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Tom Bauermann

Governmental Policies to Reduce Unemployment during Recessions

Insights from an ABM

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Tom Bauermann[1]

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Abstract

The persistently low and (partly) negative output growth in Germany in 2019 evoked memories of the recent global economic crisis and, by this, sparked debates about measures to counter the growing number of unemployed, for example changing the generosity of unemployment benefits (UB) and short-time work. This paper aims to contribute to the theoretical literature of policy responses to recessions by analyzing three prominent instruments: a) a permanent (simultaneous) reduction of unemployment benefits and increasing search efforts, b) a fiscal stimulus and c) short-time work. In contrast to other studies that use, e.g., search (and matching) models, I build an agent-based macroeconomic model (ABM). Using an ABM allows me to analyze the macro- and microeconomic effects of such policies as well as their interplay. Further, I can analyze the effects from the heterogeneity of agents. I find four main results: 1) a) has nearly no effect on unemployment in the short run and its effects are limited in the long run. This is contrary to the canonical search and matching models, even though the policy reveals the same „desired" effects, e.g. shorter unemployment spells. Nevertheless, it confirms recent research on the topic. 2) However, contrary policies, i.e. increasing the unemployment benefits, do not improve the situation either. Unemployment rather increases in the long run. 3) In comparison to a), policies b) and c) can dampen unemployment in the short run. 4) In contrast to representative agent (equilibrium) models, I can show that short-time work supports the economic recovery through demand stabilization and distributive effects among heterogeneous firms. Especially, the distributive effects of short-time work have not been shown in other papers so far.

JEL-Code: E12, E24, C63, E32, H12

Keywords: Agent-based model; governmental policy responses; macroeconomics; recession; unemployment

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1 Introduction

Persistently low and (partly) negative GDP growth rates in Germany in 2019 evoked memories of the recent global financial crisis. The financial crisis and its repercussions provoked governments around the world to respond to the economic downturn. The policy responses mostly focused on avoiding (further) job losses. Prominent policy responses were fiscal policies in nearly all OECD countries, altering the generosity of unemployment benefits (hereafter: UB), as in Japan and the US, and the extension of the short-time work programs, as in Germany and France (Brenke et al., 2013). Due to their intensive use, governmental interventions that try to reduce unemployment have become a topic of debate in macroeconomics again (e.g., Dosi et al. (2017b) or Hagedorn et al. (2013)).

The extension of the unemployment benefits (hereafter: UB) in the US in particular sparked a large debate about its effects on unemployment. The effects are mainly analyzed within (canonical) search (and matching) models. Most of these studies find that unemployment increases due to the extension of the eligibility of UB (e.g. Mitman and Rabinovich (2014)). If the recession is modeled as a drop in productivity, an extension of the eligibility of UB raises wages. Hiring becomes less profitable for firms and the recovery remains jobless. Other studies stresses that increasing UB (partly) increase unemployment by inducing lower recipient application efforts (Marinescu, 2017). However, two questions remain unanswered by this strand of literature. First, besides the effects on the behavior of agents, it would of interest to take into account the effects of the benefits on aggregate demand. Gruber(1997,1998) stresses that, due to UB, agents can smooth consumption over the different states of employment. In the case of a sudden, large rise in unemployment, UB can dampen the negative feedback effects from unemployment on output.[1] Second, the models mainly use productivity shocks. To my knowledge, there is no recent search and matching model that focuses on the effects of labor market policies if the recession is primarily caused by bankruptcies of firms. In contrast to the search and matching models, pure macroeconomic models mainly find that increases in UB dampen unemployment (e.g., Davanzati and Pacella (2014) and Byrialsen and Raza (2018)). The positive effect is due to multiplier effects from (aggregate) demand. However, since these models are not micro-founded, they cannot evaluate positive and negative effects from the extension of UB. E.g., extensions of UB may increase reservation wages (Brown and Taylor, 2013) and, thus, unemployment spells (Card and Levine, 2000), which mitigate the positive effects of consumption on employment. Agent-based models (ABM) also take part in the debate on changing labor market policies (e.g. Dosi et al., 2017a,b). In Dosi et al., 2017a,b, the economy changed from a "Fordist" to a "Competitive" regime, a set of

[1] A more recent work that takes up this argument, is, e.g., Kekre (2016).

modifications on the labor market, like a reduction of UB to zero. The papers find that unemployment mainly increases due to the taken measures.

Short-time work is treated to much lesser extent in the theoretical literature for its effects on unemployment and output. Cooper et al. (2017) consider short-time work in a search model. The authors find dampening effects on unemployment growth but also the deteriorating effects on productivity growth and the reallocation efficiency of labor in the long run. However, due to their modeling approach, the paper does not analyze the effects of heterogeneity among firms, e.g. the effect of a reduction of output of some firms on the sales of firms in general as well as the effects on the consumption of households. The effect of fiscal policy on unemployment is more widely analyzed. In contrast to older works like Alesina and Perotti (1996), more recent works find that fiscal policy reduces unemployment rather quickly due to positive effects on demand and its feedback effects on output and employment (Rendahl, 2016; Gechert and Rannenberg, 2018).

This paper aims to contribute to the theoretical debate about the effects and mechanisms of a) reducing unemployment benefits and increasing search efforts, b) fiscal policy and c) short-time work on unemployment when the economy faces a recession. It reassesses the respective policies within an stock-flow consistent ABM (henceforth: (SFC)ABM). It contributes to the ABM and labor economics literature in five respects. First, due to micro-foundations and the micro-macro-link, ABM are able to account for macro- and microeconomic effects on unemployment. For example, reducing UB can, on the one hand, increase employment by reducing reservation wages. On the other hand, negative effects from consumption on labor demand can emerge. This model can analyze which effect is dominating in the short and the long run. Second, due to the interdependence of heterogeneous agents in an ABM, external effects from one group of agents to the other become visible. Relying on external effects, this paper reveals a new channel for the effectiveness of short-time work in reducing unemployment. Third, boom and bust cycles are endogenous to ABM and often the result of bankruptcies (e.g., Delli Gatti et al. (2011)). This work contributes to the literature by analyzing the effect of the policies a), b) and c) when the recession is caused by insolvencies and dismissals rather than exogeneous (productivity) shocks. Fourth, this paper differs from previous works in ABM (Dosi et al., 2017a,b) in three respects. The work focuses on a recessionary scenario, it uses small policy responses that are related to the empirical literature and I analyze the effects of short-time work. Lastly, the paper compares the effects and underlying mechanisms of a) and c) to a rather standard approach like fiscal policy(b)). The remaining parts of this paper are organized as follows: Section 2 describes the underlying model of this paper, Section 3 presents the stylized facts produced by the model and Section 4 analyzes the above-mentioned policies. Section 5 sums up the results of this work.

2 Model description

The model of this paper is a modification of the baseline model of Delli Gatti et al. (2011). It contains households, firms, a government, a central bank and an aggregated banking sector. Fig. 13 (Appendix) provides an overview over the entities and their relations. This model accounts for the relations between output production and money supply and, thereby, strictly follows SFC-principles to ensure accounting accuracy (Godley and Lavoie, 2012).[2] The model descriptions follows the timeline of events during a period (Section 6.2 (Appendix)).

2.1 Pricing, production and labor market

Firms, heterogeneous with respect to their size and wealth, produce homogeneous, perishable goods with labor as the only input factor and constant returns to scale (eq. (1)):

$$Y_{i,t} = L_{i,t} \tag{1}$$

$Y_{i,t}$ denotes output and $L_{i,t}$ units of labor of a firm i (with $i = 1, ..., I$) at time t. Since this paper does not focus on the productivity effects, technological progess is absent and real output does not grow in the long run. By rearranging eq. (1), using d to denote desired entities and $L^S_{i,t-1}$ as the endowed units of labor at the beginning of t, desired labor units are $L^d_{i,t} = Y^d_{i,t} - L^S_{i,t-1}$. Workers sign permanent contracts. Thus, $L^s_{i,t-1}$ are last period's labor units at firm i. Firms lay off workers if $Y^d_{i,t} < L^S_{i,t-1}$ or available funds (Section 2.2) is insufficient. Firms post vacancies if $Y^d_{i,t} > L^S_{i,t-1}$. Firms decide on desired output ($Y^d_{i,t}$) and prices ($p_{i,t}$) by following a boundedly rational adjustment process. It considers previous period's unsold goods $S_{i,t-1}$ and average prices[3] $\bar{p}_{t-1}$. Eq.(2) describes the pricing mechanism:

$$p_{i,t} = \begin{cases} \max\left(p^l_{i,t}, p_{i,t-1}(1+\eta_{i,t})\right) \text{ if } S_{i,t-1} = 0 \text{ and } p_{i,t-1} < \bar{p}_{t-1} \\ \max\left(p^l_{i,t}, p_{i,t-1}(1-\eta_{i,t})\right) \text{ if } S_{i,t-1} > 0 \text{ and } p_{i,t-1} \geq \bar{p}_{t-1} \end{cases} \tag{2}$$

If a firm sold all goods produced ($S_{i,t-1} = 0$) but its price was below the average, it tries to catch up with the competing firms by raising its price by a random mark-up ($\eta_{i,t}$ in eq. (2)). If a firm could not sell all of its goods and the price was above or equal to the average, it tries to gain competitiveness by reducing the price by a random mark-down ($\eta_{i,t}$). Thus, firms follow a mark-up pricing rule (Dosi et al., 2006; Delli Gatti et al., 2011). To avoid losses, firms charge at least a price $p^l_{i,t}$ that covers the average cost of production, determined by

[2]The model is implemented in the Java-based software Repast Simphony 2.6. The Java-code can be provided on request.

[3]The average price is calculated by the government as the weighted average with respect to production.

interest payments on debts, $r_{i,t}$, and wages, $w_{i,t}$ (eq. (3))(Delli Gatti et al., 2011).

$$p^l_{i,t} = \frac{w_{i,t}L_{i,t} + (1 + r_{i,t})B_{i,t}}{Y^d_{i,t}} \tag{3}$$

Adjustments in desired output are derived from expected demand, $D^e_{i,t}$ ($Y^d_{i,t} = D^e_{i,t}$). Due to uncertainty and constraint ressources, firms apply simple rules to form expectations. This work follows Dosi et al. (2006), who found that myopic expectations show the best results with respect to capturing the stylized facts of observable data. $D^e_{i,t}$ is determined by

$$D^e_{i,t} = \begin{cases} Y_{i,t-1}(1 + \chi_{i,t}) \text{ if } S_{i,t-1} = 0 \text{ and } p_{i,t-1} \geq \bar{p}_{t-1} \\ Y_{i,t-1}(1 - \chi_{i,t}) \text{ if } S_{i,t-1} > 0 \text{ and } p_{i,t-1} < \bar{p}_{t-1} \end{cases} \tag{4}$$

If a firm sold all of its previous period's produced output and its price was already above or equal to the average price, the firm forms positive expectations on demand in the upcoming period (first part of eq. (4)). In this situation, firms fear losing competitiveness from price increases, and instead prefer to increase desired output through a random mark-up ($\chi_{i,t}$) and, as a consequence, post job openings. If the firm was unable to sell all of its goods but the price was already below the average price, firms hardly expect positive results from further price reductions. Instead, firms reduce desired output by a random mark-down and, consequently, lay off workers. Eq. (4), (3) and (2) build a matrix for output and price decisions, which is illustrated in Fig. 14 (Appendix). The process described is taken from Delli Gatti et al. (2011). Firms change prices and quantities, but not both at the same time. This points into the direction of the empirical findings of Bhaskar et al. (1993).

After firms posted vacancies, households apply for the open positions. In line with most ABM (e.g. Riccetti et al. (2015)) and search and matching models (e.g. Mitman and Rabinovich (2014)), only unemployed send their applications. A household consists of one agent, who either works or is unemployed. They are homogeneous with respect to their productivity and offer, inelastically, one unit of labor while firms use one unit of labor for production per worker. Households are denoted by h (with $h = 1, ..., H$). The search and matching process on the labor market is endogenous, following Neugart (2004). The households are boundedly rational agents with limited information. Among all N posted vacancies, the unemployed send their applications to M firms, at maximum, which cover at least their reservation wage ($w^r_{h,t}$). If the unemployed do not find a job during the respective period, they reduce their reservation wage ($w^r_{h,t}$) by a random mark-down (ζ) (eq. (5)).

$$w^r_{h,t} = \max\left(w^r_{h,t-1}(1 - \zeta_{h,t}), \underline{w}^r_h\right) \tag{5}$$

Reservation wages have a lower bound $\underline{w}^r_{h,t}$, determined by a household-specific mark-up (ν_h) on unemployment benefits (UB):

$$\underline{w}^r_{h,t} = UB_t(1 + \nu_h) \tag{6}$$

The reservation wage mechanism, described in eq. (6), combines two observations. First, reservation wages and UB are positively correlated (Gorter and Gorter, 1993), which is a common modeling approach in both, search-and-matching models (e.g. Pissarides (2000)) and agent-based models (e.g. Riccetti et al. (2015)). Second, based on Krueger and Mueller (2016), reservation wages fall only modestly and, hence, remain high across the duration of unemployment. This work captures this fact by using a lower bound above the UB.
Firms gather applications from the unemployed, order them randomly and offer working contracts to each applicant one by one. When a potential worker is signed already, firms make their offer to the next one in the queue. The process stops when the amount of desired workers is satisfied or when the queue is empty. If the firm was not able to fill all open vacancies, it increases the wage offered in the upcoming period by a random mark-up, $\delta_{i,t}$,(eq. (7)).

$$w_{i,t} = w_{i,t-1}(1 + \delta_{i,t}) \tag{7}$$

Firms are aware of potential rationing in their production when wage offers are too moderate to attract workers. Firms try to avoid such a non-realized production by setting $\delta_{i,t}$ such that wages do not fall but slightly increase or stay constant (in eq. (7): $\delta_{i,t} \geq 0$). Workers are paid equally within a firm. The implied downward rigidity in eq. (7) is consistent with the insights from Bewley (1999) and Campbell and Kamlani (1997) on wage-setting which found that firms are reluctant to cut nominal wages to avoid demotivation and that downward rigidity is also observable for newly hired workers.
In contrast to Delli Gatti et al. (2011), this model does not contain a minimum wage. Besides the mentioned increase in wages, firms adjust the wage by the annual rate of inflation or less depending on the price setting of the firm ($\psi_{h,t}$, eq. (8)).

$$w_{i,t} = w_{i,t-4}(1 + \psi_{i,t}) \tag{8}$$

The firm determines prices before it adjusts wages. If the selling price exceeds the previous period's wages plus the rate of inflation, a firm raises its wage by the rate of inflation. Otherwise, a firm raises the wage to the selling price. The periods of the model are considered as quarters, which implies that wages are updated every fourth period.

