employment rises in recessions but shows no significant effect to a discretionary STW policy shock in expansions.

Second, we apply a simple Cholesky recursive identification scheme and hence depart from our short-run restriction in the spirit of Blanchard and Perotti (2002). Note that for this identification strategy, the ordering of variables matters. We keep the order of our variables with log(GDP) being the first variable, followed by log(STW) and log(N). Hence, we impose the assumption that GDP does not react contemporaneously to STW policy changes but STW may react within the same quarter to output shocks. As a result, this ordering provides a VAR-based estimate of the rule-based STW component. The STW elasticity to output shocks according to the estimated VAR coefficients is $-5.63$ in recessions and $-6.06$ in expansions. This number is about twice as large as our estimate from the establishment-level data. In this specification, we therefore have a higher weight on the rule-based component of STW, particularly in expansions. Our main results are nevertheless robust (see Figure 24 in Appendix F). The VAR-based estimate with Cholesky identification also implies a higher elasticity in expansions, in line with our results in Section 4.3.1.

Next, we check whether anticipation of STW policy matters for our results. Ramey (2011) argues that anticipation of fiscal policy shocks plays a crucial role when using a Blanchard Perotti type of identification for fiscal policy. If discretionary STW policy changes are implemented by law (see the changes in Appendix B), the law is typically passed before the legislation is implemented. However, once the law is passed, agents anticipate that the policy change will occur. Therefore, as a first check, we control for this type of anticipation by including a dummy variable in our STVAR that takes the value of one for the period between the passing of a law regarding changes in STW policy until its implementation. The employment response is not affected by this anticipation dummy (see panel 1 of Figure 22). Second, we check whether agents anticipate discretionary policy interventions in recessions. We perform Granger causality tests with the null hypothesis that different recession indicators $y$ do not Granger cause discretionary policy shocks $x$ (see Granger, 1969). The corresponding F-statistics in Table 5 show that several business cycle indicators such as GDP growth, GDP in levels, a ECRI recession dummy and our weight on recession regimes do not Granger-cause our discretionary STW policy shocks. Hence, we conclude that positive discretionary STW policy shocks are not anticipated if the economy slides into a recession.

## 6.2 Alternative recession definitions and switching parameters

To estimate the STVAR, the calibration of the weight on being in a recession is crucial. In this subsection, we show that our results are robust to different choices along this dimension. In Germany, no official recession dating exists. Table 6 gives an overview of the

| | GDP growth | GDP | ECRI recessions | Recession weights |
|---|---|---|---|---|
| x $\rightarrow$ STW policy shocks | 0.98 | 0.77 | 0.86 | 0.77 |

Table 5: F-statistics for Granger causality tests: Does x (GDP growth, GDP, ECRI recessions and Recession weights) Granger cause STW policy shocks? (H0: x does not Granger cause STW policy shocks). The critical value for $F$-statistic is 3.9 (at a 5 % significance level), maximum lag length is set to 12. Source: Own calculations.

employment effects per discretionary short-time worker for average downturns across different recession definitions. We illustrate employment effects per discretionary short-time worker for our baseline recession definition (ECRI recessions, $F(z_t) > 0.69, 31\%$ recessionary periods): the definition by the German Council of Experts ("Sachverständigenrat") ($F(z_t) > 0.60,\ \gamma = 1.45,\ 40\%$ recessionary periods), the OECD ($F(z_t) > 0.55,\ \gamma = 1.5,\ 45\%$ recessionary periods) and the common definition of two consecutive quarters of negative GDP growth ($F(z_t) > 0.86,\ \gamma = 1.82,\ 14\%$ recessionary periods). Our baseline result lies between the definition of the German Council of Experts and the widespread definition of two consecutive quarters of negative GDP growth. Overall, the magnitude of the effects does not depend on the underlying definition of recession to a large extent. Since these different recession definitions lead to different switching parameters $\gamma$, which govern the speed of transition between regimes, they are robustness checks for different values of $\gamma$ at the same time. The corresponding employment responses for each of these definitions hardly differ compared to our baseline (see also Figure 23 in Appendix F).

| | Maximum | Impact | Cumulated 4 qrts. | Cumulated 12 qrts. |
|---|---|---|---|---|
| Baseline (ECRI) | 0.47 | 0.17 | 0.41 | 0.57 |
| Council of Experts | 0.46 | 0.20 | 0.40 | 0.72 |
| OECD | 0.47 | 0.17 | 0.37 | 0.70 |
| 2Q negative GDP growth | 0.57 | 0.19 | 0.47 | 0.90 |

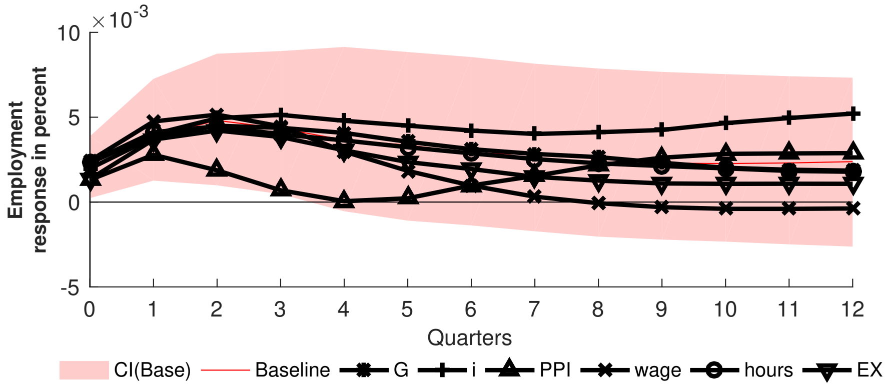
Table 6: Historical employment effects per short-time worker for different recession definitions. Source: Own calculations.

### 6.3 Level vs. differences

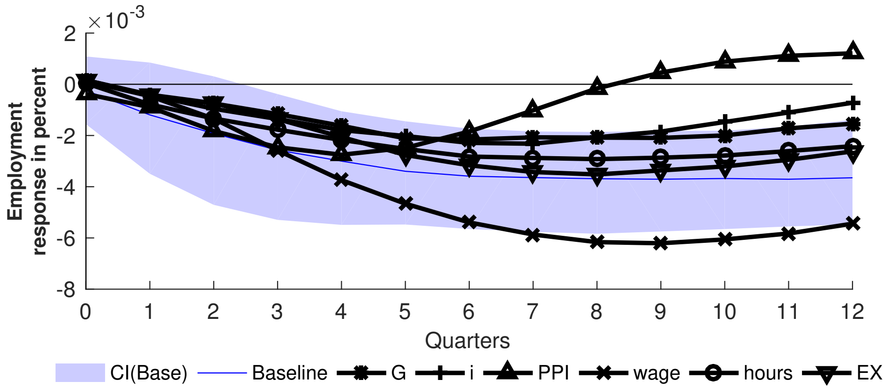
Thus far, we follow the literature and estimate our baseline VAR in levels (e.g., Blanchard and Perotti, 2002 or Auerbach and Gorodnichenko, 2012). Nonetheless, we check for robustness to estimate the STVAR model with GDP growth instead of levels (then, $X_t = [\Delta\ GDP_t\ STW_T\ EMPL_t]$). We further include a trend and a shift-dummy for the German reunification. Figure 24 in Appendix F depicts the employment response after a discretionary STW shock for the specification with GDP growth: The non-linearities across regimes persist, and the results are very similar to our baseline.

