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Rates: The Role of Age**

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Unemployment Benefits and Interest Rates: The Role of Age

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Abstract

This paper studies how unemployment benefits affect aggregate outcomes through general equilibrium effects. First, we document that lower unemployment benefits tend to reduce the real interest rate in a structural vector autoregression with narrative sign restrictions. Young workers experience greater employment gains than older workers. An overlapping generations model with labor market frictions rationalizes these findings. Reduced benefits boost employment among younger working-age populations, raising their incomes and enabling them to reduce borrowing, which in turn lowers real interest rates. This endogenous interest rate response amplifies the expansionary effects of the benefit reduction. The interest rate channel proves quantitatively relevant, suggesting important general equilibrium considerations for unemployment benefit design.

Keywords: Unemployment benefits, narrative SVAR, life-cycle model, real interest rate, search and matching

JEL-Codes: E24, E21, E43

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1 Introduction

Unemployment insurance is a key characteristic of advanced economies. While unemployment insurance allows consumption smoothing and is an important automatic stabilizer in economic downturns (McKay and Reis, 2021; Kekre, 2023), it may distort job search behavior, labor supply and wage setting (Schmieder and Von Wachter, 2016). Given these competing effects, understanding the net impact of unemployment benefits on aggregate economic outcomes remains both a central question in macroeconomics and labor economics and a contentious issue in policy debates.

We contribute a novel perspective to the debate by documenting that unemployment benefits have systematically different effects across age groups. This age heterogeneity has previously unrecognized general equilibrium consequences. We find that benefit cuts increase employment, in particular, among younger working-age populations and affect the life-cycle consumption-saving decisions of workers. This reduces the equilibrium real interest rate which subsequently stimulates economic activity in general equilibrium.

We make the argument in two steps. First, we provide empirical evidence using a structural vector autoregression (SVAR) to identify the aggregate effects of unemployment benefit changes. We propose a novel identification strategy that combines narrative and sign restrictions, exploiting major policy reforms in Germany over the past decades. Our results show that lower unemployment benefits persistently reduce both unemployment and the real interest rate in the medium to long run. Crucially, we find that unemployment of young workers falls by more compared to that of older workers.

Second, we develop a life-cycle model with search and matching labor market frictions that provides a theoretical foundation for these empirical patterns. The model demonstrates how unemployment benefits directly affect the equilibrium real interest rate through workers' saving decisions. Consistent with our empirical evidence, the model replicates overall income and saving increases, while younger workers are more responsive to changes in unemployment benefits. The increase in savings depresses the real interest rate, which stimulates production and amplifies the employment gains from benefit cuts. It turns out that models that ignore this interest rate channel through life-cycle consumption-saving adjustments substantially underestimate the employment and output effects of unemployment insurance.

Our SVAR uses monthly German time series data and narrative information on major policy changes between 2000 and 2019. Germany provides an ideal laboratory for this analysis for several reasons. First, there have been major reforms in the relevant time period and we can resort to the narrative dataset of exogenous social security benefit shocks as constructed by Gechert et al. (2021) to extract seven major German policy reforms of the unemployment benefit system. These include the major reforms between 2003 and 2005, known as the 'Hartz' reforms. Second, administrative data from the German Public Employment Agency allows us to construct precise measures of aggre-

gate unemployment benefit expenditures. Combining this expenditure series and the narrative shocks allows us to identify the general equilibrium effects of unemployment benefit shocks with a hybrid approach using narrative sign restrictions on the shocks and sign restrictions on the impulse responses of the expenditure series. We document that an unemployment benefit cut reduces the unemployment rate in a significant and persistent way. The interest rate tends to increase in the short run, but falls in the medium to long run by up to 0.1 percentage points. We decompose the unemployment response by age and find that unemployment of young workers (age 15-24) responds by more than twice as much as unemployment of older workers (older than 55). These results should be interpreted as average effects over the whole sample period and may differ, for example, in deep recessions.

We formalize our empirical findings through a life-cycle model as going back to Auerbach et al. (1987) and Ríos-Rull (1996). Following the seminal work of Diamond (1982), Mortensen (1982), and Pissarides (1985), we combine the life-cycle model with a labor market where job matching is costly and time-consuming for firms, creating unemployment in equilibrium and generating disincentive effects of unemployment benefits through Nash wage setting.