2.2 Credit market

The main mechanisms of the credit market are taken from Delli Gatti et al. (2011). Since the interaction between credit markets and goods production is of minor interest, the banking sector exists in a reduced form to replicate only the basic interactions between banks and firms. In contrast to Delli Gatti et al. (2011), this model contains one commercial bank, comparable to an aggregated banking sector, that decides on the allocation of loans.
Every firm in the beginning of time t has retained earnings ($A_{i,t-1}$). Firms pay their workers before the goods market interactions take place and prefer using internal funds, i.e. their retained earnings, to pay the wages. If the desired wage bill is larger than the internal funds (eq. (10)), firm i sends its credit demand ($B^d_{i,t}$) to the banking sector. The banking sector arranges the credit applications in an ascending order with respect to the borrowers leverage ratio (eq. (11)) and serves the demand up to the upper bound (K_t), which is a multiple of its equity base (eq. (12)). v in eq. (12) can be interpreted as a capital requirement coefficient with its reciprocal representing the maximum allowable leverage of the bank.[4]

$$B^d_{i,t} = \max\left(w_{i,t}L_{i,t} - A_{i,t-1}, 0\right) \tag{10}$$

$$l_{i,t} = \frac{B^d_{i,t}}{A_{i,t-1}} \tag{11}$$

$$K_t = \frac{E_t}{v} \tag{12}$$

For simplicity, it is assumed that v is determined by the regulatory authority. If credit demand exceeds credit supply, firms face credit rationing such that the desired loan exceeds the assigned one ($B^d_{i,t} > B_{i,t}$). In this case, the respective firm lays off workers until internal funds are sufficient to pay the wage bill. Implicitly, the model assumes external and internal funds are imperfect substitutes. Due to the cost advantages of internal funds, business entities prefer to use internal funds, like equity, to finance production expenditures over external funds. The described pecking order of financing production costs is based on the empirical findings of Fazzari et al. (1988).
Eq. (13) presents the computation of the interest rate that has to be paid by the respective firm i. Firm i's interest rate contains a base rate ($\hat{r}$) and a mark-up that increases linearly

[4]It is assumed that the bank only accepts the firm's loan application if it does not exceed the fixed, maximum debt ratio. The debt ratio is calibrated following Kalemli-Özcan et al. (2012) and Remmers et al. (1974). The latter assumption is based on the theory of credit rationing (Wolfson, 1996)).

$$\frac{B^d_{i,t}}{A_{i,t-1}} \leq \iota \tag{9}$$

with i's financial fragility. The increasing mark-up is due to, implicitly, higher auditing costs for banks in case of a higher financial fragility of firms (Delli Gatti et al., 2011).

$$r_{i,t} = \hat{r}(1 + \theta l_{i,t}) \tag{13}$$

For simplicity, it is assumed that firms repay the debt at the end of the period. If the firm is able to fullfill the payments, it repays its debt plus interest rate (eq. (14)). Otherwise, the bank receives only the residual, $R_{i,t}$, (eq. (15)).

$$B_{i,t}(1 + r_{i,t}) \text{ if } A_{i,t} - B_{i,t}(1 + r_{i,t}) \geq 0 \tag{14}$$

$$R_{i,t} \text{ if } A_{i,t} - B_{i,t}(1 + r_{i,t}) < 0 \tag{15}$$

Besides the banking sector, the model contains a passively acting central bank. It provides the government with money if it needs to borrow and supplies this credit without charging an interest rate. Further, it holds the deposits of the banking sector, also for an interest rate equal to zero. The money supply in this model is completely endogenous and follows the accounting logic of Godley and Lavoie (2012).

2.3 Goods market and consumption

After the credit and the labor market close, the number of workers and unemployed is determined for the period. Firms start output production (eq. (1)) and pay workers. While workers receive a firm-specific wage, unemployed receive UB. UB is paid by the government, which provides UB in relation to the length of the unemployment spell of the household and the average wage ($UB_t^{short} = \kappa_{short}\bar{w}_t$ and $UB_t^{long} = \kappa_{long}\bar{w}_t$). κ_{short} is the net replacement rate of short-term unemployment, i.e. unemployed for up to four periods, and κ_{long} is the net replacement rate of long-term unemployment, i.e. unemployed for more than four periods.[5] UB is updated every fourth period to keep up with average wage developments. The unemployment benefit scheme is similar to most OECD states and follows the recommendations of economists and research institutions in the recent decades, i.a. (OECD, 1994; Bassanini and Duval, 2006; Siebert, 1997). It captures the idea of reducing the drop in consumption for short-term unemployed while setting unemployment benefits that put pressure on long-term unemployed but maintain a minimal level of consumption (OECD, 1994). The unemployment benefit scheme in this work differs from Delli Gatti et al. (2011).

After they received their income, households compute their desired consumption and (precautionary) savings by applying a buffer-stock savings concept, as in Seppecher and Salle

[5]The numbers for the generosity of UB were set to reflect the net replacement rate of van Vliet and Caminada (2012) and the duration of benefits in Germany.

(2015). Following Seppecher and Salle (2015), eq. (16) and eq. (17) depict the desired consumption and desired saving behaviour in this model. As in Riccetti et al. (2015), households' minimum consumption level is UB_t, which ensures consumption on a subsistence level.

$$C^d_{h,t} = \begin{cases} UB_t + c_{h,t}(I_{h,t}(1-\tau) - UB_t) \text{ if } W_{h,t} \leq W^t_{h,t} \\ I_{h,t}(1-\tau) + \lambda(W_{h,t} - W^t_{h,t}) \text{ if } W_{h,t} > W^t_{h,t} \end{cases} \tag{16}$$

$$S^d_{h,t} = \begin{cases} (1 - c_{h,t}(1-\tau))I_{h,t} - (1+c_{h,t})UB_t \text{ if } W_{h,t} \leq W^t_{h,t} \\ 0 \text{ if } W_{h,t} > W^t_{h,t} \end{cases} \tag{17}$$

$c_{h,t}$ denotes the marginal propensity to consume from income over minimum consumption (UB_t), λ the marginal propensity to consume from excess wealth, $I_{h,t}$ the pre-tax labor income, τ the (uniform) taxrate, $C^d_{h,t}$ current desired consumption, $S^d_{h,t}$ current desired saving, $W_{h,t-1}$ current (inherited) wealth and $W^t_{h,t}$ the wealth-target of household h in period t. UB_t denotes unemployment benefits. $UB_t = UB^{short}_t$ and, therefore minimum consumption, for workers and short-term unemployed. $UB_t = UB^{long}_t$ for long-term unemployed. It should be noted that only employed households are taxed. Thus, $\tau = 0$ for unemployed. Following eq. (17) and (16), consumers save parts of their income until the target wealth level ($W^t_{h,t} = \xi * I_{h,t}$) is attained, with ξ denoting the factor (buffer-stock ratio) of the period's income. If current wealth exceeds the target wealth level, consumers slowly reduce the excess wealth, i.e. the difference between current and target wealth level, by consuming their income and a share of λ of the excess wealth. In this model, consumers' $W^t_{h,t}$ equals two periods of the individual income, as found in Carroll et al. (1992). Following the specification of Delli Gatti et al. (2011), the marginal propensity to consume is:

$$c_{h,t} = \frac{1}{1 + (tanh(\frac{S_{h,t}}{S^t_{h,t}}))^\beta} \tag{18}$$

Eq. (18) pays attention to the empirical works of Pressman (1998) and Carroll and Kimball (1996), who find that marginal propensity to consume declines with increasing personal wealth. Eq. (18) further shows that households smooth consumption across different states of employment. In other words, consumers smooth consumption by reducing the buffer stock if income is falling, which can be interpreted in the light of the aversion against the loss in status (van Treeck, 2013). When goods production took place, firms offer these products on the goods market. Due to bounded rationality, consumers send their orders to a limited number of firms, denoted by O, which are sorted according to their sales prices. Firms serve

the demand in a random order and stop whenever they run out of products or no consumer is left in the queue (Delli Gatti et al. (2011)). The autonomous matching of firms and households on goods markets can and, by default, does lead to coordination failures. Thus, unsold goods and involuntary saving coexist. It further implies that an equilibrium price in the classical sense cannot be found. Similar coincidences appear on the labor market. In other words, ABM usually contain the situation in which demand and supply do not equalize. Hence, due to bounded rationality and asymmetric information, firms may become insolvent or gain market power.

2.4 Wealth, entry and exit

At the end of the period, after the goods market closes, firms compute their wealth, denoted by A_t (eq. (19)) and repay their debts. If revenues ($p_{i,t}Y_{i,t}$) exceed costs, the wage bill ($w_{i,t}L_{i,t}$) and, in case a loan was drawn, interest rate costs ($r_{i,t}B_{i,t}$), firms repay their debts and their net worth grows ($A_{i,t} > A_{i,t-1}$) as expressed in eq. (20). If costs exceed revenues, but retained earnings from previous periods ($A_{i,t-1}$) are sufficient to cover these losses, firms repay debt but wealth decreases (eq. (21)). If firms' inherited wealth is insufficient to cover the losses or firms lose all of their wealth, the respective firm becomes insolvent and leaves the market (eq. (22)).

$$A_{i,t} = p_{i,t}Y_{i,t} - w_{i,t}L_{i,t} - r_{i,t}B_{i,t} + A_{i,t-1} \quad \text{with} \quad \Delta A_{i,t} = A_{i,t} - A_{i,t-1} \tag{19}$$

$$\Delta A_{i,t} \geq 0 \ \textbf{if} \ \ p_{i,t}Y_{i,t} - w_{i,t}L_{i,t} - r_{i,t}B_{i,t} \geq 0 \tag{20}$$

$$\Delta A_{i,t} < 0 \quad \text{with} \quad A_{i,t} > 0 \quad \textbf{if} \quad p_{i,t}Y_{i,t} - w_{i,t}L_{i,t} - r_{i,t}B_{i,t} + A_{i,t-1} > 0 \tag{21}$$

$$\Delta A_{i,t} < 0 \quad \text{with} \quad A_{i,t} \leq 0 \quad \textbf{if} \quad p_{i,t}Y_{i,t} - w_{i,t}L_{i,t} - r_{i,t}B_{i,t} + A_{i,t-1} \leq 0 \tag{22}$$

Every market exit is replaced by an entry such that the number of firms stays constant. In contrast to Delli Gatti et al. (2011), the government provides start-up subsidies, newcomers apply a low price strategy and a search process of the new firms replaces the automatic matching on the labor market. Entrants try to gain market share by offering a price ($p_{i,t}^{New}$) below the lowest price (p^{Low}) that is visible for the entering firm (eq. (23)), by random mark-down $\gamma_{i,t}$. Due to imperfect information, entrants do not see the lowest price but only one of the lowest α-percent of all prices. Besides the low price strategy, new firms avoid losses by offering (low) wages ($w_{i,t}^{New}$) that equal their entry prices (eq. (24)).

$$p_{i,t}^{New} = p^{Low}(1 - \gamma_{i,t}) \tag{23}$$

$$w_{i,t}^{New} = p_{i,t}^{New} \tag{24}$$

The setting with respect to entries and exits, which was made up for this paper, follows empirical investigations and theoretical considerations. First, entries and exits are highly correlated in most of the Western economies (Geroski (1995) and Shane (2009)). The assumption is a common practice in macroeconomic ABM to avoid monopolization (e.g. Delli Gatti et al., 2011; Dosi et al., 2017a,b). Further, the assumption serves as a stability condition such that the model does not ex- or implode. Such stabilization mechanisms are well known in various in macroeconomic modeling classes, e.g. autonomous demand in Keynesian models.[6] Based on Nyström and Elvung (2014), new firms that enter the market without entry barriers do usually not compete on technology. Instead, these newcomers rather enter via low prices and offer low wage contracts.

The government covers the debt from the bankruptcy of firms and banks, and pays out a start-up-subsidy to firms (μ_F) and the banking sector (μ_B), which is updated by the rate of inflation. For this purpose, the government receives loans from the central bank. On the one hand, that governments cover the debts from bankruptcies is a common mechanism among macroeconomic agent-based modelers, like Riccetti et al. (2015), Dosi et al. (2017a) or Delli Gatti et al. (2011). On the other hand, since this paper does not target questions of governmental indebtedness and industrial dynamics, it is a simple way to provide stock-flow consistency. Further, the indebtedness of the government follows the basic logic of national accounting that the deficit of one entity, the government, is the surplus of the other entities, households' and firms' net worth (OECD (2018)).

3 Baseline simulation and validation

The aim of this paper is to analyze a) a simultaneous reduction in the unemployment benefits and an increase in search efforts, b) additional governmental transfers and c) short-time work. The analyses and evaluations focus on the effects of the respective policy on the labor market performance. These policies will be analyzed in comparison to the counterfactual developments on the labor market. That means, the policies will be analyzed in comparison to the scenario in which any policy response is absent, which marks the baseline scenario.