### 6.4 Additional controls and alternative VAR specifications

If our baseline 3-variate VAR is misspecified in the sense that it omits variables with relevant information for the shocks or the interactions among the variables, our results may




(a) Additional control: Recession




(b) Additional controls: Expansion

Figure 12: Robustness with additional control variables. Median employment responses to a STW policy shock normalized to one: Robustness checks. Solid red/blue line refers to the baseline response, the shaded areas denote the corresponding 68% confidence bands. Further responses are employment responses in a 4-variate VAR [Y STW EMPL X] with X being log of government spending (G), 3-month interest rates (i), producer price index (PPI), log of hourly wages (wage), log of total hours worked (hours) and German currency to USD exchange rate (EX). Estimation includes a trend and a shift-dummy for the German reunification. Source: Own calculations.

be spurious. For example, macroeconomic indicators such as interest rates or government spending may have additional explanatory power, and including them controls for the effects of monetary and fiscal policy shocks. We tackle this issue by expanding our baseline VAR specification towards additional endogenous control variables. We proceed in two steps: First, we augment our baseline 3-variate VAR one by one with a fourth endogenous variable and compare the resulting employment response to the one in our baseline VAR specification. Figure 12 illustrates the results across all the different VAR specifications. Both in recessions and in expansions, the resulting employment responses remain within the 68 percent confidence bands of the baseline VAR.

If we apply different specifications of our VAR, for example, not controlling for the German Hartz reforms, dropping the shift dummy for the German reunification, or explicitly including a dummy for recessionary periods, our results remain unaffected.[30]. Further, we assess a specification with unemployment instead of employment (see Figure 17 in Appendix F), which gives us consistent results in the sense that unemployment drops (significantly in

[30] Figure 22 in Appendix F shows the corresponding employment responses.

deep recessions), whereas in expansions, unemployment may even tend to rise after a discretionary STW policy shock. Our results in extreme events also hold for the specification with unemployment (see Figure 18 in Appendix F).

### 6.5 Sign and size of the shock

Since the GIRFs allow the shock responses to differ by sign and size of the shock (see for example Weise, 1999), we check whether a negative discretionary STW shock leads to different responses compared to an expansionary discretionary STW shock (see Figure 27 in Appendix F for the GIRFs). However, the results are very similar for positive and negative shocks. A positive STW shock has slightly larger employment effects in recessions than a negative shock does.

Nevertheless, the size of the shock matters. A twentyfold shock causes employment to rise by more than twenty times the response to a unit shock (see Figure 28 in Appendix F). Nonetheless, these differences are not statistically significant.

## 7 Concluding remarks

This paper analyzes the effects of STW over the business cycle using smooth transition VARs. We provide three insights. First, our findings suggest that the effects of discretionary STW policy vary significantly over the business cycle. Discretionary STW increases employment when implemented in recessions, whereas the effect in expansions is insignificant and may even turn negative in the long-run. Looking at extreme events and particularly at the Great Recession, the estimated effects are higher in magnitude and more persistent. Second, we calculate time-varying employment effects per short-time worker. We define this employment effect as the number of jobs saved per employees on STW due to discretionary policy. The effect varies considerably over time and is higher in recessions than in expansions. It peaked during the Great Recession, amounting to $0.8$ saved jobs per discretionary short-time worker. However, this effect may turn negative during expansions. In fact, if quarterly GDP growth exceeds $0.5$ percent, discretionary STW policy leads to a negative employment response.

We interpret these findings in the following way: Our result of a strong, positive effect of discretionary STW policy in recessions is consistent with the view that STW subsidies reduce labor costs and hence dissolve credit and liquidity constraints at the firm level. We support this argument using establishment-level data. Further, an explanation for the potential negative effect of STW in expansions could be the interpretation of Cooper et al. (2017), who find a misallocation of labor due to STW: If a shrinking firm uses STW, it contracts by less than it does without making use of STW, which reduces the pool of unemployed workers, decreases the vacancy-filling probability of growing firms and makes hiring more costly for expanding firms. We argue that the negative employment effect is the result of composition effects: In expansions, there are more growing firms than there are in recessions, which explains negative effects if shrinking firms use discretionary STW in expansions.

Last but not least, we use our results to shed light on the exceptional development of the German labor market in the Great Recession. Even though the GDP drop was larger than it was in many other industrialized countries, including the US, unemployment hardly increased. According to our estimates, the unemployment rate would have increased by approximately $0.2$ more percentage points if discretionary STW would not have been present.[31] As a result, if implemented in recessions, STW policy turns out to be an effective policy in terms of automatic stabilization (Balleer et al., 2016) and discretion.

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[31] Gehrke et al. (2017) provide a detailed analysis of the German labor market in the Great Recession and argue that a substantial share of the German labor market experience in the Great Recession was explained by factors other than STW, particularly beneficial labor market shocks connected to previous labor market reforms.

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# A Data appendix

Table 7 gives an overview of the data used and the corresponding sources. In case of a level shift in the series due to German Reunification in 1991, we clear for this break using a dummy for the growth rates of the respective series. Government spending is defined as government final consumption expenditure in constant prices. The short-term interest rate is a three-month money market rate. The exchange rate is defined as US dollar to the national currency spot exchange rate for Germany.

| Data series | Abbreviation | Source |
|---|---|---|
| Number of short-time workers (sa) | STW | Federal Employment Agency |
| Employment (sa) | N | German Quarterly National Accounts |
| GDP (sa) | GDP | German Quarterly National Accounts |
| Recessionary periods | REC | ECRI |
| Unemployment (sa) | unemp | Federal Employment Agency |
| Total hours worked (sa) | hours | German Quarterly National Accounts |
| Gross real wages | wage | German Quarterly National Accounts |
| Real government spending (sa) | G | OECD (Main Economic Indicators) |
| interest rate | i | OECD (Main Economic Indicators) |
| Producer price index (domestic) | PPI | German Federal Statistical Office |
| Industrial production (monthly, sa) | IP | German Federal Statistical Office |

Table 7: Data sources. “sa” denotes seasonally adjusted data.

# B Details on discretionary STW

| Regime | Change | Month/year | |
|---|---|---|---|
| REC | + | Jan-75 | Increase of STW allowance to 68% of net income. |
| REC | + | Jan-82 | Increased offset of lost hours with overtime hours. |
| EXP | - | Jan-83 | Decrease of STW allowance for beneficiaries without children to 63% of former net income. |
| EXP | + | Jul-87 | For companies in the steel industry, the maximum period of eligibility is extended to 36 months. |
| EXP | - | Jan-89 | Employers with STW beneficiaries stop receiving health insurance subsidies. |
| REC | - | Jan-93 | STW allowance will only be paid for more than 6 months the beneficiary is at the employment service's disposal. |
| | - | | If STW allowance is received for more than 6 months, subsidies for the employer's expenditures of the pension insurance scheme are dropped. |
| EXP | + | Dec-00 | The limited regulations regarding "structural STW" are extended to the end of 2006. |
| REC | - | Dec-00 | Renaming of "structural STW" to "transfer STW"; Limitation of the maximum duration of eligibility to 12 months. |
| EXP | + | Apr-06 | Introduction of "seasonal STW". |
| REC | + | Mar-09 | Until the end of 2010, instead of one-third of the workforce, only 10 percent of the workforce must be affected by a considerable income loss. Temporary workers can receive STW allowance until the end of 2010. The Federal Employment Agency partly covers the employer's part of social contributions. |
| REC | + | May-09 | The maximum period is extended from 18 to 24 months (until end of 2009). |
| REC | + | Jul-09 | From the 7th month on STW, the employer will be reimbursed by the Federal Employment Agency for social security contributions. |
| REC | + | Dec-09 | The maximum period of eligibility is extended to 18 months until the end of 2010. |
| EXP | + | Sep-10 | The simplified eligibility criteria introduced as part of the Economic Recovery Package II passed by the Government are extended until the end of March 2012 (so far until the end of 2010). STW can still be used for temporary workers . |
| REC | - | Nov-11 | The simplified eligibility criteria will end prematurely by the end of 2011. |
| REC | + | Dec-12 | The period of eligibility is extended from 6 to 12 months until the end of 2013. |
| REC | + | Oct-13 | The period of eligibility is further extended from 6 to 12 months. |
| REC | + | Nov-14 | The extended period of eligibility is maintained until the end of 2015. |

Table 8: Most important discretionary changes of STW. Source: Arbeitsförderungsgesetz (AFG) und Sozialgesetzbuch (SGB) III of Germany.