We categorize agents into three life-cycle stages: young households (who do not work), middle-aged households (who can be either employed or unemployed), and retired households. All age groups face intertemporal consumption-saving decisions, though only middle-aged households participate in the labor market. Following standard practice in the search and matching literature, we treat labor supply as exogenous. However, employment rates, wages, and unemployment benefits all influence the consumption-saving choices across the life cycle. Consequently, the equilibrium interest rate becomes endogenously determined by labor market characteristics, including the generosity of unemployment insurance.

The key insight is that unemployment benefit cuts affect workers differently depending on their life stage. As unemployment benefits distort Nash wage setting, reducing benefits leads to lower wages and stimulates job creation. This is the contractionary equilibrium effect of unemployment benefits on labor demand as prominently stressed by Hagedorn et al. (2019). In our model, the implied employment gains more than offset the losses from reduced wages and benefits, leading to higher overall income of all working-age groups. Young workers benefit the most from this income increase, because they have entered the labor market more recently, hold fewer existing contracts and gain the most from job creation. This last effect aligns with our empirical evidence that youth unemployment falls the most. The policy further benefits the oldest working-age groups, as these contribute the most to financing unemployment benefits through taxes. Benefit cuts reduce their tax burden accordingly. These income changes affect life-cycle consumption and saving patterns. Prime-age workers will optimally choose to borrow more, while the younger workers borrow less and older workers save more.

Consumption increases across all age groups, with the youngest workers benefiting the most. The income increase further drives up savings, which in turn depresses the real interest rate in equilibrium.

Lower real interest rates reinforce job creation by reducing the opportunity cost of investing in future employment. By incorporating life-cycle saving and borrowing decisions – we call this the real interest rate channel in the following –, our model substantially amplifies the expansionary effects of benefit cuts compared to standard models that ignore this mechanism.

The real interest rate channel matters quantitatively. Using a calibrated version of the model for the German economy, we find that unemployment benefit cuts can have substantial expansionary effects on output and employment in the long run. Output rises by 0.4 percent in response to a one percent unemployment benefit cut. Compared to a representative agent model, the elasticity is thirteen times higher. This suggests that the real interest rate channel plays a quantitatively large role. The amplification is particularly strong in labor markets with greater search frictions, such as those in Europe as they benefit more strongly from the positive employment effects of the reforms.

The short-run effects of an unemployment benefit cut differ substantially from the long-run effects: As employment responds more sluggishly compared to the wage, an unemployment benefit reduction decreases the income of working-age groups in the short run. They reduce consumption and their savings, putting, in contrast to the long-run adjustment, upward pressure on the real interest rate. Once employment starts to increase, the effects are reversed and follow the long-run pattern as discussed above.

In principle, alternative economic mechanisms may also explain why unemployment benefits affect real interest rates in general equilibrium. If higher unemployment benefits are financed with public debt, increased government borrowing may put upward pressure on interest rates. Similarly, if lower unemployment benefits stimulate economic activity, they will increase investment and capital demand, putting upward pressure on the interest rate.

In our baseline model, unemployment benefit cuts imply lower distortionary labor taxes on workers. As a robustness check, we examine financing through government debt instead. Under debt financing, the real interest rate channel weakens: the elasticity drops to -0.29 (from -0.4). This occurs because with debt financing, the immediate income gains for working-age groups through lower taxation disappear. Older workers, in particular, increase their savings less in this scenario, resulting in a smaller decrease in real interest rates.

Further, we extend our baseline model by adding capital as a second production input. While higher capital demand indeed dampens the reduction of the interest rate due to benefit cuts, the real interest rate channel, as described above, remains quantitatively relevant. Therefore, introducing physical capital affects the results only quantitatively. If lower unemployment benefits trigger precautionary savings, this may also reduce the

interest rate (Kekre, 2023; Dengler et al., 2025). We consider this mechanism as complementary to the one that we focus on. Precautionary savings could potentially strengthen our interest rate channel as younger workers have a higher lifetime risk of being unemployed and are particularly exposed to save more (borrow less) if unemployment benefits are reduced. This would put even more downward pressure on the real interest rate, amplifying our channel. Simultaneously, lowering benefits may become less expansionary or may even be contractionary if precautionary savings increase by a lot and aggregate demand drops. Such a scenario is particularly likely in recessions or at the zero lower bound. Further, in the short run, the increased economic activity due to lower unemployment benefits triggers a monetary policy response (Christiano et al., 2016). Our model focuses on the long-run adjustment, leaving monetary policy interactions aside. As a result, our results should be interpreted as average long-run effects.