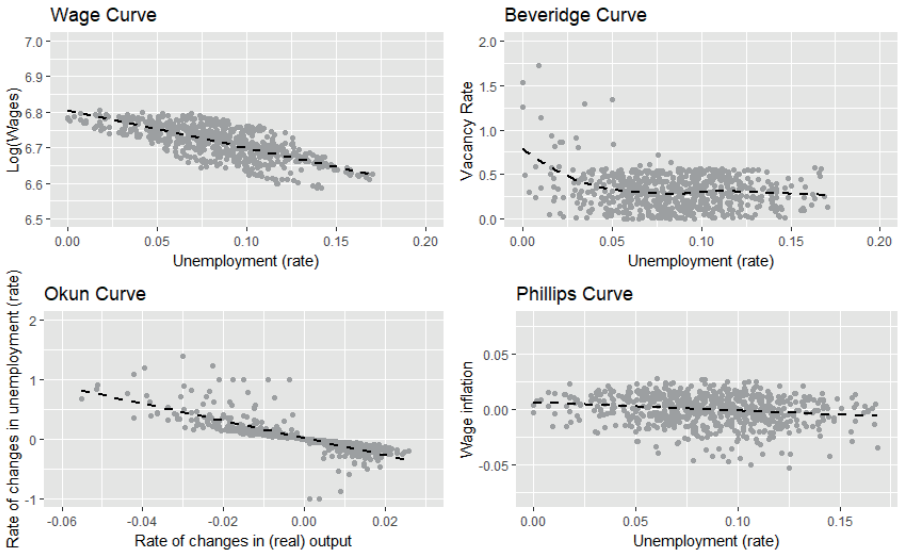
3.1 Baseline scenario and emergent features

The purpose of this model is to describe the mechanism underlying the labor market policies and thus to provide a contribution to the theoretical debate on governmental interventions to reduce unemployment. Therefore, the model is only roughly calibrated to match the numbers of the German economy from the second half 1960 to the early 1990s, using indirect

[6] For a (partly critical) overview, see: Skott (2017)

calibration, as suggested by Fagiolo et al. (2007). The tables and figures in this chapter show the descriptive statistics of the baseline scenario, averaged over 800 runs[7] and neglecting the burn-in phase of the model.[8] The parameter values are shown in Tab. 4 in the Appendix. Fig. 1 shows that the model economy is able to reproduce common stylized facts. Following Neugart and Richiardi (2012), replicating the Wage Curve, Beveridge Curve, Okun Curve and Phillips Curve provides a common validation criteria. The Wage Curve negatively relates nominal wages and unemployment rates (Blanchflower and Oswald, 1995), the Beveridge Curve reflects the negative relationship between unemployment and vacancy rate (Neugart and Richiardi, 2012), the Okun Curve posits a negative relationship between the changes in the unemployment rate and changes in GDP (Prachowny, 1993) and the Phillips Curve presents the relation between changes in nominal wages (wage inflation) and unemployment. Even though all correlation structures are significantly different from zero, the relation between the logarithmized (nominal) wages and the unemployment ($\rho = -0.662$) and between the changes in unemployment and output ($\rho = -0.7698$) are high, compared to the correlation between the vacancy rate and unemployment rate ($\rho = -0.378$) as well as between wage inflation and unemployment ($\rho = -0.166$).

Figure 1: Emergent dynamics from the model



Graphs depict Wage, Beveridge, Okun and Phillips Curve from a representative simulation.

Further, following the tradition of Dosi et al. (2006), the ABM was empirically validated

[7]As it is standard in ABM, 800 runs imply 800 different random seeds.

[8]The model settles into its statistical equilibrium after more or less 200 periods, the burn-in phase. The descriptive statistics were calculated for the periods between 800 to 1500 to ensure that the burn-in phase was passed in every run.

by comparing the model to certain macroeconomic regularities. Fiorito and Kollintzas (1994) and Brandner and Neusser (1992) published relative standard deviations and cross-correlations for output, consumption, real wages, employment, prices, inflation and interest rates for the Germany, as shown in Tab. 2. Tab. 1 presents the standard deviation of the respective time series relative to the standard deviation of output and their correlation with output. The time series were filtered with the Hodrick-Prescott filter ($\lambda = 1,600$) and averaged for 800 runs.

Table 1: Stylized facts from the artificial time series

Series of Model	**Rel. SD**	**Corr. with output**
Output	1	1
Consumption	0.85	0.60
Real wages	1.04	0.65
Price level	0.60	-0.19
Employment	1	1
Inflation	1.21	0.30
Real interest rate	1.02	0.35

Table depicts the relative standard deviation (Rel. SD, in %), i.e. in relation to output, and cross-correlation with output (Corr. with output) for the respective time series. The model was simulated for 800 runs and the time series were filtered with the Hodrick-Prescott-Filter ($\lambda = 1,600$). The numbers present the average over the runs.

Table 2: Stylized facts from the empirical time series

Series of Reference	**Rel. SD**	**Corr. with output**
Output	1	1
Consumption	0.92	0.69
Real wages	0.97	0.55
Price level	0.58	-0.25
Employment	0.69	0.68
Inflation	1.41^a	0.21
Real interest rate	1.24^b	0.28^c

The descriptive statistics were mainly taken from Fiorito and Kollintzas (1994) and complemented by Brandner and Neusser (1992) for the German economy between the 1960's and 1990's. The respective time series were detrended by the Hodrick-Prescott-Filter ($\lambda = 1,600$).^{a} and ^{b} were taken from Agresti and Mojon (2001) from the Euro Area.^{c} was taken from Fiorito and Kollintzas (1994)

Comparing Tab. 1 and 2 shows that the presented model can capture the main stylized facts. Compared to the other components, output is one of the most volatile time series while consumption and prices are less volatile. In other words, these components are smoother than output. Wages, interest rates, inflation and employment are as volatile as output. Since, employment fluctuates with output the strong correlation and volatility become clear. With respect to cross-correlation with output, the majority of the time series do not differ too much in sign and magnitude from their empirical counterparts. Consumption, real wages and employment are rather strongly correlated with output. Interest rates and inflation

show rather small correlation structures with output while prices shows a moderately but negative correlation with real output. Fig. (17) and Fig. (18) in the Appendix present the distributions of the mentioned statistics of Tab. 1 across varying parameter settings and, thereby, show the stability of the findings for several parameters settings.
Tab. (3) depicts the mean and the average standard deviation of the major variables of the model. In the absence of any long run output growth, the average unemployment rate is 8.5%, log of (real) output and (real) consumption are 7.31 and 6.72, annual inflation is 0.008%, which is acceptable in the absence of investment in technological progress and capital accumulation, and the interest rate is 0.018.

Table 3: Average of general statistics

Series	**Unemployment**	**Log((Real) Output)**	**Log((Real) Consumption)**	**(Annual) Inflation**	**Interest Rate**
mean (sd)	0.0851 (0.0233)	7.31 (0.037)	6.72 (0.039)	0.009 (0.008)	0.018 (0.006)

Average mean and the average standard deviation over 800 runs. Descriptives were calculated after the burn-in phase had passed.

3.2 Statistical equilibrium and boom-and-bust-cycles

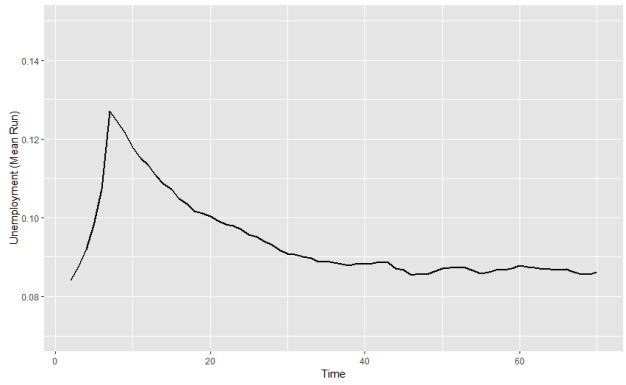
The model of this paper has a (statistical) equilibrium unemployment rate,[9] which implies that, in case of an (endgenous) outbreak of a recession, the model always returns to its equilibrium rate of unemployment. For the sake of clarity, the (statistical) equilibrium is called normal unemployment rate, which is the average long-term unemployment rate. Whenever a crisis breaks out in the model, internal methods, e.g. the entry-and-exit-assumption, bring unemployment back to the normal rate, even in the absence of a policy response.[10] Fig. 2 illustrates the average development of unemployment in the baseline scenario,i.e. no intervention, over 800 runs. While unemployment increases sharply prior to the critical level, unemployment returns, slowly, to its normal level within 40 periods after its peak. As laid out in the baseline model of Delli Gatti et al. (2011), the business cycles within this model are mainly driven by the positive expectations of firms. During a boom, increasing consumption leads to accelerated output growth and, thus, to rising employment and increasing prices. Apart from prices, wages also increase, since it becomes more difficult to hire workers during an economic upswing. Due to the increasing costs of production accompanied by improving sales expectations, firms increase their liabilities. The increasing liabilities imply higher costs for taking loans, i.e. higher interests rates, and, thus, increasing fragility in the economy as a whole. Since production increases, competition becomes more and more fierce

[9]For the concept of statistical equilibrium, see: Grazzini (2012)

[10]Due to the statistical equilibrium the model cannot consider genuine hysteresis. Since this model does not target the question on genuine hysteresis, I have to refer to existing works in this field. Bassi and Lang (2016) built a Post-Keynesian ABM that deals with hysteresis in the case of a negative demand shock.

and losses slowly increase among firms. When these losses exceed net wealth, firms become insolvent and leave the market. The insolvency has negative effects for the other firms since they face a loss in demand. I.e., a downward spiral emerges from the model. The recession is partly halted by automatic stabilizers, like UB, that avoid an infinite reduction in demand for goods. To a large extent, the economic recovery is driven by solvent entrants with a sound financial base that increase demand for labor. However, the recovery is partly, but not entirely, caused by reservation wages since new firms, which offer low wages, face problems in finding employees (Holzer (1994)). Entrants increase their wage offers only slowly. When they find workers the recovery and positive expectations start to grow again.

Figure 2: Average run in unemployment (baseline scenario)



Graph shows the average run of unemployment in case of a recession in the baseline scenario. The model was simulated for 800 runs.

4 Policy experiments and results

This paper analyzes the effects of a) a simultaneous reduction in unemployment benefits and an increase in search efforts, b) additional governmental transfers and c) short-time work. The policy responses, hereafter called policy scenario, will be compared to the counterfactual scenario, the baseline scenario, in which changes in the governmental policy are absent. As mentioned above, the model has a statistical equilibrium, expressed in terms of a long-term unemployment rate. Since the model returns to its normal unemployment rate by itself, the effectiveness of a policy response is evaluated by the (speed of) convergence to the normal unemployment rate in comparison to the baseline scenario. The analyses of the policy responses will be carried out as policy experiments in the following subsections. The model will be simulated until it passes the burn-in phase for both, the baseline and the policy scenario. In the case of the policy scenario, the government will intervene when unemployment exceeds the average rate by more than the average standard deviation multiplied by 1.5, which is assumed to be an extraordinary unemployment rate. Recalling that the average

rate of unemployment in the model is 8.5% and the average standard deviation is nearly 2.3%, the government will intervene in the case of the policy scenario when unemployment exceeds 12%. As it is standard in ABM (see e.g. Dosi et al. (2017a) and Riccetti et al. (2015)) the effects of the policy responses will be visualized by illustrating the development of unemployment in the baseline and the policy scenarios, averaged over several hundreds runs.[11] Further, to visualize the the deviation of the unemployment rate in the case of a policy response, the following subsections will show the development of the average relative difference in the unemployment rate between baseline and policy scenarios. Since the magnitude of deviations can differ between the runs due to stochastic effects, the latter illustrations will also show the confidence intervals of the relative differences.

4.1 Reduction of unemployment benefits (UB) and increasing search efforts

In the first policy experiment, the government responds to the critical number of unemployed by permanently reducing the long-term unemployment benefits, i.e. by altering parameter κ_{long}, and demanding higher search efforts from unemployed. Implicitely, it is assumed that the government will fully succeed in its plans to increase search efforts. κ_{long} decreases from 40% to 20% of the average wage[12] while search efforts increase to 14 applications per agent. The magnitude of the reduction was found by following the reduction of UB for long-term unemployed in Germany in the course of the labour market reforms in the 2000's (Engbom et al., 2015). A reduction of κ_{short} is neglected here, since it is rather uncommon to reduce short-term unemployment benefits (OECD, 2019). Due to the absence of clear criteria, the increase in search efforts was chosen to show a significant increase (e.g., as in Shimer (2004)). The effect of various levels of search efforts and κ_{long} will be shown later on.

The reduction on UB can have positive and negative effects on unemployment. The underlying intuition for the positive effects from a reduction in long-term UB is compatible with the basic search and matching model (Pissarides, 2000). Due to long-term UB, the reservation wages are downwardly rigid and act as a barrier against accepting low-paid jobs. A reduction of κ_{long} decreases the opportunity costs for employment and is supposed to reduce the length of unemployment spells (Gorter and Gorter, 1993). This should affect only long-term unemployed who have already reached the lower limit of the reservation wage (see: eq.(6)). The unemployment rate should converge more quickly to the normal rate. The negative feedback effect from consumption on output and unemployment should be limited, since more generously supported short-term unemployed are not affected by the policy.

[11] Considering the criteria of variance stability (Lee et al., 2015), the model will be simulated for 800 runs.