## C Estimation procedure

We follow Auerbach and Gorodnichenko (2012) and apply Maximum Likelihood estimation.[32] The log-likelihood for our model is

$$\log\ L = \text{const.} - \frac{1}{2}\sum_{t=1}^{T}\log|\Omega_t| - \frac{1}{2}\sum_{t=1}^{T}u_t'\Omega_t^{-1}u_t \tag{5}$$

where $u_t = X_t - (1-F(z_{t-1}))\Pi_E(L)X_{t-1} - F(z_{t-1})\Pi_R(L)X_{t-1}$ is the vector of residuals. Our model parameters are $\psi = \{\gamma, \Omega_R, \Omega_E, \Pi_E(L), \Pi_R(L)\}$. Due to the high non-linearity of the model, the application of standard optimization routines may not work. Therefore, we apply the following procedure proposed by Auerbach and Gorodnichenko (2012): Conditional on $\{\gamma, \Omega_R, \Omega_E\}$, the model is linear in $\{\Pi_R, \Pi_E\}$. Given a guess for $\{\gamma, \Omega_R, \Omega_E\}$, $\{\Pi_R, \Pi_E\}$ can be estimated using WLS with weights $\Omega_t^{-1}$. Parameter estimates $\{\Pi_R, \Pi_E\}$ have to minimize $\frac{1}{2}\sum_{t=1}^{T}u_t'\Omega_t u_t$.
The objective function is

$$\frac{1}{2}\sum_{t=1}^{T}(X_t - \Pi W_t')'\Omega_t^{-1}(X_t - \Pi W_t') \tag{6}$$

where $W_t = [(1-F(z_{t-1}))X_{t-1} \quad F(z_{t-1})X_{t-1} \quad ... \quad (1-F(z_{t-1}))X_{t-p} \quad F(z_{t-1})X_{t-p}]$ is the extended vector of regressors and $\Pi = \{\Pi_R, \Pi_E\}$, hence, $u_t = X_t - \Pi W_t'$.
Rewriting and taking the FOC w.r.t $\Pi$ gives

$$vec\ \Pi' = (\sum_{t=1}^{T}[\Omega_t^{-1} \otimes W_t'W_t)^{-1}vec(\sum_{t=1}^{T}W_t'X_t\Omega_t^{-1}) \tag{7}$$

This procedure iterates on $\{\gamma, \Omega_R, \Omega_E\}$ and results in $\Pi$ and the log likelihood until an optimum is reached. However, to ensure that we found a global optimum, we apply the MCMC method proposed by Chernozhukov and Hong (2003), which is a Metropolis-Hastings algorithm. The procedure consists of the following two steps:

1. Draw a candidate vector of parameters $\Theta^{(n)} = \Psi^{(n)} + \varphi^{(n)}$ for the $n+1$st chain value, where $\Psi^{(n)}$ is the current state and $\varphi^{(n)}$ are i.i.d shocks from $N(0, \Omega_\Psi)$.

2. Accept the candidate vector with probability $\min\{1, \exp[\log\ L(\Theta^n) - \log\ L(\Psi^n)]\}$, where
$\log\ L(\Theta^n)$ is the likelihood of the candidate vector and $\log\ L(\Psi^n)$ is the likelihood of the current state of the chain. Otherwise, keep the current state of the chain and set $\psi^{(n+1)} = \psi^{(n)}$

The starting value $\Theta^n$ is computed using a second-order Taylor approximation of our model 4 to 3, so that the model can be rewritten as regressing $X_t$ on lags of $X_t, X_t z_t$ and $X_t z_t^2$. We take the residuals of this estimation and estimate $\Omega_E$ and $\Omega_R$ using MLE. Given our estimates for $\Omega_E$ and $\Omega_R$ and our calibration for $\gamma$, we use the fact that the model is linear

[32] This section heavily draws on the “Appendix: Estimation Procedure” in Auerbach and Gorodnichenko (2012).

conditional on $\Omega_E$ and $\Omega_R$ and construct starting values for $\Pi = \{\Pi_R, \Pi_E\}$ using equation 7.

The initial shock is calibrated to one percent of the parameter values and then adjusted on the fly to generate the typical 30 percent acceptance rate (Canova, 2007). We generate N=100,000 MCMC draws and discard the first 70 percent as burn-in. We run CUSUM convergence tests, which indicate the convergence of our estimates.

Chernozhukov and Hong (2003) show that $\bar{\psi} = \frac{1}{N}\sum_{n=1}^{N}\Psi^{(n)}$ is a consistent estimate of $\Psi$ under standard regularity assumptions of MLE. In addition, they show that the covariance matrix of $\Psi$ is given by $V = \frac{1}{N}\sum_{n=1}^{N}(\Psi^{(n)} - \bar{\Psi})^2 = var(\Psi^{(n)})$.

## D Details on Generalized Impulse Response Functions (GIRFs)

The estimated smooth transition VAR is evaluated following the method proposed by Koop et al. (1996) for non-linear VARs. The algorithm we apply builds on modifications by Caggiano et al. (2015) and consists of the following steps:

1. Separate the dataset of all possible histories $\lambda_i$ into recessionary periods and expansionary periods using the switching variable $z$, where the threshold $\bar{z}$ is chosen in order to match the number of recessionary periods according to the ECRI definition. Define the set of recessionary histories $\Lambda^R$ with $\lambda_i \in \Lambda^R$ if $z_{\lambda_i} < \bar{z}$, and the set of expansionary histories $\Lambda^E$ with $\lambda_i \in \Lambda^E$ if $z_{\lambda_i} \geq \bar{z}$.

2. Randomly draw values of the MCMC chain after burn-in for the corresponding parameter estimates $\Pi = [\Pi_E \; \Pi_R]$ and for the identified matrices $A0_E^{-1}$ and $A0_R^{-1}$. Note that $A0_E^{-1}A0_E'^{-1} = \Omega_E$ and $A0_R^{-1}A0_R'^{-1} = \Omega_R$.

3. Calculate the model residuals $u_t$ using the randomly drawn parameter estimates: $u_t = X_t - (1 - F(z_{t-1}))\Pi_E(L)X_{t-1} - F(z_{t-1})\Pi_R(L)X_{t-1}$, where $F(z_t)$ is the recession probability.

4. Randomly draw a history $\lambda_i \in \Lambda^R$ corresponding to a recessionary period.

5. For a given impulse response horizon $h$, randomly sample $h + 1$ values of residuals.

6. Compute the inverse of the A0-Matrix at corresponding time $t$, $A0_t^{-1}$: $A0_t^{-1} = F(z)A0_R^{-1} + (1 - F(z))A0_E^{-1}$.

7. Transform the randomly drawn vector of residuals into structural shocks using $\Sigma_e = A_t\Sigma_u A_t'$.

8. Add the one standard deviation shock at $h = 1$ and transform the structural shocks back into residuals using $\Sigma_u = A_t^{-1}\Sigma_e A_t^{-1'}$.