Our paper examines how unemployment benefits influence wage setting, life-cycle financial decisions, and consequently real interest rates across age groups. However, we do not model other beneficial labor market effects of benefit cuts. For instance, reduced benefits may incentivize greater job search effort among the unemployed or improve job matching quality. Lichter and Schiprowski (2021) demonstrate with German data that extending unemployment benefit duration by one month reduces search effort. We exclude these additional mechanisms because they would likely amplify our results if they made unemployment benefit cuts even more effective.

Related literature Our paper relates to different parts of the existing literature. First, there is a large literature on optimal unemployment insurance (Bailey, 1972; Chetty, 2006). Landais et al. (2018b) extend this approach to take into account general equilibrium effects through labor market tightness. Michelacci and Ruffo (2015) analyze the optimal unemployment insurance in a life-cycle setting under search frictions. They find that younger generations respond differently to unemployment benefits compared to older generations. They highlight a significant consumption gap between unemployed and employed households, which widens for younger households. As a result, consistent with our model, younger households benefit more from unemployment benefits. Mitman and Rabinovich (2015) analyze optimal cyclical unemployment insurance in a search model. Their results show that unemployment benefits should be pro-cyclical. Our paper distinguishes itself from this literature in several ways. First, we do not examine welfare or age-dependent unemployment benefit reforms. Second, this literature does not explore the impact of the real interest rate channel.

Second, Christiano et al. (2016) use an estimated general equilibrium search and matching model with nominal rigidities to document an important relation between unemployment benefits, price stickiness, and monetary policy. When lower unemployment benefits reduce wages, lower inflation implies an expansionary monetary policy response lowering interest rates. They show, among other things, that a transitory one percentage point increase in unemployment benefits increases the unemployment rate between

0.15 and 1.25 percentage points in the short run, while the effects may revert at the zero lower bound. Our paper further relates to the literature that studies unemployment benefits with heterogeneous agents in general equilibrium models (McKay and Reis, 2021; Kekre, 2023). While these studies investigate insurance in incomplete asset markets, we focus on distinct age groups from a long-run perspective.

Third, a number of empirical papers estimate the effects of unemployment insurance extensions. Schmieder and Von Wachter (2016) review the literature on partial equilibrium effects on the labor market. One prominent finding of these microeconomic studies is that a longer potential unemployment benefit duration substantially prolongs actual unemployment duration. It is well documented that the general equilibrium effects of unemployment benefits may differ from partial equilibrium effects. Recent studies that focus on local general equilibrium effects of unemployment benefits policies tend to find effects close to zero. Examples include Acosta et al. (2023) who also provide an excellent literature survey.¹ Interestingly, Acosta et al. (2023) find that the effect is small when the initial benefit duration was already long, whereas effects can be much larger when duration was initially short. Importantly, however, these *local* general equilibrium effects as typically identified from cross-sectional variation do not include *national* general equilibrium effects. The interest rate channel that we are interested in is thus not captured by these estimates. This is why we propose a structural time series identification instead. Further, these studies typically evaluate temporary policy changes, while we focus on permanent policy reforms.

Rünstler (2024) is closely related to our empirical analysis in terms of its methodology. He utilizes narrative labor market sign restrictions in a panel setup for European countries to quantify the effects of labor market reforms and finds that unemployment benefit cuts lead to higher output and employment, in line with our findings. However, he does not analyze the interest rate or age-dependent behavior. Gechert et al. (2021) estimate the aggregate effects of shocks to social security in Germany. They find a positive multiplier suggesting that an additional Euro spent on social security expenditures increases GDP by somewhat more than one Euro. In contrast to us, their expenditure shocks include expenditure on pensions, health care, long-term care, basic social security and family benefits next to unemployment benefits. They argue in favor of a strong demand stimulus of expenditure shocks. We find a negative effect of unemployment benefit expenditure. This discrepancy can be explained by the fact that unemployment insurance as one component of social security is subject to substantial distortionary effects, e.g., by increasing wages and discouraging job search, while the remaining social security components may indeed stimulate demand.