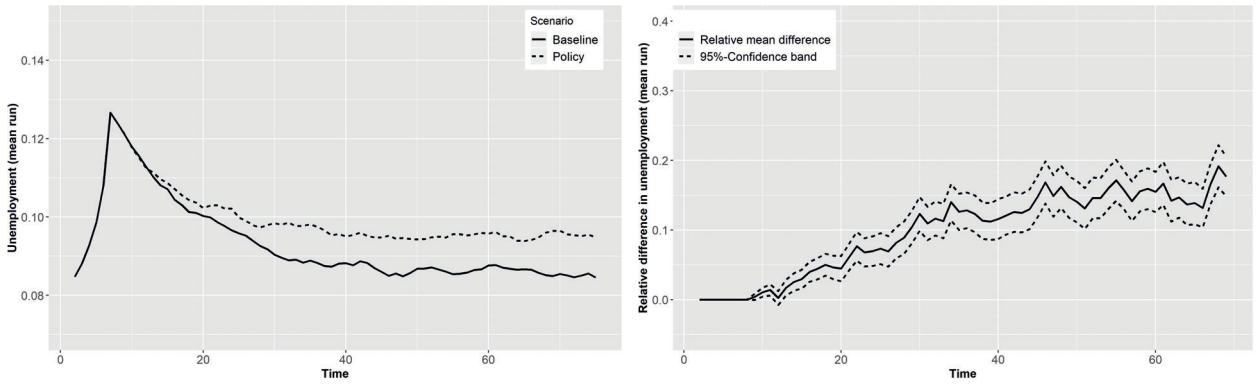
[12] The number was taken from the net replacement rate statistics of (van Vliet and Caminada, 2012).

Increasing search efforts should reduce unemployment by avoiding coordination failures on the labor market, i.e. the coexistence of unemployed that are willing to accept a job and open vacancies. When unemployed send more applications, firms should less often run out of candidates to fill the positions. Further, the combination of both mentioned policy responses should enhance each other's effect. When the unemployed reduce their reservation wages and send out more applications, the applications may be spread more evenly among firms. Entering firms that mainly post low-paid job offers, increase hirings, which may result in higher output and, thus, in decreasing unemployment.

Fig. 3 shows the results of the policy experiment. The left figure presents the average development of unemployment for baseline (solid line) and policy scenarios (dashed line) across 70 periods. The figure to the right presents the average relative difference between the baseline and the policy scenario (solid line) and the 95% confidence interval (dashed lines) for the same periods. The policy response starts in period 8. Following Fig. 3a, the development of unemployment in the case of the mentioned policy responses does not differ during the first seven periods after the policy response from the baseline scenario. Fig. 3b confirms, that the developments between both scenarios are not significantly different. However, in the long run, unemployment does not return to the normal rate of unemployment of about 8.5% but converges to the average unemployment rate of about 9.5%, i.e. a significant increase of about 15%. Thus, the permanent change in the governmental policy changes unemployment permanently but to limited extent.

Figure 3: Effect of reducing UB and increasing search efforts

(a) Development in unemployment (b) Relative difference in unemployment



Figures show the effect of a simultaneous reduction in κ_{long} and an increase in search efforts. The left figure shows the mean development of unemployment of the baseline (solid) and the policy scenario (dashed). The policy response starts in period 8. The right figure shows the mean relative difference between the policy and the baseline scenario (solid line) and its 95% confidence bands (dashed lines). The confidence interval is computed the average difference ± 2 time the standard errors.

The development of the variables in Fig. 4 provides an explanation for the diverging development in unemployment. Fig. 4 shows the relative difference between the baseline and policy scenarios in terms of (real) consumption, (real) output, wages, average duration of unemployment spells, vacancy rates and the number of applications for low-paid jobs.[13] Considering the development of the latter three variables, the policy response has the "desired" effects in the short run. In comparison to the baseline scenario, the number of applications for low-paid jobs is higher and the reduction of the reservation wages slow down the dynamic developments of wages such that firms can hire more easily. Therefore, the duration of the unemployment spells is lower than in the baseline scenario. Because production is less constrained by a lack of labor, output is nearly unaffected by the lack of consumption, i.e. consumption drops more than output (Fig. 4d and 4e). However, in the short run, the positive effects are rather small and restricted by the negative ones from consumption. Coordination failures play a minor role during a recession because the number of posted vacancies is relatively low compared to the number of unemployed. This can be taken from the small relative difference in the vacancy rate (Fig. 4f). Thus, unemployment spells are only two percent lower than in the case of the baseline scenario. The negative effects on consumption (Fig. 4e) feed back into output (Fig. 4d) in the long run. In comparison to the (baseline) scenario, expectations are worsened, due to a lower (aggregate) demand, which increases unemployment and also the duration of unemployment spells in the long run.

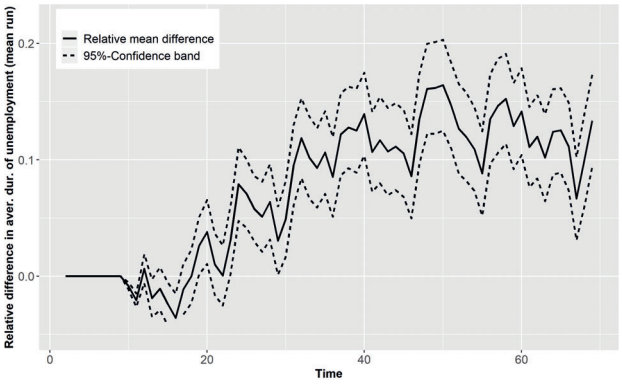
The sensitivity analyses in Fig. 5 show the effects of various levels of changes in κ_{long} and search efforts on short and long run unemployment, defined as the mean unemployment rate from periods 1 to 10 and from 40 to 150, after the policy response took place. In the short run, effects of both parameters are limited. Increasing κ_{long} to values between 0.4 and 0.5 has small, dampening effects, while search efforts have nearly no effect. There is a linear, dampening effect from search efforts on long-term unemployment. The relationship between unemployment and κ_{long} is u-shaped. Increasing the generosity of the transfers dampens the normal unemployment rate only up to κ_{long} between 0.4 and 0.5. Unemployment increases when long-term unemployment benefits exceed this level, since it becomes more difficult to hire workers due to high reservation wages. Both parameters are partly complementary.

In summary, by using a modeling approach, an ABM, that takes into consideration micro effects, e.g. on the behavior of unemployed, and macro effects, e.g. feedback effects, and relies on endogenous business cycles, I found that a moderate drop in UB, accompanied by increasing search efforts, has nearly no effect on unemployment in the short run when the economy is in a recession. The negative effects in the long run are limited. Due to the consideration of micro and macro effects the results differ from comparable works in search

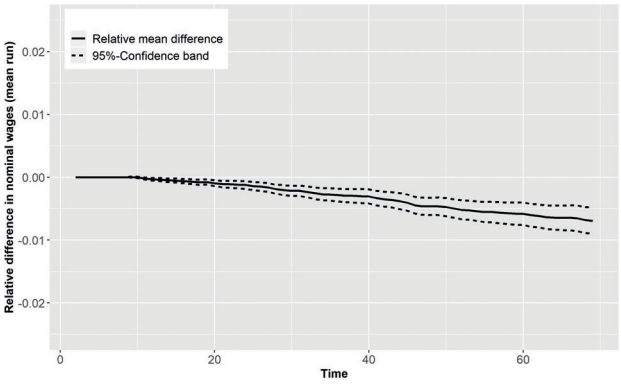
[13] By definition, low-paid job offers are the bottom-20% of the job offers with respect to wages.

Figure 4: Effects of reducing UB and increasing search efforts on various variables (across time)

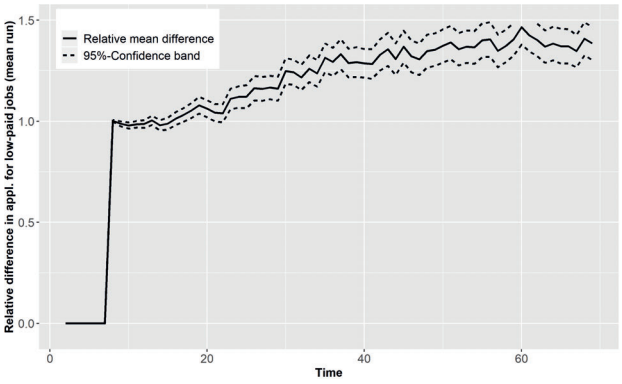
(a) Relative difference in the average duration of unemployment spells



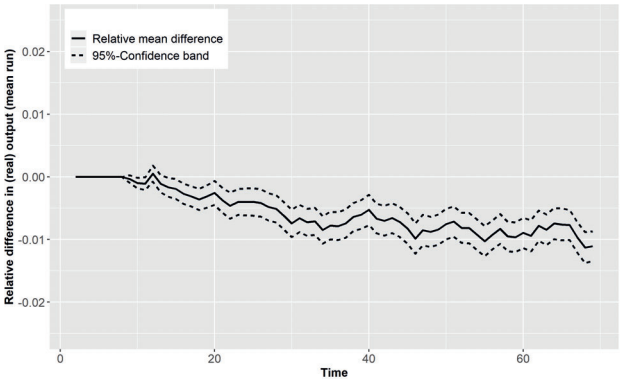
(b) Relative difference in nominal wages



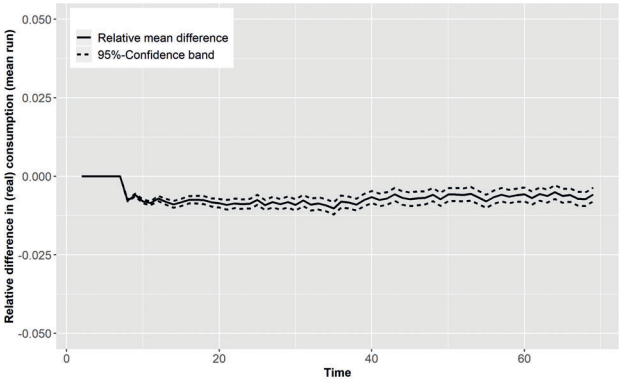
(c) Relative difference in applications to low-paid jobs



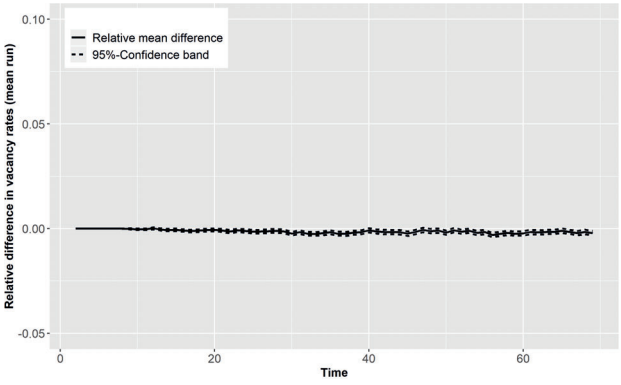
(d) Relative difference in output



(e) Relative difference in consumption



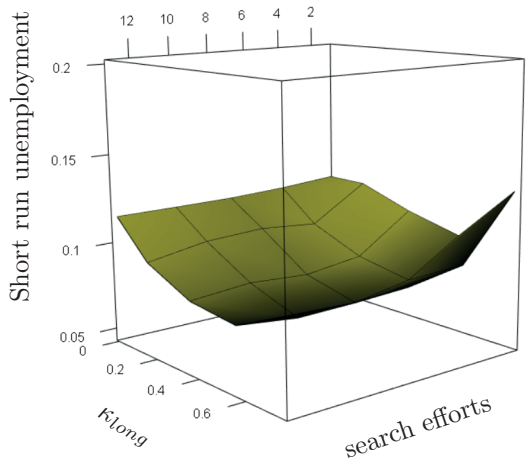
(f) Relative difference in vacancy rate



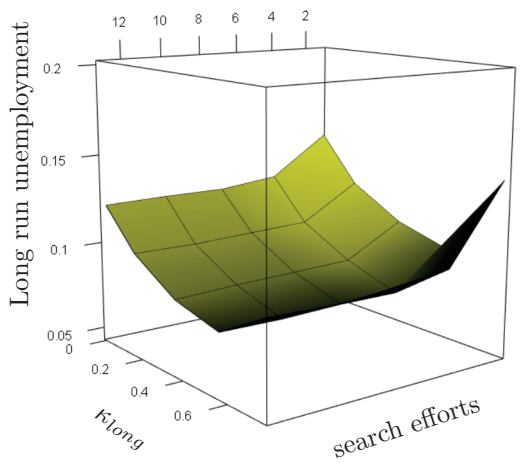
Figures show the relative difference between baseline and policy scenario across time for (a) average duration of unemployment spells, (b) nominal wages, (c) applications for low-paid jobs, (d) output, (e) consumption and (f) log of vacancy rate. The confidence interval computed as the average difference ± 2 time the standard errors.

Figure 5: Sensitivity analyses for different levels of UB and increasing search efforts

(a) Sensitivity analyses with respect to short run unemployment



(b) Sensitivity analyses with respect to long run unemployment



Figures show the effects of various levels of the reduction of κ_{long} and the increase in search efforts on long and short run unemployment. Long run unemployment is defined as unemployment between period 60 and 150 after the policy response. Short run unemployment is defined as unemplomyent between periods 1 and 10 after the policy response. The model was simulated for κ_{long} between 0 and 0.75 and search efforst varying from 1 to 13. The model was simulated for 320 runs per parameter combination. The values in the graphic show the average over the 320 runs per parameter setting.

and matching and macroeconomic modeling literature. However, the paper is in line with the more recent position in the debate, e.g., Howell and Rehm (2009), Launov and Wälde (2013) and Chodorow-Reich et al. (2019). The effects here are smaller than in Dosi et al. (2017b), since unemployment benefits were moderately reduced and only for long-term unemployed.