9. Simulate a time path of $Y_{t0}$ over $h$ periods, using the history for the vector of original residuals and another path $Y_{t1}$ using it for the vector of residuals containing the one standard deviation shock. At every step in $h$, use the VAR to forecast two periods

ahead. The forecasted values are used to update the switching variable as a centered 5Q moving average of GDP growth. Take the difference between the paths: $GIRF_i = Y_{t1} - Y_{t0}$.

10. Repeat steps 5.-8. $B = 500$ times and calculate the median $\overline{GIRF}$ conditional on the specific history draw. $\overline{GIRF^i} = median(GIRF^i_{b=1:B})$.

11. Repeat steps 1.-10. $R = 1,000$ times and compute the median GIRF, which corresponds to the average GIRF under recessions, $\overline{GIRF^R} = median(GIRF^i_{r=1:R})$. In addition, compute the 68% confidence bands by picking the 84th and 16th percentiles.

12. For illustrative purposes, normalize the shock to one.

# E Details on the identification strategy

## E.1 Elasticity estimation

Balleer et al. (2016) use establishment survey data from the IAB establishment panel to estimate the automatic STW response to output changes. The yearly IAB data provide information on a number of establishment characteristics, including revenue, which serves as a proxy for aggregate output. We have information on the number of short-time workers in 2003, 2006, 2009, and 2010. A standard establishment-level fixed effects equation while controlling for observable establishment characteristics $z_{it}$ and year fixed effects identifies the automatic response of firms' with STW to output shocks.[33]

$$\frac{\text{STW}}{\text{EMP}}_{it} = \text{log exp. revenue}_{it}(\beta_1 + D_t^{rec}\beta_1^{rec}) + \alpha_i + \gamma_t + \mathbf{z}_{it}\beta_2 + u_{it}$$

Given that we are interested in potential non-linearities in STW usage, we check whether the automatic STW response to output shocks varies in recessions and expansions. For this purpose, we augment the baseline specification of Balleer et al. (2016) with an interaction of revenue and recession years (2003 and 2009) and estimate regime-specific elasticities.[34] Table 9 summarizes the estimated elasticities. The interaction term is significant and positive, which implies that the derived elasticity will be smaller (in absolute terms) in recessions: We estimate an elasticity of $-4.75$ in expansions and one of $-3.43$ in expansions. This finding fits the observation documented in Balleer et al. (2016) that firms also use the intensive margin of STW, i.e., the hours decrease more in expansions compared to recessions. Intuitively, in expansions, productive firms will use STW less on average. These firms then use STW more.

Further note that we estimate our VAR with the number of short-time workers rather than the the percentage of short-time workers in employment. However, we control for the contemporaneous change in employment in the fixed effects estimation. In the VAR, by

[33] Balleer et al. (2016) also account for the decision to apply STW in their elasticity estimates.

[34] In our VAR, we require an elasticity as the short-run restriction on STW. Hence, we rescale the point estimate of $\beta_1$ by the average number of short-time workers relative to total employment in the sample (.7%).

construction, the STW shock is orthogonal to the shock in employment and due to the Cholesky identification, the employment shock has no contemporaneous effects on STW. As a result, on impact, the percentage STW response is equal to the percentage response of the number of short-time workers in employment (given that the percentage employment response is zero). Hence, the above elasticity can be applied as a short-run restriction in our VAR.

| | log exp. revenue | exp.rev. $\times D^{rec}$ | elasticity | | observations |
|---|---|---|---|---|---|
| *Baseline (no interaction term)* | | | | | |
| $(1)$ | $-2.319^{***}$<br>$[0.286]$ | | $-3.31$ | | $31,824$ |
| $(2)$ | $-3.131^{***}$<br>$[0.342]$ | | $-4.47$ | | $31,824$ |
| *2003 and 2009 recession* | | | | | |
| $(3)$ | $-3.322^{***}$<br>$[0.342]$ | $0.925^{***}$<br>$[0.087]$ | $-4.753$<br>$[EXP]$ | $-3.429$<br>$[REC]$ | $31,824$ |

Table 9: Results from the microeconomic elasticity estimation on the IAB establishment panel. (1) and (2) are Tobit and OLS estimates from Balleer et al. (2016), respectively, while (3) is our estimate when adding the interaction in recession years. We control for the number of employees, the change of employment, and year fixed effects in the estimation. $^{***}$ denotes 1% significance, $^{**}$ denotes 5% significance, $^{*}$ denotes 10% significance.

## E.2 Identification of policy shocks

In the spirit of Blanchard and Perotti (2002), we can rewrite a reduced bivariate version of our VAR in output and STW in the following form:

$$\begin{aligned} Y_t =& a_1 e_t^{STW} + e_t^Y \\ STW_t =& b_1 e_t^Y + e_t^{STW} \end{aligned}$$

with the uncorrelated structural shocks $e_t^Y, e_t^{STW}$. The second equation states that within a quarter, unexpected movements of STW can be due to structural shocks to GDP ($b_1 e_t^Y$) or structural shocks to STW ($e_t^{STW}$). Therefore, unexpected STW movements can be caused by two effects: First, the automatic response of STW to output changes ($b_1 e_t^Y$), which we call the rule-based component, and second, changes due to discretionary STW policy. See also Caldara and Kamps (Forthcoming) for a detailed description of the identification of policy shocks in SVARs.