Fourth, we relate to the literature that studies the downward trend in interest rates over the last decades. Among others, Carvalho et al. (2016) and Auclert et al. (2025) show that the demographic transition towards an older population tends to put downward

¹ Famous contributions are Boone et al. (2021), Chodorow-Reich et al. (2019), Landais et al. (2018a), Marinescu (2017), Hagedorn et al. (2015) and Jessen et al. (2025).

pressure on real interest rates. We highlight that unemployment benefit reforms also affect interest rates.

Outline The remainder of the paper is organized as follows. Section 2 shows the empirical results of the SVAR model with narrative sign restrictions. Section 3 develops the life-cycle model with equilibrium unemployment, discusses how the steady state real interest rate depends on labor market characteristics, and introduces the calibration of the model. Section 4 examines the steady-state properties of the model at various levels of unemployment benefits, as well as the dynamic adjustments of the model following an unemployment benefit reform. Section 5 provides quantitative results, model extensions and robustness. Section 6 concludes.

2 Empirical evidence

In this section, we identify and estimate the aggregate effects of lower unemployment benefits using a structural vector autoregressive model (SVAR) with narrative sign restrictions. In particular, we will document the effects of unemployment benefits on interest rates and on unemployment of workers of different ages.

2.1 The narrative SVAR model

We construct a SVAR model with a combination of traditional sign restrictions on the impulse responses and narrative sign restrictions on the shocks in the spirit of Antolín-Díaz and Rubio-Ramírez (2018). The general structural form of the VAR model is as follows:

$$A_0 y_t = c + \sum_{l=1}^p A_l y_{t-l} + \epsilon_t, \quad (1)$$

where y_t is an $n \times 1$ vector of time series and p is the lag length. We set $p = 12$ for monthly data. A_l is an $n \times n$ matrix of parameters for $0 \leq l \leq p$. The model includes a constant c ($1 \times n$) and ϵ_t is the vector of structural shocks which is normally distributed with a mean of zero and the $n \times n$ covariance matrix $E(\epsilon_t \epsilon_t') = I_n$.

By using $A_0 y_t = A_+ v_t + \epsilon_t$, where A_+ is a $(np + 1) \times n$ matrix and v_t is a $(np + 1) \times 1$ matrix, we derive the reduced form representation as

$$y_t = B v_t + u_t; \quad (2)$$

with $B = A_0^{-1} A_+$, $u_t = A_0^{-1} \epsilon_t$ and $E(u_t u_t') = \Sigma_u = (A_0 A_0')^{-1}$.

We identify the structural form by imposing sign restrictions on both the impulse responses and the structural shocks ϵ . Our estimation employs Bayesian methods following the algorithm proposed by Antolín-Díaz and Rubio-Ramírez (2018). Before present-

ing our identifying restrictions, we first provide a brief overview of the German unemployment insurance system, which serves as the foundation for deriving our sign restrictions.

2.2 A short overview of the German unemployment insurance system

The German unemployment benefit system operates through two main tiers: an earnings-related insurance benefit ('Arbeitslosengeld I') and a means-tested basic allowance ('Bürgergeld'). The insurance benefit provides 60% of previous net income (67% for parents) for a duration of up to 24 months, depending on previous employment and age. These benefits are financed predominantly through payroll contributions. To be eligible, workers had to be employed for at least 12 months within the 30 months preceding their unemployment episode. Workers under 50 are eligible for a maximum of 12 months, while older workers obtain progressively longer benefit periods: those aged 50-54 can receive up to 15 months of benefits after 30 months of employment, and workers aged 58 and above can receive up to 24 months of benefits if they have contributed for 48 months. There are specific provisions for workers who have only been employed for short periods. Workers who have exhausted unemployment insurance or who are for other reasons not eligible for insurance receive the basic allowance that is independent of age but has significantly lower benefit levels unrelated to previous earnings. This study focuses on the unemployment insurance system in the following.

The German unemployment system has undergone major reforms over the last few decades, one prominent example being the 'Hartz' reforms that were implemented between 2003 and 2005. These changes have affected the criteria for eligibility, the duration of benefits, and the amount provided. The Hartz reforms further increased labor market flexibility towards non-standard employment. For more information about the Hartz reforms, please see, e.g., Launov and Wälde (2016); Hochmuth et al. (2021). As we discuss in the next subsection, we will exploit these and other reforms for the identification of unemployment benefit shocks. The details of the reforms that we use for identification are discussed more thoroughly in Appendix A.1.