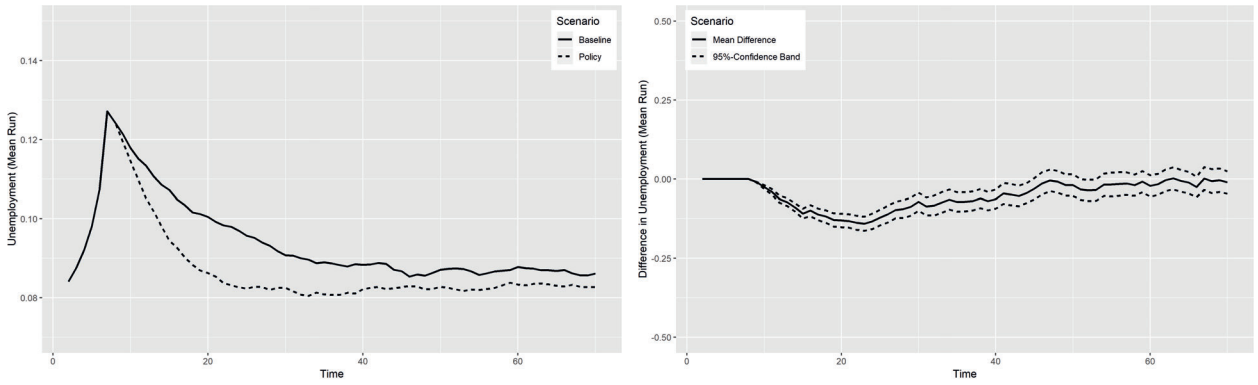
4.2 Additional governmental transfers

The second policy experiment analyzes the effects of a stimulation of aggregate demand. For this purpose, the government targets household consumption in this model. The paper assumes that the government transfers, once, 20% of the average wage to every household. The stimulus package is calibrated to sum up to 10% of nominal GDP (ILO, 2011). Such a policy experiment follows the research question of Djuric and Neugart (2017) who analyzed how a helicopter drop of money, e.g. as a transfer, would be used by households.

The policy response starts in period 8 and uses the similar figures to Section 4.1. As it is presented in Fig. 6, the policy instrument succeeds in reducing unemployment rather quickly. Fig. 6a shows that convergence to the normal unemployment rate speeds up. Fig. 6b further shows that the relative difference between policy and baseline scenario is significant in the short and medium run. In the long run, the difference between policy and baseline scenario is no longer significant. The dynamics that lead to the economic recovery are shown in Fig.

Figure 6: Effects of a fiscal stimulus

(a) Development in unemployment (b) Relative difference in unemployment

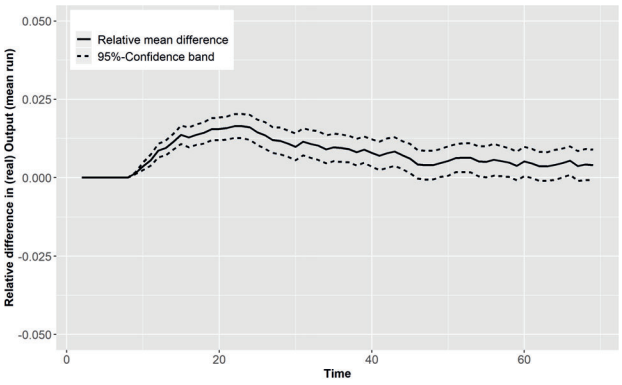


Graphs show the effect of an additional income transfer. The left figure (a) the average development of unemployment of the baseline (solid) and the policy scenario (dashed). The policy response starts in period 8. The right figure shows the average relative difference between the policy and the baseline scenario (solid line) and its 95% confidence bands (dashed lines). The confidence interval computed as the average difference $\pm$2 time the standard errors.

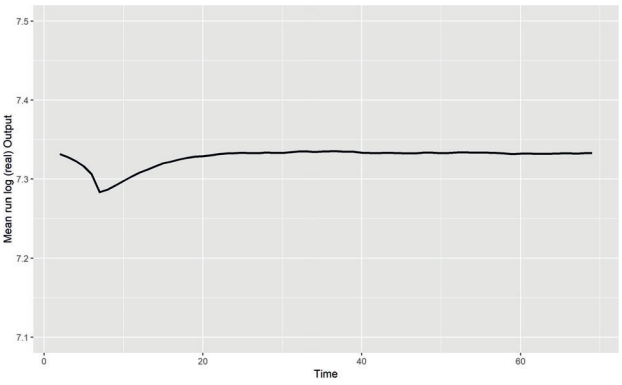
7. Fig. 7 shows the relative difference between policy and baseline scenario in terms of log (real) output, log (real) consumption and public debt, and the absolute difference in profits. Further, it contains the average runs of log (real) output and log (real) consumption. The impact of the fiscal stimulus on demand is responsible for the improved performance on the labor market. The additional transfer to households stimulates goods demand (Fig. 7d), which feeds back to output (Fig. 7b) and, due to the formation of positive expectations and rising profits (Fig. 7e), to employment in the following periods. The stimulus has lasting effects on demand and output development, which causes the economy to return to normal unemployment quickly. The lasting effect is due to, first, the multiplier effect, since additional demand induces higher employment. Second, since households reduce excess wealth slowly and firms only slowly adapt to the risen demand, due to careful expectation formation, the sudden growth in consumption does not diminish immediately, but over several periods. Therefore, output in the policy scenario is above the baseline scenario for around 30 periods (Fig. 7a). The positive effects of this instrument comes with an increased public debt. Fig. 7f shows that public debt rises strongly in the short run, compared to the baseline level. However, the stimulus reduces unemployment and, hence, increases tax revenues while governmental expenditures, e.g. on unemployed agents, decreases more quickly. In other words, the stimulus repays itself in the long run (Corden, 2010). The positive effects of fiscal policy on employment, especially if it was implemented as governmental spending, finds wide empirical support (e.g., Gechert and Rannenberg (2018)).

Figure 7: Effects of an additional governmental transfers (across time)

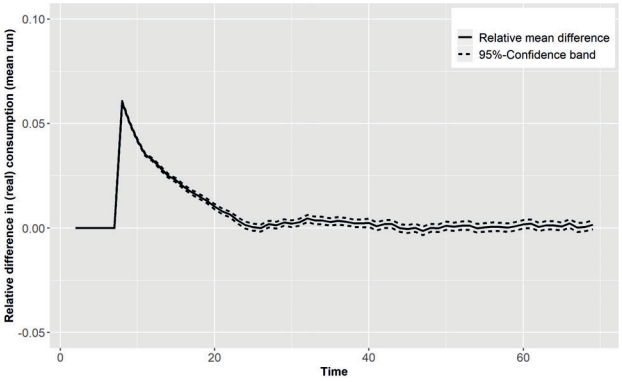
(a) Relative difference in output



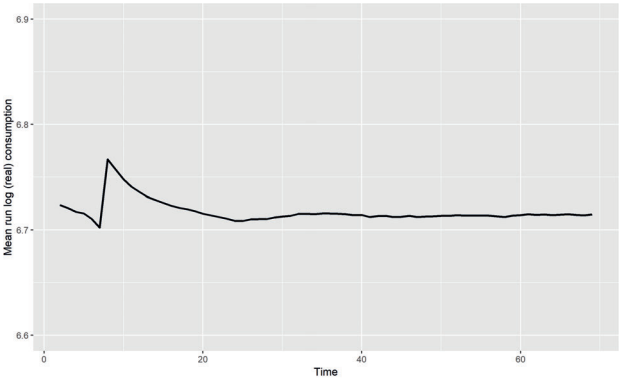
(b) Mean development in output



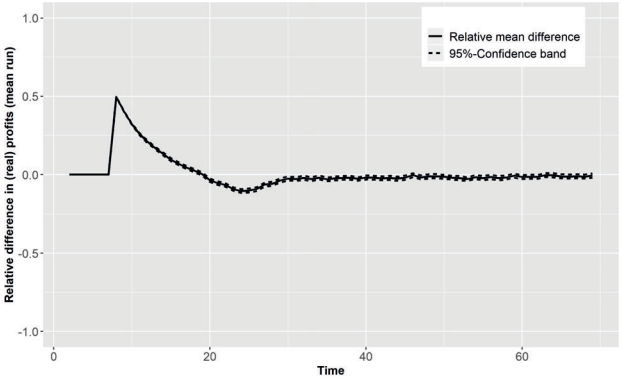
(c) Relative difference in consumption



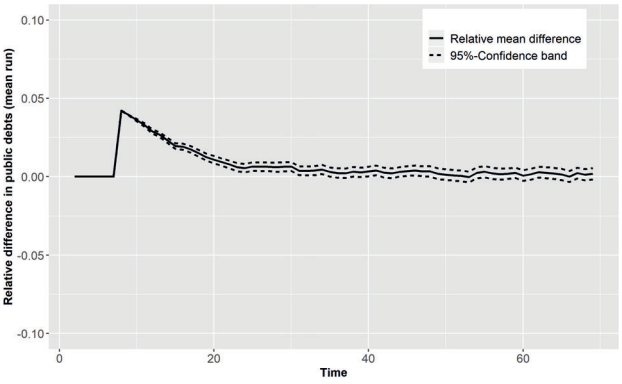
(d) Mean development in consumption



(e) Difference in average profits of firms



(f) Relative difference in public debts (governmental debts to norminal output)



Graphs (a) and (c) show the relative difference between baseline and policy scenario across time for log(output) and log(consumption). Graph (e) shows the absolute difference between baseline and policy scenario of the average firm profits across time. The confidence interval computed as the average difference ± 2 time the standard errors. Graphs (b) and (d) show the average run of log(output) and log(consumption) across time. Graph (f) shows the average relative difference between baseline and policy scenario across time for public debts, expressed as the ratio of public debts to nominal GDP. In all graphs, the policy starts in period 8.

The sensitivity checks (Fig. 8a and 8b) show how different levels of the stimulus package affect short and long run unemployment. Intuitively, larger stimulus packages reduce unemployment more quickly than smaller ones, as presented in Fig. 8a. Nevertheless, after 30 periods the effect of the additional transfer vanishes across various levels of these transfers and the long run unemployment rate is unaffected (Fig. 8b).

Figure 8: Sensitivity analyses for different magnitudes of the fiscal stimulus

(a) Sensitivity analyses with respect to short run unemployment

(b) Sensitivity analyses with respect to long run unemployment

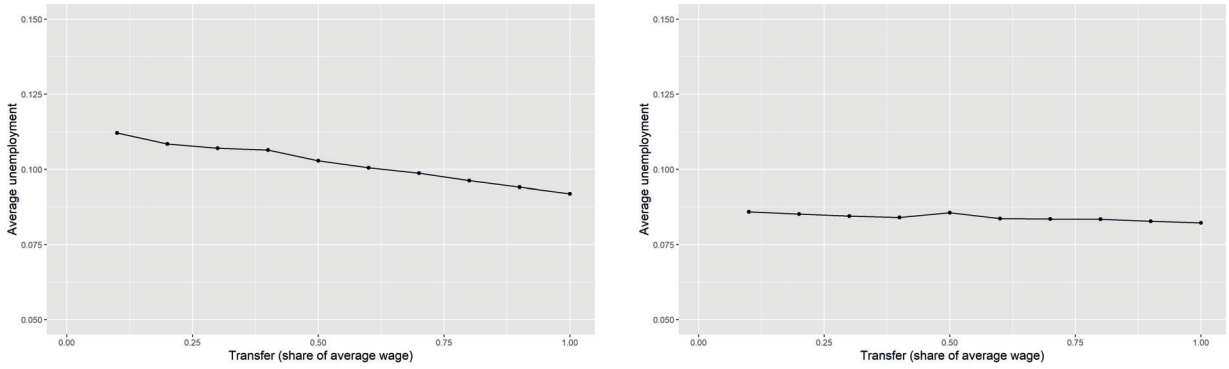


Fig. 8a and 8b present the effects of various levels of the governmental transfers on short and long run unemployment. Long run unemployment is defined as unemployment between periods 40 and 150 following the policy response. Short run unemployment is defined as unemployment between periods 1 and 10 after the policy response. The governmental transfers are denoted as the share of the average wage that is transfered to the households in the respective period. The model was simulated for the share of the average wage varying (discretely) between 0.1 and 1. The model was simulated for 320 runs per level of transfers. The values in the graphics show the average over the 320 runs.

4.3 Short-time work

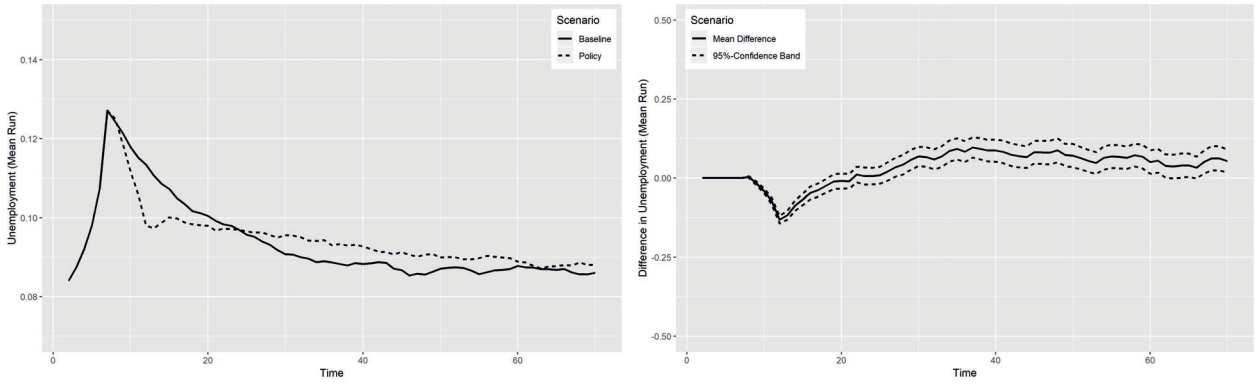
The third policy experiment introduces a short-time work scheme when unemployment hits the above-mentioned critical level. A firm is applicable for short-time work if it realized significant losses in the previous period but is still solvent. Due to this rule, fragile firms do not benefit from short-time work. The model was calibrated to reflect that firms reduce hours worked to 75% of the level of full-time work. The government partly compensates workers for the loss in income by providing 60% of the net income loss. The policy stops after four periods. The short-time work scheme followed, roughly, Brenke et al. (2013). Further, it is assumed that firms that apply short-time work do not hire workers, but can lay them off during the application of the program. It is expected that due to short-time work, the firms that are affected by the recession are rather reluctant to lay off workers, which reduces the number of dismissals, and the risk of firms becoming insolvent is reduced due to lower (absolute) wage costs. As the business environment improves, which induces positive

expectations for firms, unemployment may start to fall sustainably.