# F Additional figures

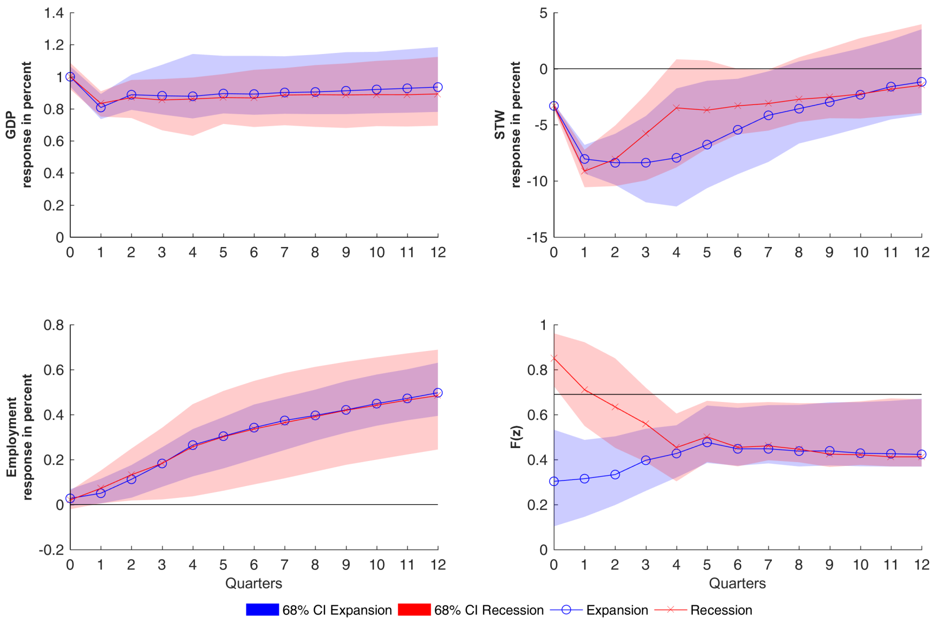
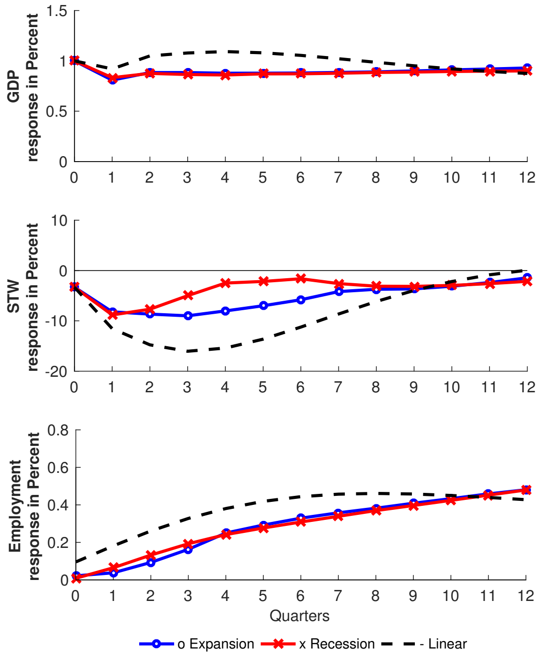
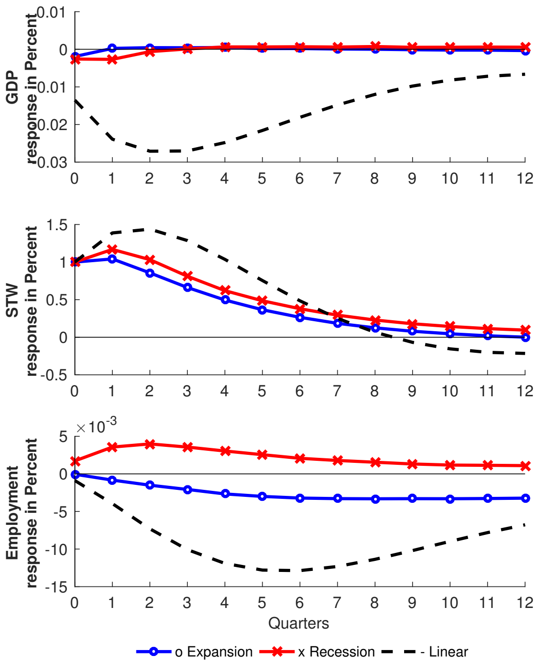



Figure 13: Output shock: Generalized Impulse Responses (median responses) of a one-standard-deviation output shock normalized to 1. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.




(a) Responses to output shock




(b) Responses to policy shock

Figure 14: Linear model: Generalized Impulse Responses including linear model responses. Median responses to an output and STW policy shock normalized to one.

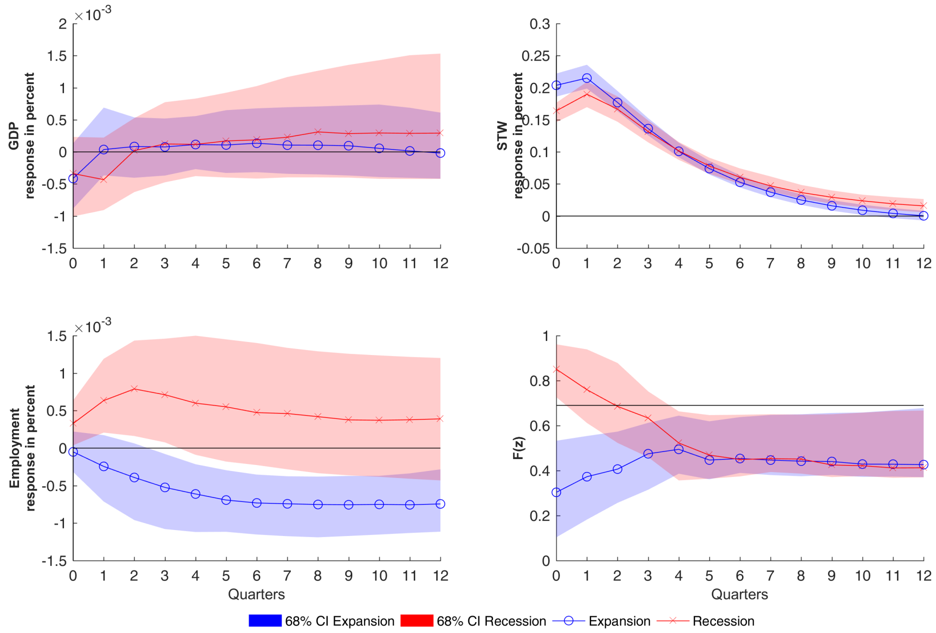



Figure 15: Not normalized: Generalized Impulse Responses of a one-standard-deviation shock (not normalized). Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

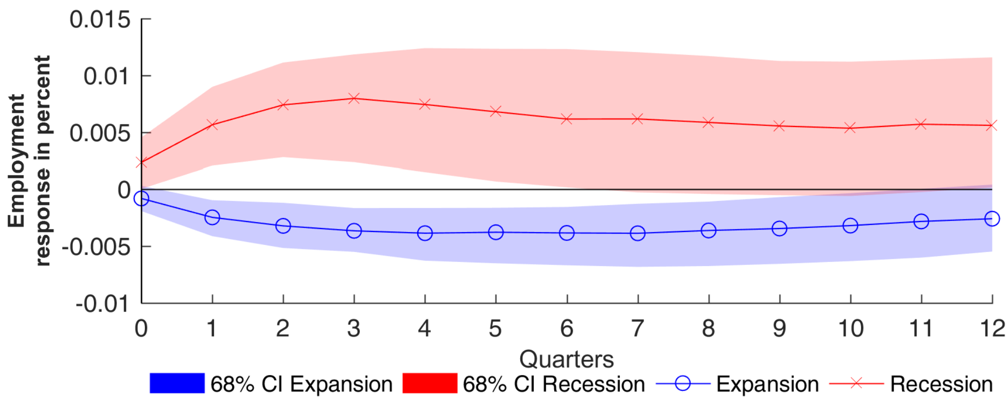



Figure 16: Regime-specific elasticities, extreme events ($\pm$ 1 std.): Generalized Impulse Responses of a one-standard-deviation shock with regime-specific micro-elasticities. Median responses to an output and STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

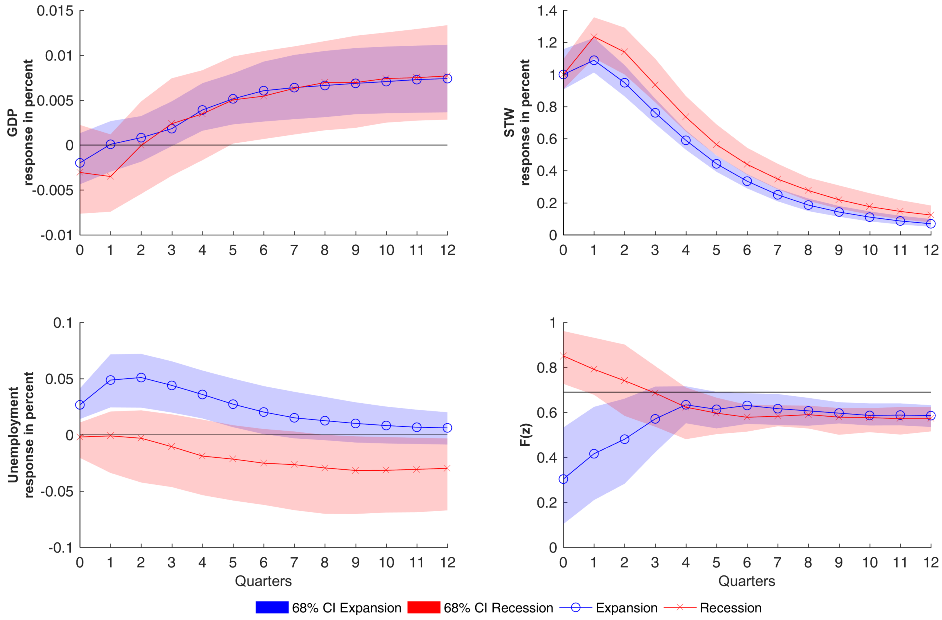



Figure 17: Unemployment: Generalized Impulse Responses for the specification with unemployment. Median responses to an output and STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