2.3 Identification of unemployment benefit shocks

Unemployment benefits change in response to the business cycle and due to exogenous, e.g., policy-related reasons. To isolate the effect of unemployment benefits on the economy, we propose a strategy to identify the latter effect using a mixture of traditional and narrative sign restrictions on the actual expenditures of the public employment agency on unemployment benefits. As exogenous changes to unemployment benefits are relatively rare events, narrative sign restrictions are well-suited for our analysis because they require fewer policy events than e.g., in the case of the instrumental variables. Narrative sign restrictions rely on events, for which researchers agree on the sign and

importance of the shock and/or the responses of other variables. In our context, we use seven narrative events that have substantially changed the German unemployment benefits system in the last decades. These include the major labor market reforms, known as the Hartz reforms around 2005. We rely on events as collected by Gechert et al. (2021), who document major social security law changes in Germany, classify them according to whether they are structural or cyclical and estimate the impact of the law changes in Euros. We restrict the analysis to policies that are explicitly related to unemployment benefits.² We further restrict the analysis to major reforms with an overall impact of above one billion euros. For identification, we only use the sign of a policy shock and not the size.

For narrative identification, the timing of the shocks is crucial. We use the implementation date of the policies as the publication dates and implementation dates are usually only a couple of days apart. For only two policy changes, the implementation date and publication date are three months apart. For example, the ‘Hartz IV’ reform was enacted in late 2003, but was implemented in 2005. To take out potential anticipation effects, we remove this policy change in a robustness check (see Section 2.6). Table 1 lists the seven events that we use for identification, the publication and implementation dates of the policies, and the implied sign restrictions on expenditures on unemployment benefits that we derive. Five events have a negative sign and two events have a positive sign. The signs follow the Gechert et al. (2021) database. If a policy event increases the Euro amount of paid unemployment benefits or the budget of the German employment agency, we assign a positive sign; if a policy decreases the Euro amount of paid unemployment benefits or the budget of the German employment agency, the policy gets a negative sign. For example, the Hartz 1&2 reforms implied budget cuts of 6.46 billion Euros. Thus, we impose a negative sign restriction in 2003m1.

Besides the narrative restrictions, we add sign restrictions on the impulse responses and restrict the expenditure on unemployment benefits for the first six periods of the impulse horizon to be negative.

Our narrative sign restrictions on the Hartz reforms are in line with a large literature that evaluates these reforms. They agree on the importance and sign of the unemployment benefit response (see, e.g., Hochmuth et al., 2021; Rünstler, 2024).

2.4 Data on unemployment benefit expenditures

In the spirit of the fiscal policy SVAR literature that uses government spending, we use data on expenditures on unemployment benefits in the following. The German public employment agency provides a time series on the gross benefit payments to the unemployed in Germany starting in 2000. Table 5 in Appendix A.1 provides details about

² Gechert et al. (2021) evaluate general changes in the social security system (including health insurance and the pension system), not only unemployment benefits. Unemployment benefit policies in Germany are scarce. That is one of the reasons why this paper uses narrative sign restrictions and not an IV-VAR as Gechert et al. (2021).

	Policy event	Publication	Implementation	Sign on UB
(1)	One-time payment regulation law	12/01/2000	01/01/2001	+
(2)	Hartz 1&2	12/23/2002	01/01/2003	-
(3)	Hartz 3 and reforms on the labor market	12/23/2003 12/30/2003	01/01/2004	-
(4)	Hartz 4	12/23/2003	01/01/2005	-
(5)	Contribution rate change 2007	12/21/2006	01/01/2007	-
(6)	Contribution rate change, UB adjustments for older unemployed	12/22/2007	01/01/2008	+
(7)	Law to Improve Integration Opportunities in the Labor Market	12/20/2011	04/01/2012	-

Table 1: Narrative sign restrictions as imposed on the shock on unemployment benefit expenditures (UB) and the underlying policy events. The policy events are translated from German; please refer to Appendix A.1.1 for the original wordings.

data sources of all data used in this paper. Gross benefit payments include the net unemployment benefits and contributions to health, care, and retirement insurance. We include these contribution payments for two reasons. Firstly, while unemployed individuals do not gain immediate benefits from insurance contributions, the payments are immediately utilized in the economy, as the German insurance system operates on a pay-as-you-go basis. Therefore, we regard these payments as fiscal expenditures. Secondly, the distinction between these four groups has only been possible since 2003. By using all four components, we are able to analyze an additional three years of data. We check for robustness when we include only net unemployment benefits below.