The application of short-time work in the policy experiment starts in period 8 (see Fig. 9b and 9a) and uses similar figures as in Sections 4.2 and 4.1 to present the effects of the policy on unemployment. Fig. 9a shows the average path of unemployment in baseline and policy scenario while Fig. 9b shows the average relative difference in unemployment between policy and baseline scenario, and the confidence intervals. Following Fig. 9a, short-time work is effective in reducing unemployment quickly. Fig. 9b further shows that there is a significant difference between both scenarios in the first periods. However, it does not affect unemployment in the long run. In contrast to governmental transfers, the sharp reduction in unemployment is partly turned around after the short-time work program stops. In period 13, unemployment rises for a brief period but returns to its falling trend afterwards.

Figure 9: Effects of short-time work

(a) Development in unemployment (b) Relative difference in unemployment



Figures show the effect of short-time work. The left figure shows the mean development of unemployment of the baseline (solid) and the policy scenario (dashed). The policy response starts in period 8. The right figure shows the mean relative difference between the policy and the baseline scenario (solid line) and its 95% confidence bands (dashed lines). The confidence interval is computed as the average difference $\pm$2 times the standard errors.

Fig. 10 shows additional graphs to explain the effects in Fig 9. In contrast to pure demand management, e.g. governmental spending, short-time work stabilizes unemployment by affecting supply, via a *distributive effect*, and demand, by *demand stabilization*. Fig. 10b and 10d show the average run of (log (real)) output and (log (real)) consumption while Fig. 10a and 10c present the relative difference between the policy and baseline scenario of (log (real)) output and (log (real)) consumption. Fig. 10f shows the mean run of the share of firms applying short-time work in case the short-time work program is active. Fig. 10e is explained below. The policy starts in period 8 and ends in period 12. Prior to the introduction of the short-time work scheme, output (Fig. 10b) and consumption (Fig. 10d) drop in the course of a recession. As shown in Fig. 10a and 10b, the application of the short-time

work scheme by a significant number of firms, around 16%,[14] implies a reduction in hours worked and, thus, a further reduction in output after the policy starts. Considering Fig. 10c and Fig. 10d, consumption drops less than output, which is due to two developments in case of short-time work. First, firms reduce hours worked rather than laying off workers and second, workers are partly compensated for their loss of income. Instead of losing their income due to unemployment, workers keep a large part of it and, hence, their consumption. This is the above-mentioned *demand stabilization* effect, which has positive feedback effects on output. Further, since some firms avoid job separation and others hire, unemployment decreases more quickly than in the baseline scenario.

Apart from demand stabilization, short-time work has a *distributive effect*, which is illustrated in Fig. 10e and Fig. 11. Fig. 10e presents the absolute difference in average profits on the firm-level between baseline and policy scenario. They are measured in nominal terms. As mentioned above, the short-time work program starts at period 8. The graphs of Fig. 11 show the distribution of sales (Fig. 11a) and profits (Fig. 11b) among firms, expressed in terms of the Gini index, the median sales and median profits (Fig. 11c and 11d) of firms, and the mean sales on the firm-level (Fig. 11e). Sales are measured as the amount of sold goods. The variables mentioned are shown before (period 0) and during the application of short-time work (periods 1 to 4). As noted above (Fig. 10), output further drops after the application of short-time work. However, since output decreases mainly because of a reduction in hours worked, instead of a lack of demand, the situation on the goods market improves. As it can be seen in Fig. 11c and Fig. 11a, reducing output does not imply that the amount of sold goods drops per se but the sales become more equally distributed among firms. The Gini index for sales drops significantly while the median level of sales increases. In other words, the coordinated reduction of goods, supported by a (relatively) stable demand, implies that opportunities to sell goods improves for individual firms. This is an external effect, a *distributive effect*, in which the firm sector benefits as a whole from the application of short-time work of some firms. Since firms can increase their sales, less firms realize losses and the majority even increase their profits (Fig. 11d) such that the profits also become more equally distributed among firms (Fig. 11b). The widespread growth of profits and sales improve the expectations of a large number of firms and, thus, increase labor demand. The distributive effect is particularly strong in the first period, the introduction of short-time work. The mentioned variables hold a certain median level and level of distribution in the consecutive periods, as the median and Gini index do not reverse after the introduction.

In addition, the distributive effect is further analyzed econometrically in the Appendix (Tab. 5 and Fig. 19). The results of a fixed effect model are presented in Tab. 5. Keeping the

[14] Across various runs of the policy simulations between 15% and 25% of the firms apply short-time work.

level of compensation for the loss in net wage (60%) and the eligibility of short-time work (four periods) constant, the model provides a robustness check for the distributive effect. Following the econometric analyses, the more the firms reduce the hours worked the more unemployment drops due to the distributive effect. Nevertheless, the effect is relatively small. For example, when the respective firms reduce hours worked by one percentage point, unemployment decreases in the first period after the introduction of short-time work by about 0.1%. Fig. 19 further reveals that the effect is partly non-linear. The marginal effect decreases as the working-time reduction increases.

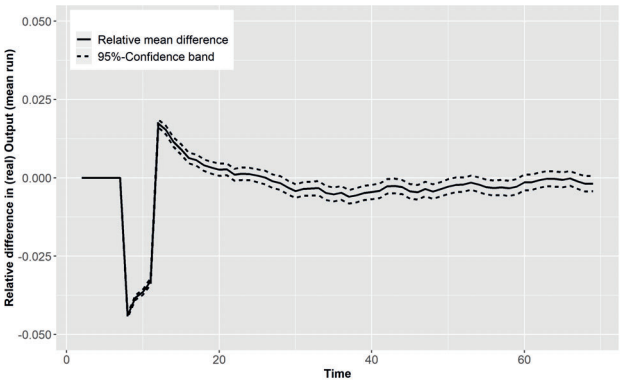
Demand stabilization and the distributive effect are complementary to each other. Since demand stabilizes on a certain level and sales are growing across firms, firms improve sales expectations and hire workers. This improves (aggregate) demand and has positive feedback effects on (aggregate) supply.

After four periods (period 12 in the Fig. 10), the short-time work program and the additional funds from the compensation stop, and firms, with their positive expectations, return to normal employment. When firms return to full workforce utilization, competitition on the goods market suddenly becomes too fierce again. For a brief period, firms realize losses such that output drops and unemployment increases (Fig. 9). However, the negative effect is only temporary and describes that, when firms get used to the policy and the additional funds, the sudden stop has negative effects on unemployment and profits. Afterwards, the system returns to its long-term statistical equilibrium.

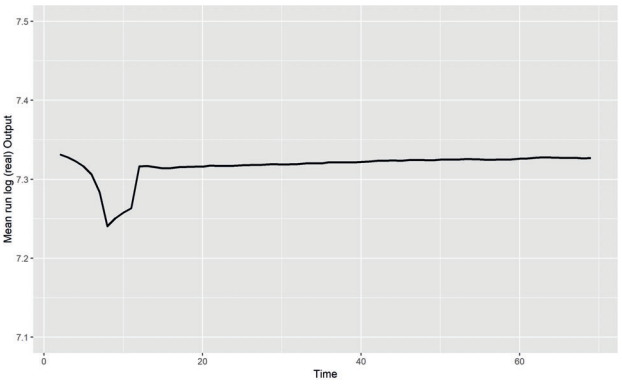
Fig. 12a and 12b show the sensitivity analyses for various settings of short-time work, mainly for varying compensation schemes and durations of the short-time work program. Short run unemployment measures the average unemployment between periods 1 and 10 after the policy starts, while long run unemployment measures the average between period 40 and 150 after the policy starts. In the short run, there are strong effects from both parameters. Both parameters dampen the short run unemployment rate to nearly the same extent. For example, when short-time work is extended from two to eight periods, holding the compensation scheme constant, unemployment falls by about one percentage point in the short run. Similarly, short run unemployment falls by one percentage point if the losses in wages are compensated by factor 0.6 instead of 0. The impact of the compensation scheme further shows the importance if the demand stabilization to reduce unemployment. Increasing both parameters can reduce unemployment even more quickly, by about two percentage points. However, short-time work does not affect long-term unemployment, irrespective of the parameter setting (12b).

Figure 10: Effects of short-time work (across time)

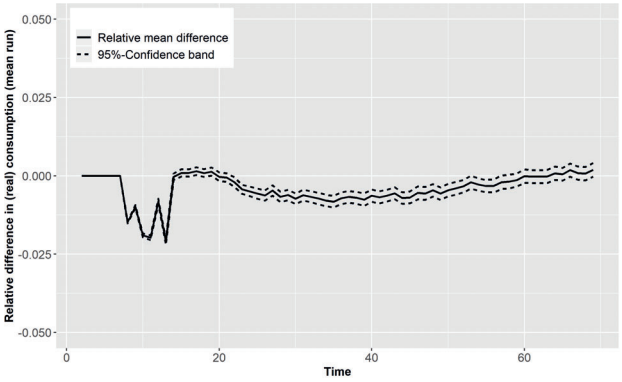
(a) Relative difference in output



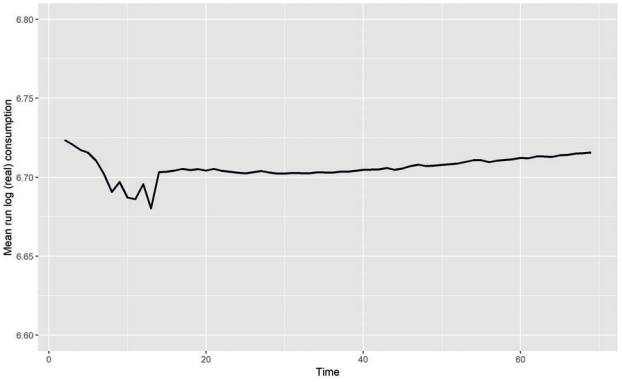
(b) Mean development in output



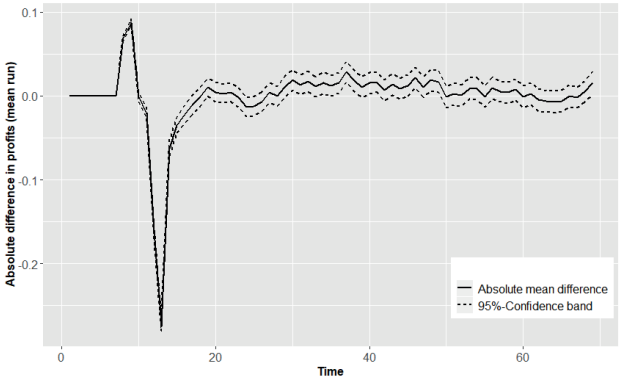
(c) Relative difference in consumption



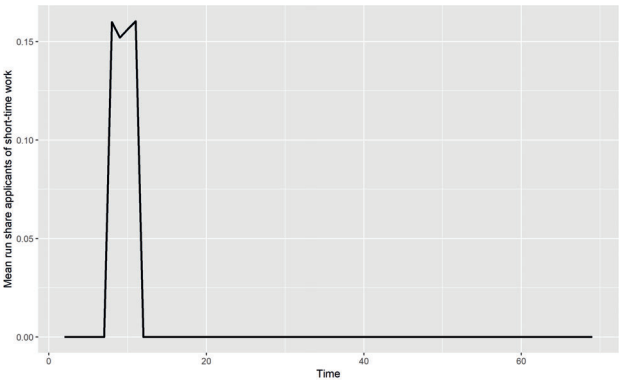
(d) Mean development in consumption



(e) Difference in average profits of firms



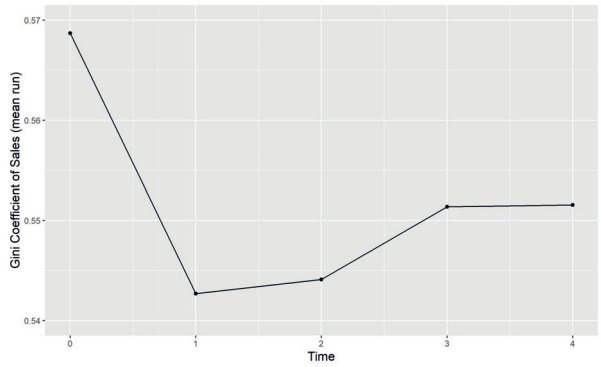
(f) Mean development of the share of firms applying short-time work



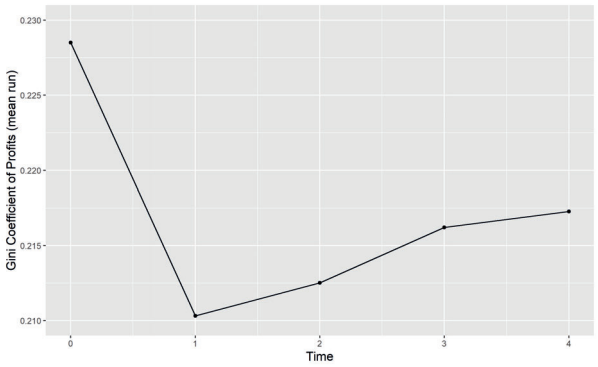
Graphs (a) and (c) show the relative difference between the baseline and policy scenarios across time for log(output) and log(consumption). Graph (e) shows the absolute difference between the baseline and policy scenarios of the average firm profits across time. The confidence interval is computed as the average difference ± 2 times the standard errors. Graphs (b) and (d) show the average run of log(output) and log(consumption) across time. Graph (f) shows the average share of firms that apply short-time work across time. In all graphs, the policy starts in period 8.