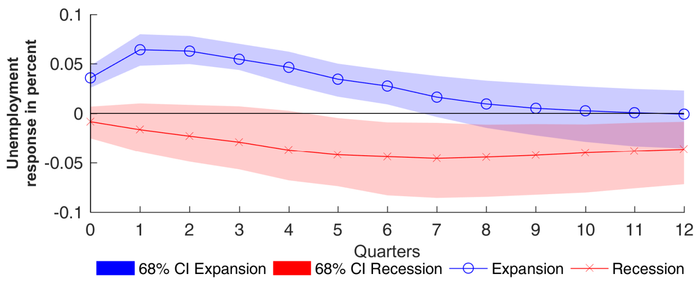



Figure 18: Unemployment responses to a policy shock in extreme events. Median responses to a STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. Source: Own calculations.

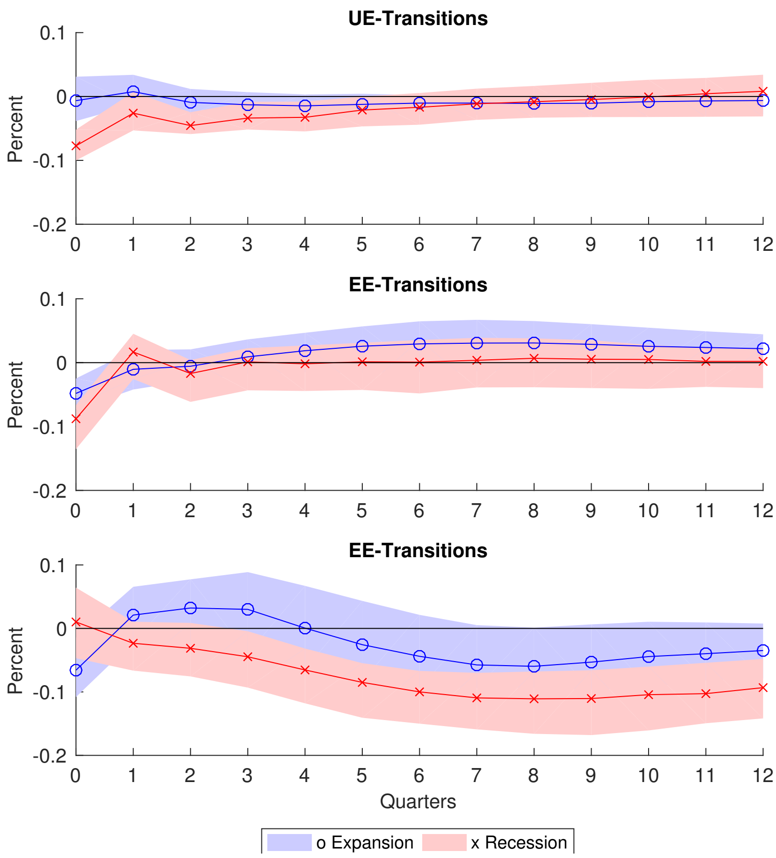



Figure 19: Responses of labor market flows to a STW policy shock. Median responses to a STW policy shock normalized to one. Shaded areas denote 68 percent confidence intervals. U-E transitions are flows from unemployment to employment (hirings), E-U Transitions denote flows from employment to unemployment (separations) and E-E transitions are job-to-job flows. Source: Own calculations.

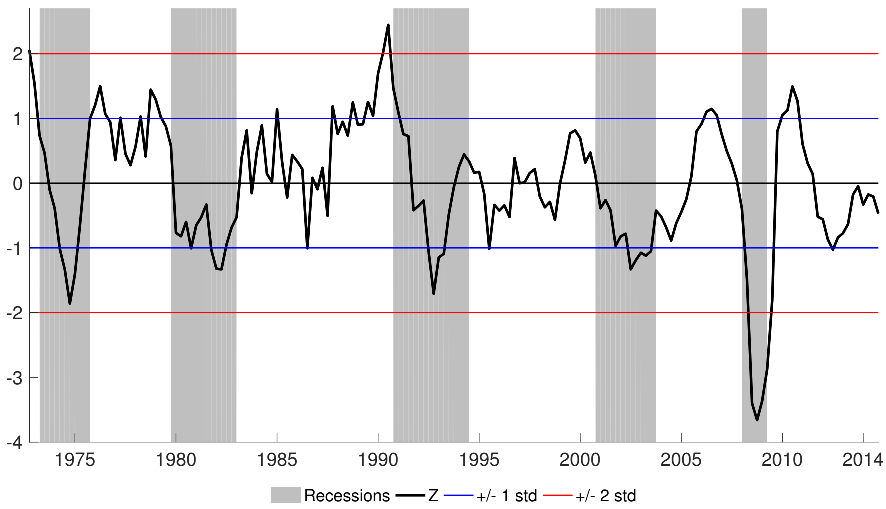
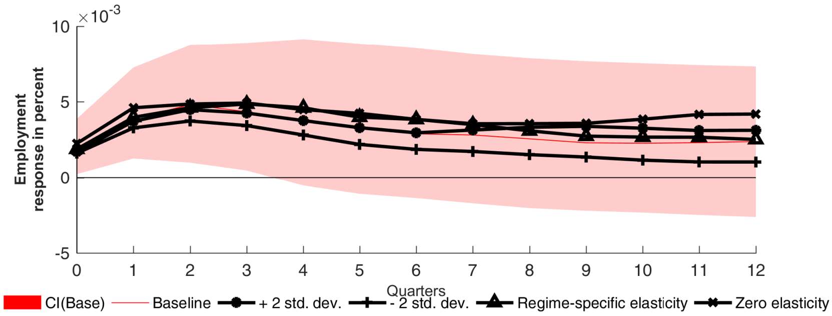
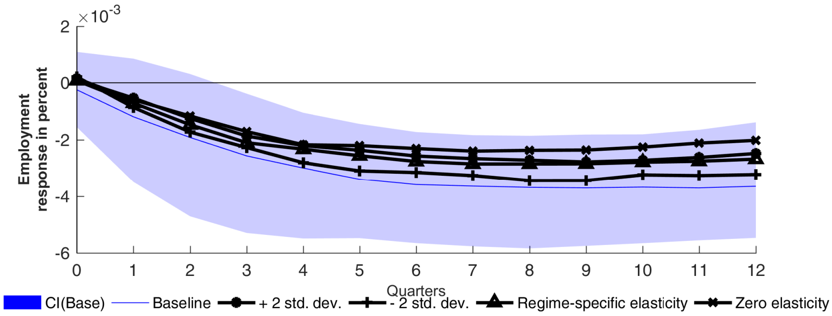



Figure 20: Definition of extreme events. Source: Own calculations.