Figure 11: Distributive effects of short-time work

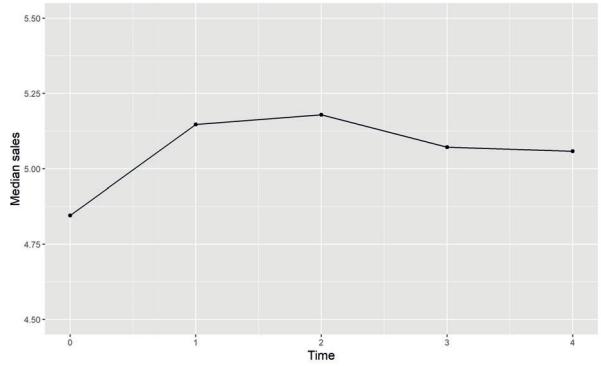
(a) Gini coefficient of sales per period (before and during short-time work)



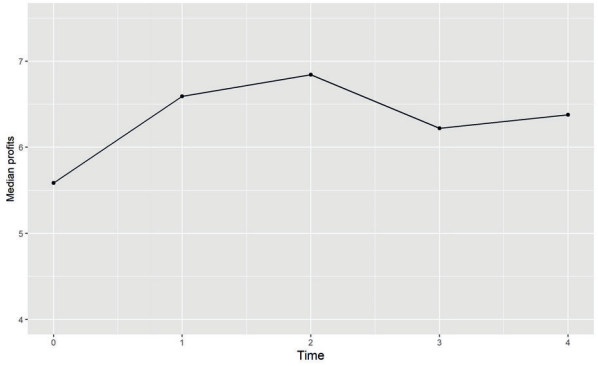
(b) Gini coefficient of profits per period (before and during short-time work)



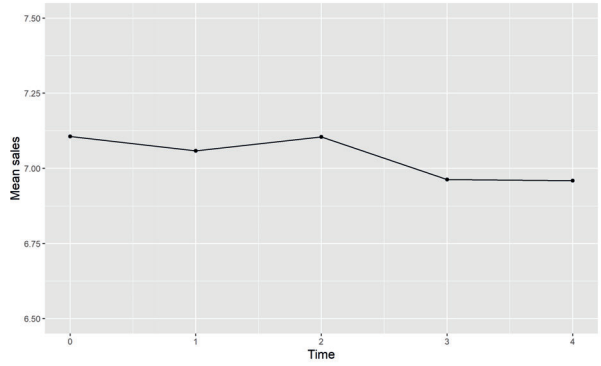
(c) Median sales of firms per period (before and during short-time work)



(d) Median profits of firms per period (before and during short-time work)



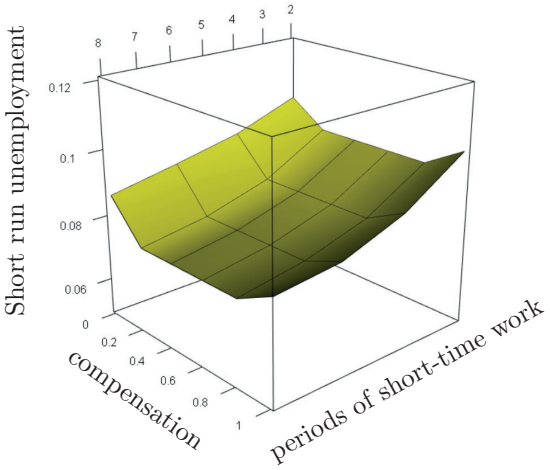
(e) Mean sales of firms per period (before and during short-time work)



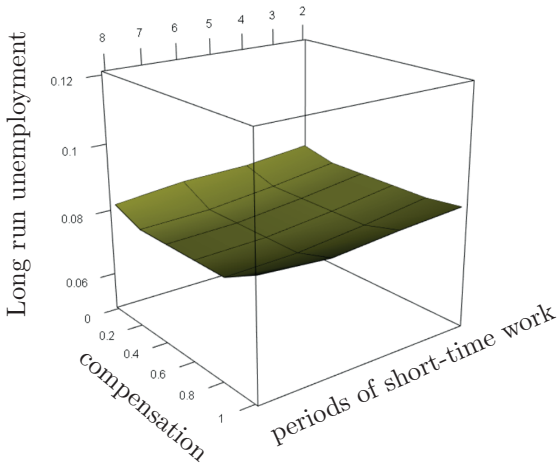
Graphs (a) and (b) show the median sales and median profits on the firm-level before and during the short-time work program. Graphs (c) and (d) show the Gini index of sales and profits on the firm-level before and during the short-time work program. Graph (e) shows the average level of sales on the firm-level before and during the short-time work program. The policy response starts in period 1 and ends in period 4. Period 0 is the last period before the policy response starts.

Figure 12: Sensitivity analyses for different parameter settings of short time work

(a) Sensitivity analyses with respect to short run unemployment



(b) Sensitivity analyses with respect to long run unemployment



The graphs show the effects of various levels of the compensation during and the duration of the short-time work program on short and long run unemployment. Short run unemployment is defined as average unemployment between periods 1 and 10 and long run unemployment as average unemployment between periods 40 and 150 after the policy response. *compensation* defines the share of the loss in after-tax wage, i.e. due to short-time work, that is compensated. *Periods of short-time work* describe the number of periods the program is active. The model was simulated for *compensation* varying between 0 and 1, and the duration of the program varying from 2 to 8 periods. The model was simulated for 320 runs per parameter setting. The values in the graphics show the average over the 320 runs per parameter setting.

In summary, short-time work can help to reduce unemployment quickly and sustainably. Empirical research also finds mitigating effects of short-time work on unemployment (Herzog-Stein et al., 2018; Brenke et al., 2013). I found that the effectiveness of the program is due to demand stabilization and the distributive effect in this work. In addition to Section 4.1, ABM has again shown to be a very suitable approach to reveal a new mechanism, since it accounts for the heterogeneity of agents and therefore for external effects. As a side remark, also the lack of a market clearing condition has shown its effect. Like many ABM (Delli Gatti et al., 2011; Dosi et al., 2006; Riccetti et al., 2015), produced and consumed goods do not equal up in the model because firms produce with respect to expected demand. Therefore, the evolution of sales in contrast to the evolution output can be seen more easily in an ABM.

5 Summary

This paper analyzed how different policy responses affect unemployment during a recession. The paper focused on a) a simultaneous reduction in unemployment benefits and increasing search efforts, b) additional governmental transfers and c) short-time work. Apart from analyzing the impact on the unemployment rate, the paper further focused on the mechanism

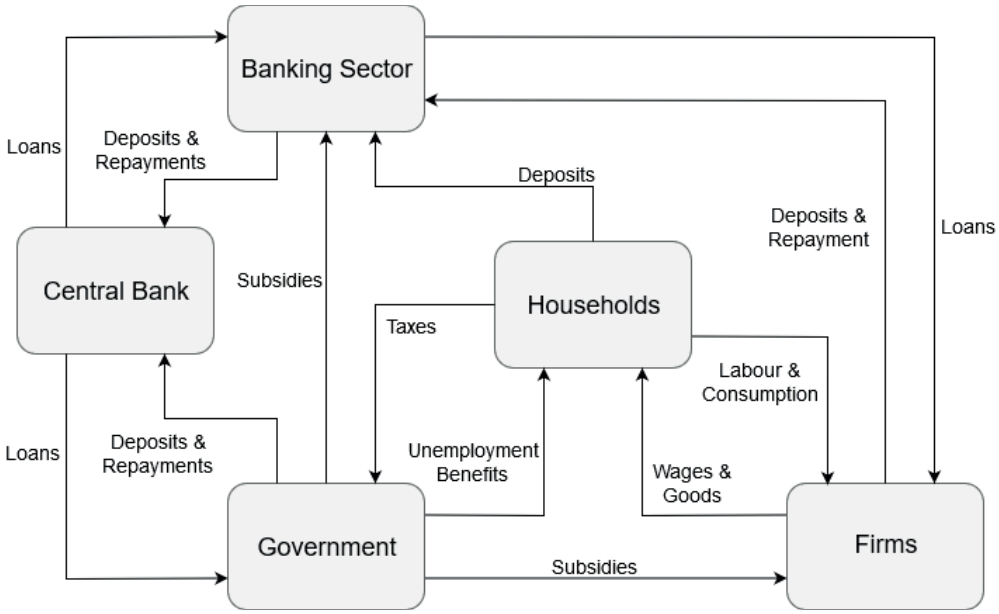
of the mentioned instruments a), b) and c). In contrast to standard search and matching models, general equilibrium models and pure macroeconomic models, this paper relied on a stock-flow consistent agent-based model. By using the new strand of micro-founded macroeconomic modeling, this paper could take into account microeconomic effects from policy responses, e.g. behavioral changes of agents, and macroeconomic effects, e.g. feedback effects from demand on supply. Further, the model could account for effects from the heterogeneity of firms, i.e. external or distributive effects, on macroeconomic performance. In particular, the opportunity to evaluate microeconomic and macroeconomic effects in a) and the opportunity to analyze the effects from heterogeneity in c) proofs the usefulness of ABM for macroeconomic analyses.

This paper presents mainly four findings. First, reducing unemployment benefits and increasing search efforts of unemployed neither yields significant positive nor negative effects on unemployment in the short run. The reason is that positive effects are rather small and partly outweighed by the negative ones. More precisely, even if the willingness to accept low-paid job offers increases, the lack of open vacancies in economically difficult situations mitigates the positive effect on employment and the negative feedback effects from reduced consumption on output and labor demand cancels out the positive effect in the short run. In the long run, the negative effects dominate the positive ones and increase unemployment. However, the effects are limited in case of a moderate reduction of unemployment benefits. The limited effects found in this work stand in contrast to other models so far (Hagedorn et al., 2013; Byrialsen and Raza, 2018). However, they are in line with more recent studies (Howell and Rehm, 2009; Chodorow-Reich et al., 2019). Second, the opposite policy response, increasing unemployment benefits, does not necessarily yield better results. If long-term unemployment benefits exceed a certain level, reservation wages increase and make it more difficult for small firms to sign workers. Hence, unemployment increases. Third, governmental transfers to steer aggregate demand and short-time work are more effective in reducing unemployment. Fourth, even if policy responses b) and c) seem to have similar effects the mechanisms are different. The fiscal stimulus increases employment by its effect on demand. More interestingly, short-time work reduces unemployment by stabilizing demand and a distributive effect among firms. On the one hand, firms prefer to reduce hours worked instead of laying off workers while others firms employ nevertheless and workers are partly compensated for the loss in income during short-time work. Therefore, separation is low and consumption stabilizes on a relatively (high) level. On the other hand, the (coordinated) reduction in output increases the chances of firms to sell their goods, implying profits and sales expectations to improve. Therefore, supply side conditions improve. The latter aspect, the distributive effect, became visible due to the application of an ABM.

6 Appendix

6.1 Overview over the Model

Figure 13: Overview over model entities



The graphic shows the main economic entities (sectors) of the model and their relation. The direction of the arrow shows from where money or goods flow to which entity.

6.2 Timeline of Events

1. Firms decide on prices and (desired) quantity and set wages. Depending on the quantity decision, firms lay off workers or post open vacancies.

2. Unemployed send their application to firms.

3. Firms hire, randomly, until the queue is empty or all vacant positions are filled. If equity is insufficient to pay complete wage bill, firms ask for a loan. If loan is not or only partly assigned, firms lay off workers until the sum of funds covers the wage bill.

4. After the labor and the credit market are closed, the number of employed and unemployed is determined and production takes place.

5. Firms pay their workers and unemployed receive unemployment benefits. Both, workers and unemployed, decide how much to consume and how much to save.

6. Firms offer the goods on the market and workers send their demand to the firms.

7. Firms serve the demand in a random order until either no consumer appears in the queue anylonger or no good is there to be sold.

8. Firms compute their profits and their wealth. If possible, firms repay the debt. If firms have zero or negative wealth or if they cannot pay a single worker in the next period, firms become insolvent and are replaced by an entrant.

6.3 Parameter setting for baseline scenario

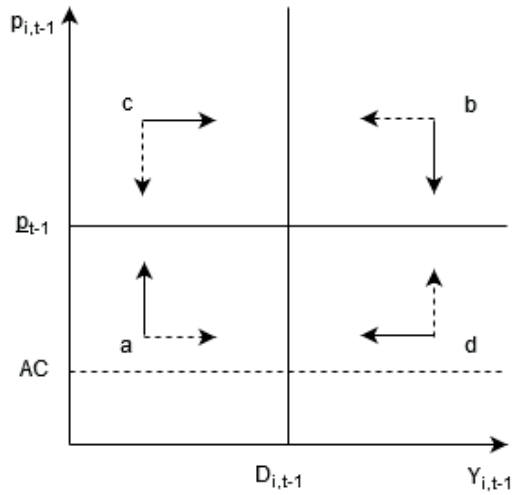
Table 4: Calibration of the baseline scenario (parameter values)

Description	**Parameter**	**Value**
Number of Firms	F	100
Number of Workers	H	1668
Number of Banks/Aggregated Banking Sector	Z	1
Number of Governments	G	1
Number of Central Banks	CB	1
Price mark(-down)-up	η	$U(0;(-)0.06)$
Quantity mark(-down)-up	χ	$U(0;(-)0.1)$
Wage mark-up (if insufficient applications)	δ	$U(0;0.03)$
Price mark-down (entrants)	γ	$U(0;-0.08)$
Reservation wage mark-down	ζ	$U(0;-0.08)$
Ratio lower bound reservation wage to UB	ν	$U(0.1;0.9)$
Ratio: Buffer-stock savings/wage	ξ	2.0
Wage tax	τ	0.05
Factor marginal propensity to consume	β	0.5
Marginal propensity to consume from excess wealth	λ	0.5
Capital requirement coefficient	v	0.4
Fragility weight of firm debt	θ	0.5
Maximal leverage of firm accepted	ι	2.0
Base (interest) rate	$\hat{r}$	0.01
Percentage of firms with lowest price checked	α	5%
Ratio: short-term unemployment benefits to average wage (Baseline)	κ_{short}	0.55
Ratio: long-term unemployment benefits to average wage (Baseline)	κ_{long}	0.4
Maximal of (job) applications to firms	M	7
Number of suppliers checked	O	6
Duration of short-time unemployment benefits (periods)	DUR	4

Description: Number of Worker was calibrated such that the ratio of workers to firms is nearly 1:16, as it is on average among OECD states (OECD). The number of the government, the commercial bank and the central bank was due to modeling. The maximum rate of the decline in reservation wage was taken from (Kiefer and Neumann, 1979) and fitted to a quarter. ξ was taken from Carroll and Kimball (1996). Tax rate on wages was taken from Riccetti et al. (2015). Base rate and fragility weight were taken from Delli Gatti et al. (2011). κ_{short} and κ_{long} were taken from the average Net Unemployment Replacement Rate of Germany before the reform in the beginning of th 2000's (van Vliet and Caminada, 2012). Price and wage mark-ups/-downs were chosen to replicate the pattern of increasing prices. λ was taken from (Seppecher and Salle, 2015). β was chosen to replicate a smooth reduction of the MPC as wealth increases. The remaining values were found by indirect calibration (see: Windrum (2007)), as it was done for example in (Dosi et al., 2006). Taking the difficulties to determine stylized facts of time series into account (see, (Canova, 1998)), the parameter setting was chosen among hundreds of parameter settings by being able to replicate, within an acceptable range.

6.4 Price-quantity-decision

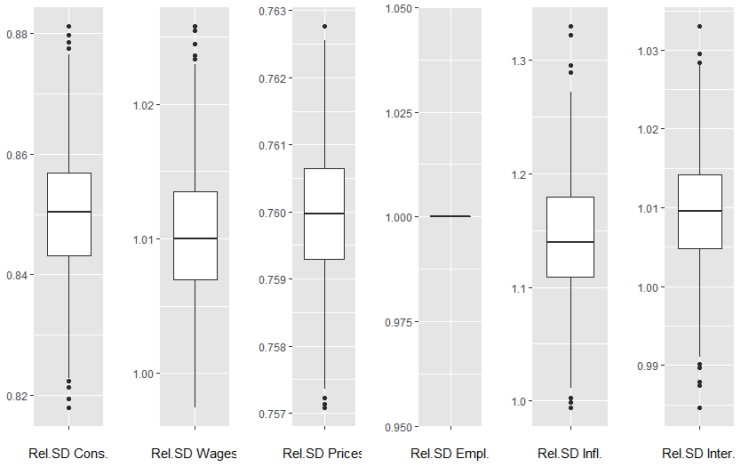
Figure 14: Price-quantity-decision matrix



Firm i changes either prices or quantities depending on the position in the price-quantity space. Line AC depicts the minimum price. $\underline{p}_{i,t}$ is the average price in $t-1$, $p_{i,t}$ is the price of firm i in $t-1$, $D-i,t-1$ is the demand of i in $t-1$ and $Y_{i,t-1}$ is the output in $t-1$. As described in eq. (2), (3) and (4), a firm changes its price in region a and c and its quantity in region c and d. The graphic was taken from Assenza et al. (2015) and adjusted for the purpose of this work.

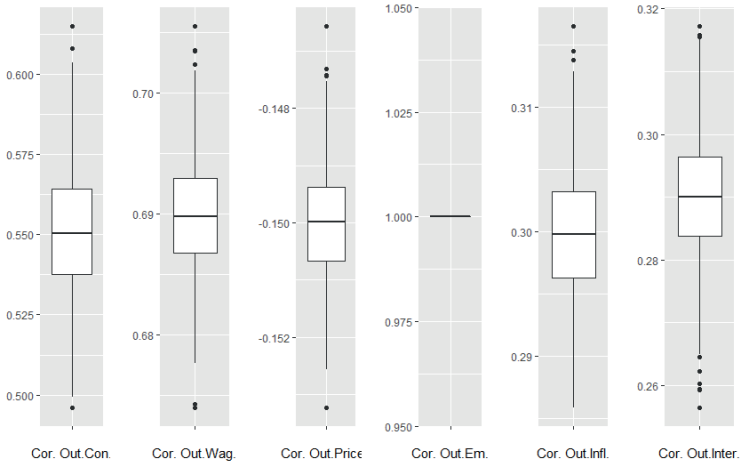
6.5 Distribution of stylized facts statistics across random seeds

Figure 15: Distribution of relative standard deviation (in %) of consumption, real wages, prices, employment, inflation and real interest rate relative to output



Graphs show the distribution of standard deviations (in percent) of consumption, real wages, employment, prices, inflation and real interest rate in relation to the standard deviation of output for 800 runs (800 random seeds).

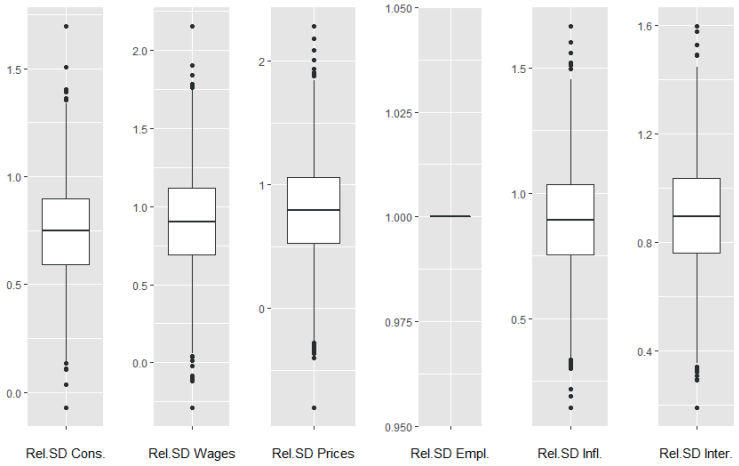
Figure 16: Distribution of correlation of consumption, real wages, prices, employment, inflation and real interest rate with output



Graphs show the distribution of correlation coefficients of consumption, real wages, employment, prices, inflation and real interest rate with output for 800 runs (800 random seeds).

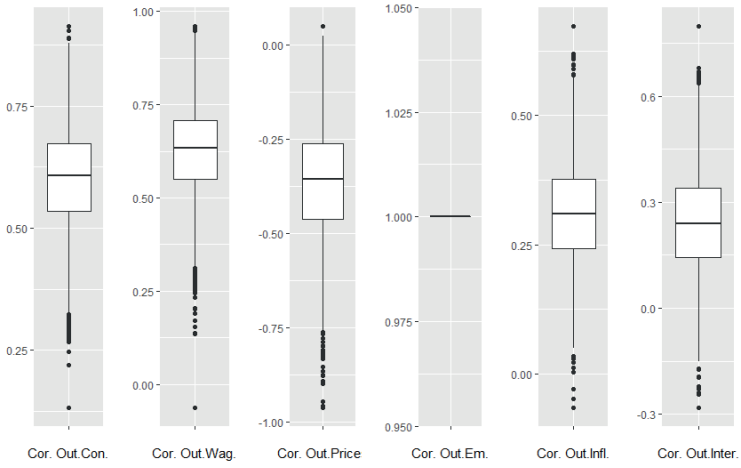
6.6 Distribution of stylized facts statistics across parameter combinations (latin hypercube sampling (LHS))

Figure 17: Distribution of relative standard deviation (in %) of consumption, real wages, prices, employment, inflation and real interest rate relative to output



Graphs show the distribution of standard deviations (in percent) of consumption, real wages, employment, prices, inflation and real interest rate in relation to the standard deviation of output for 3,008 runs (3,008 different parameter combinations, including variations of random seed). The combinations of the parameters of Tab. (4) are found via a Latin hypercube sampling (LHS). For this purpose, the baseline values were in- and decreased by 10%.

Figure 18: Distribution of correlation of consumption, real wages, prices, employment, inflation and real interest rate with output



Plot shows the distribution of correlation coefficients of consumption, real wages, employment, prices, inflation and real interest rate with output for 3,008 runs (3,008 different parameter combinations, including variations of random seed). The combinations of the parameters of Tab. (4) are found via Latin hypercube sampling (LHS). For this purpose, the baseline values were in- and decreased by 10%.

6.7 Additional statistics on the distributive effect of short-time work

Table 5: Fixed effects estimation in support of the supply effect (short-time work)

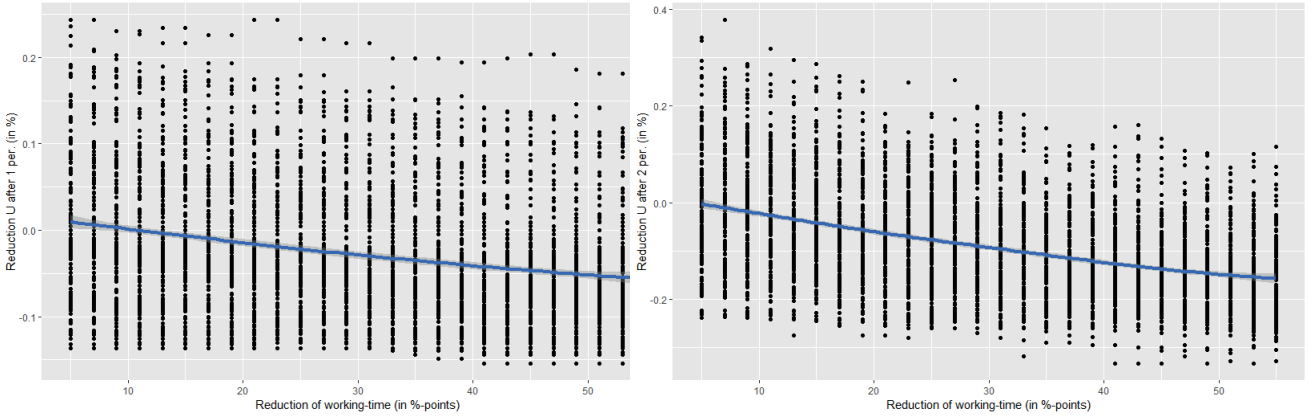
	Dependent variable:			
	diffUnempL1	diffUnempL2	diffUnempL3	diffUnempL4
	(1)	(2)	(3)	(4)
reduction	-0.001^{***}	-0.003^{***}	-0.005^{***}	-0.006^{***}
	(0.00002)	(0.0001)	(0.0001)	(0.0001)
Observations	4,160	4,160	4,160	4,160
R^2	0.640	0.470	0.472	0.493
Adjusted R^2	0.626	0.448	0.451	0.473
F Statistic (df = 1; 3999)	$7{,}111.600^{***}$	$3{,}541.089^{***}$	$3{,}578.735^{***}$	$3{,}895.714^{***}$
Note:				*p<0.1; **p<0.05; ***p<0.01

The table shows the effect of the reduction of working hours on the relative difference in unemployment after one, two three and four periods. The models are estimated via a fixed effect estimator with random seed being the fixed effect. $diffUnempL$ denotes the relative difference in unemployment after one, two, three and four periods in comparison to the rate of unemployment before short-time work program starts. *reduction* denotes the reduction in hours worked in percentage points. The compensation is held constant at 60% of the loss in net wage. The reduction of hours worked varies, discretely, between 5%-points to 50%-points with an increment of 2%-points. The model was simulated for 160 runs per increment.

Figure 19: Relation working-time reduction (in %-points) and unemployment reduction (in%)

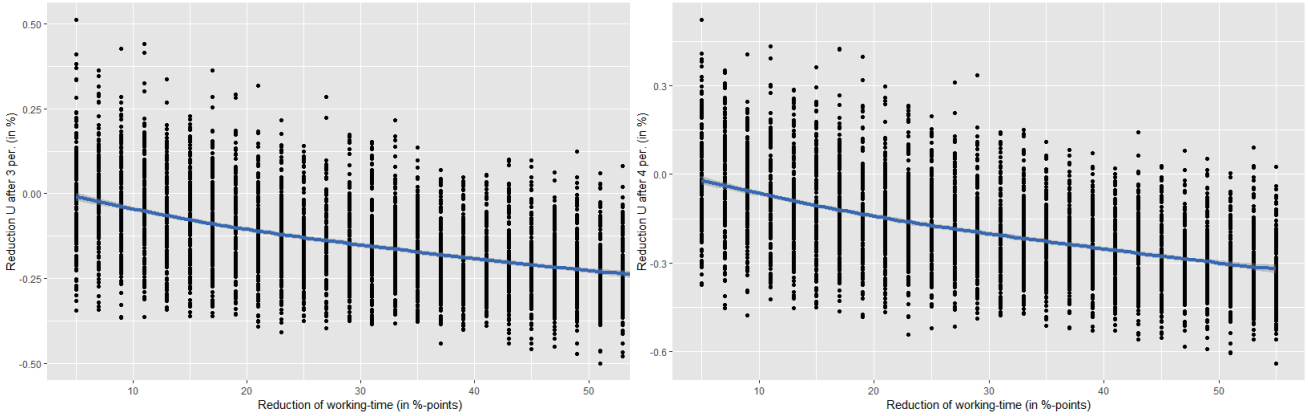
(a) Effect of working-time reduction one period after introduction of short-time work

(b) Effect of working-time reduction two periods after introduction of short-time work



(c) Effect of working-time reduction three periods after introduction of short-time work

(d) Effect of working-time reduction four periods after introduction of short-time work



Graphs present the relation between working-time reduction and the reduction of the unemployment rate. For this pupose, the short-time work program stays constant with respect to the compensation of 60% of the loss in net wage and is active for four periods. The working-time reduction is measured in %-points while the reduction in the unemployment rate is measured in %. The graphs show the effect one, two, three and four periods after the short-time work program was introduced. The blue line depicts the smoothing via a LOESS-regression.

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