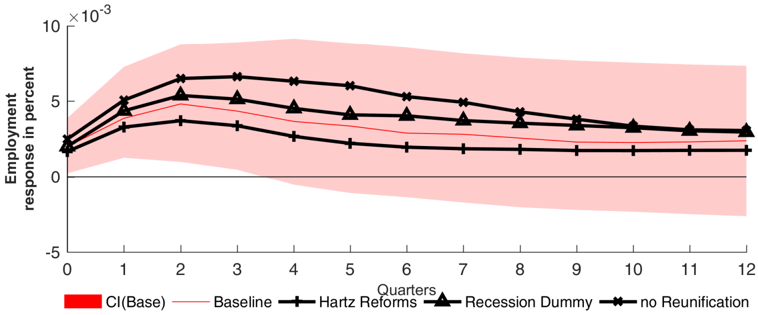



(a) Recession

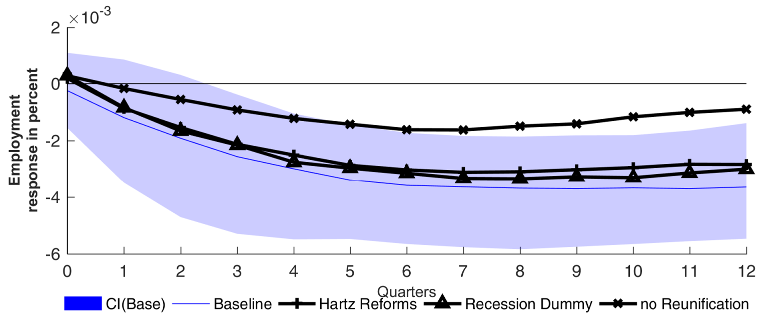



(b) Expansion

Figure 21: Robustness with different identifying elasticities. Median employment responses to a STW policy shock normalized to one: Robustness checks. Solid red/blue line refers to the baseline response, the shaded areas denote the corresponding 68% confidence bands. Further responses are employment responses to a elasticities $\pm$ 2 std. of the estimated micro-elasticity ($-4.13$ and $-2.5$ respectively), regime-specific elasticities (expansions: $-4.76$, recessions: $-3.44$) and zero elasticity. Source: Own calculations.

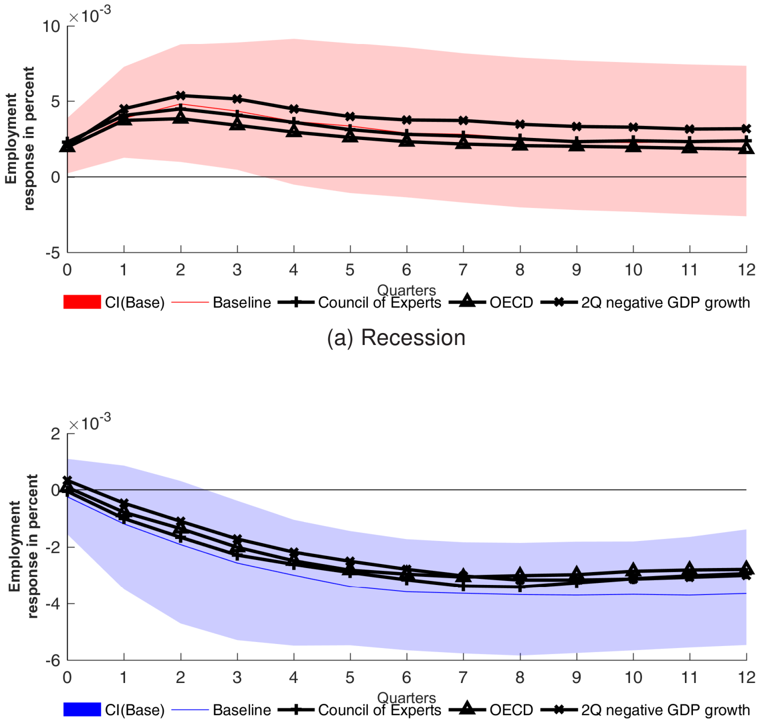



(a) Recession




(b) Expansion

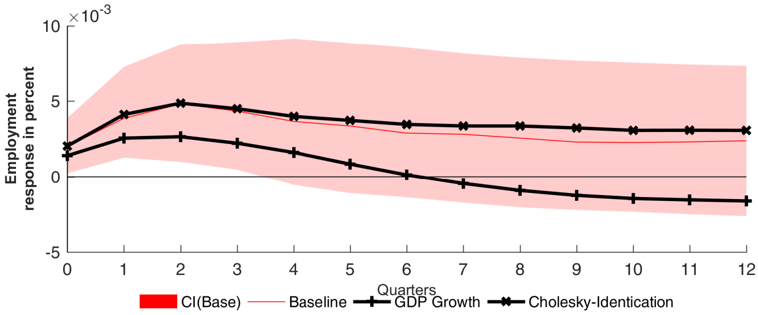
Figure 22: Robustness with additional dummies. Median employment responses to a STW policy shock normalized to one: Robustness checks. Solid red/blue line refers to the baseline response, the shaded areas denote the corresponding 68% confidence bands. Further responses are employment responses to a specification with a dummy for anticipation (time between passing a law and the law becoming effective), a shift dummy starting in 2005 for the German Hartz reforms, a specification without a reunification dummy and specification with a recession dummy. Source: Own calculations.



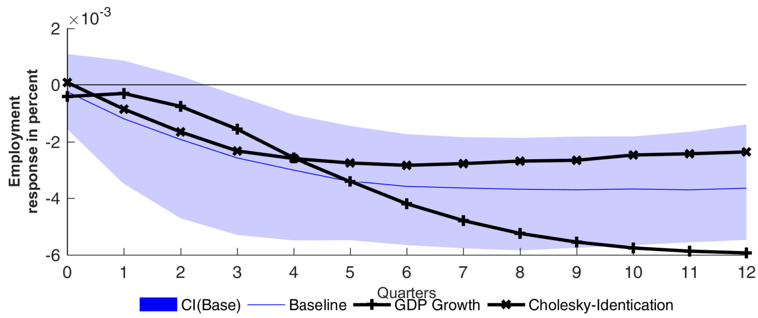

(a) Recession

(b) Expansion

Figure 23: Robustness with different recession definitions. Median employment responses to a STW policy shock normalized to one: Robustness checks. Solid red/blue line refers to the baseline response, the shaded areas denote the corresponding 68% confidence bands. Further responses are employment responses to a recession definition according to the German Council of Experts (“Sachverstaendigenrat”), the OECD and two quarters of negative GDP growth. Source: Own calculations.

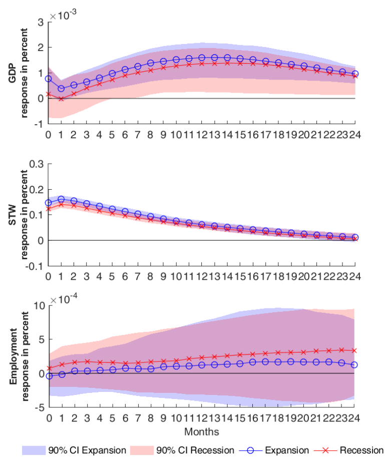



(a) Recession

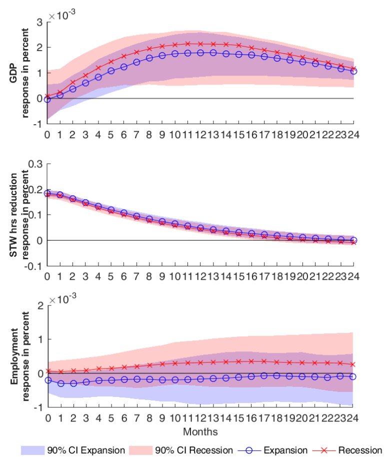



(b) Expansion

Figure 24: Robustness for a specification with GDP growth and Cholesky identification. Median employment responses to a STW policy shock normalized to one: Robustness checks. Solid red/blue line refers to the baseline response, the shaded areas denote the corresponding 68% confidence bands. Source: Own calculations.

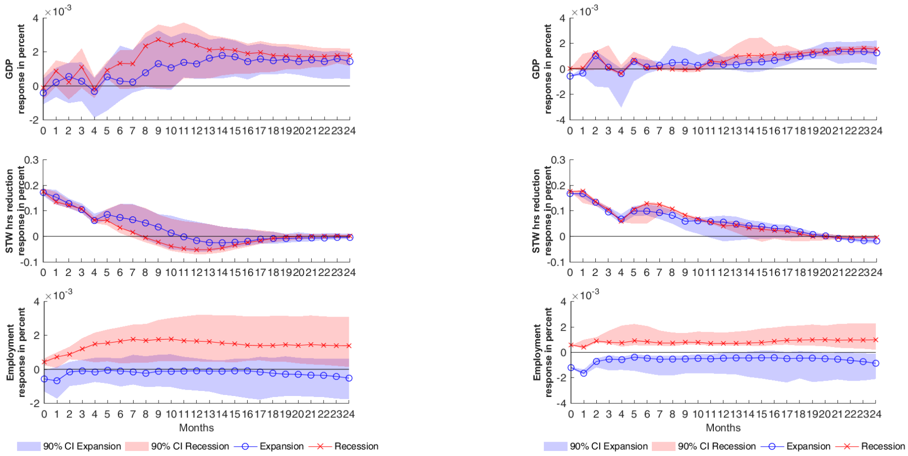



(a) short-time workers



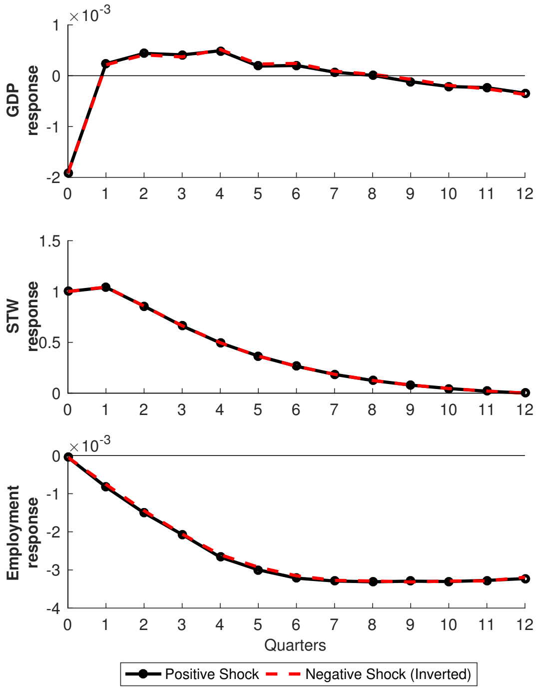

(b) STW hours reduction

Figure 25: Robustness: GIRFs for the post-reunification period. Median responses to a STW shock normalized to one. Shaded areas denote 68 percent confidence intervals. Notes: The share of recession periods for the monthly VAR starting in 1993 is 19%. Source: Own calculations.

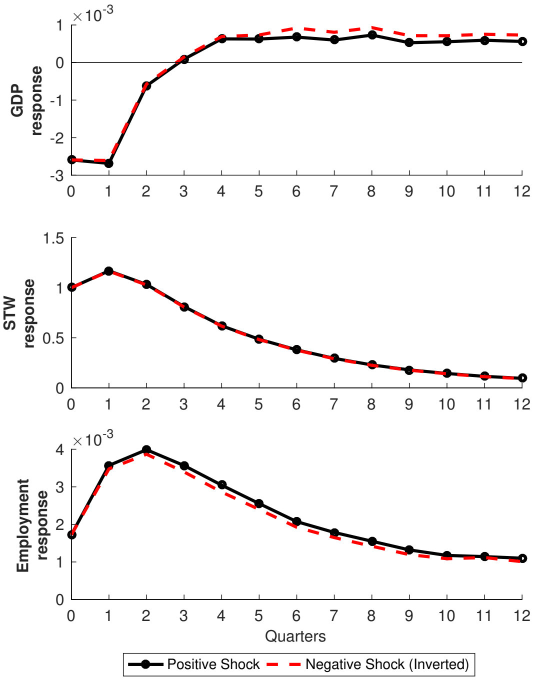


(a) STW hours reduction (b) STW hours reduction. Great Recession

Figure 26: Robustness: GIRFs for the post-reunification period. Median responses to a STW shock normalized to one. Shaded areas denote 68 percent confidence intervals. Notes: The share of recession periods for the monthly VAR starting in 1993 is 19%. The number of lags in the VAR is 6. Source: Own calculations.

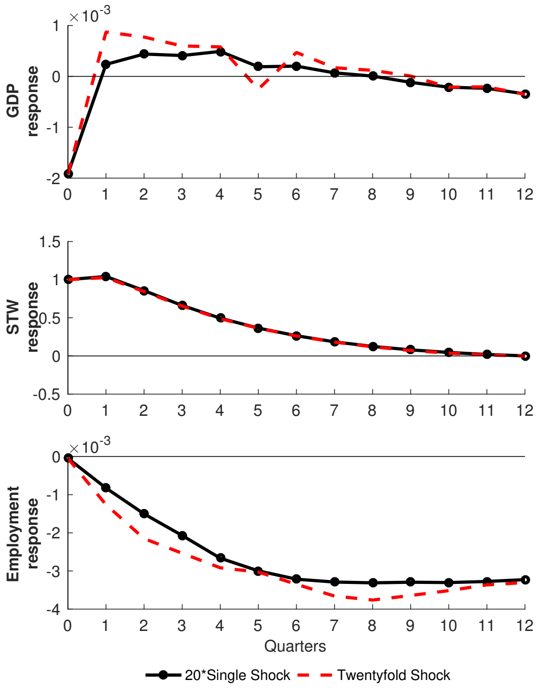



(a) Responses in expansions

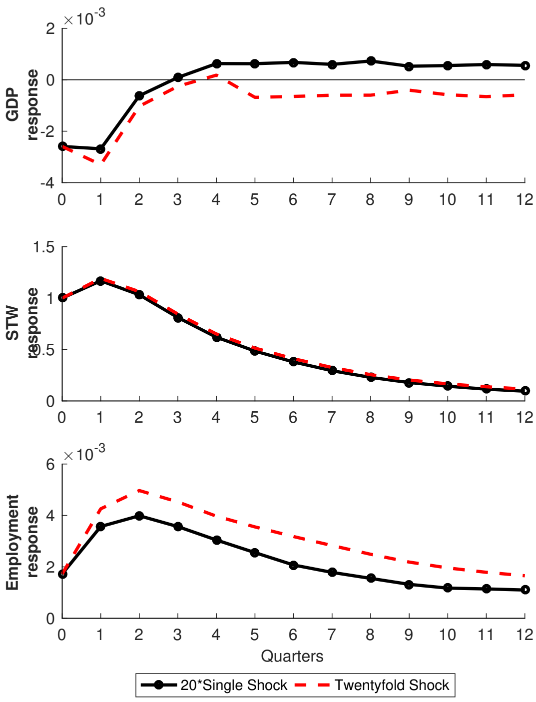



(b) Responses in recessions

Figure 27: Different shock signs. Median responses to a STW policy shock normalized to one. Source: Own calculations.




(a) Responses in expansions




(b) Responses in recessions

Figure 28: Different shock sizes. Median responses to a STW policy shock normalized to one. Source: Own calculations.

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