We adjust the series by the consumer price index level. As total benefit expenditure changes when either the number of unemployed or the benefit per unemployed changes, we refer to the expenditures per unemployed person in the following.

Figure 1 shows the real unemployment benefits per unemployed person from 2000:M1 to 2019:M12. There is substantial variation in the series that is the result of the major reforms of the system, but also reflects the composition of the unemployment pool. As unemployment benefits depend on previous earnings, the state of the labor market, the current wage level and composition effects (who becomes unemployed) all affect the expenditure by unemployed person. As we want to isolate exogenous unemployment benefit policy changes, we use the previously described combination of narrative and sign restrictions.

Figure 1 further shows the implementation dates of the seven narrative events that we use to identify the unemployment benefit shock. It highlights that the unemployment benefit expenditure has fallen substantially after the Hartz reforms.

This time series offers several advantages. It allows us to directly measure the amount spent on unemployment benefits, specifically how much is distributed to unemployed households in Euros. This expenditure impacts household budgets and their spending

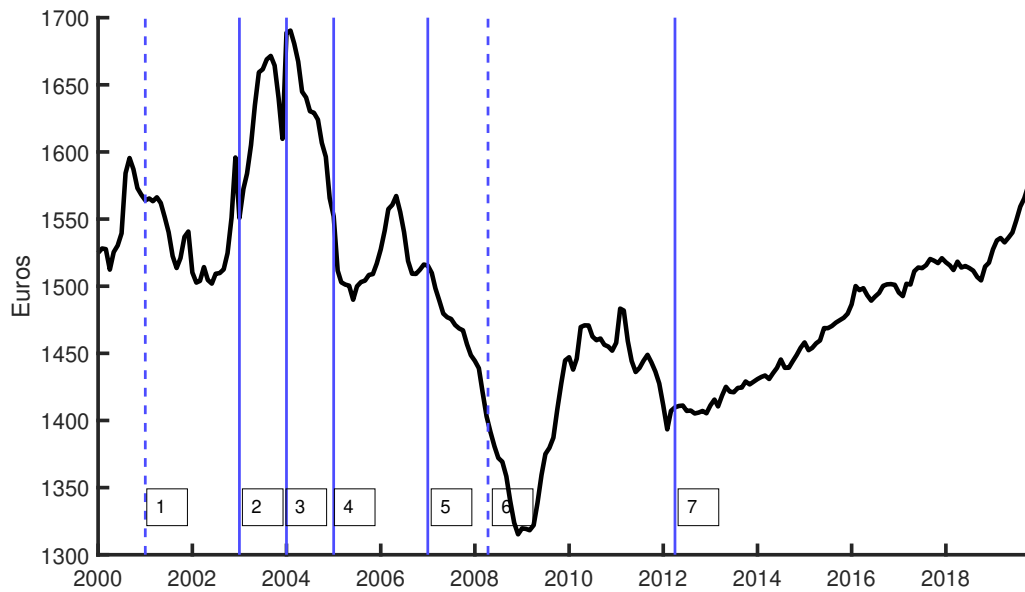


Figure 1: Time series on real unemployment benefits. Black: real unemployment benefit expenditures per unemployed, dashed blue: policy change with positive sign, blue: policy change with negative sign (compare Table 1). Time period: 2000:m1-2019:m12.

habits.

In contrast, other measures often calculate the net replacement rate or unemployment benefits for various subgroups indirectly, typically as a percentage of former wages for an artificial household. These estimates are more theoretical and do not necessarily capture actual unemployment benefit expenditures.

2.5 Results

First, we analyze the effects of an unemployment benefit policy change on the aggregate unemployment rate and the real interest rate. In a second step, we focus on the effect of these policies on unemployment by age.

Baseline model The first model consists of three variables in y_t ($n = 3$) at monthly frequency: the log of the real unemployment benefit expenditures per unemployed, the log of the unemployment rate, and the real interest rate (real one-year German bond yield).³ The analysis focuses on the period January 2000 to December 2019. The starting date is determined by the availability of the unemployment benefit expenditure series and we end before Covid-19.

Figure 2 shows the posterior median impulse response functions (IRFs) of a one-standard-deviation negative shock to unemployment benefit expenditures and the 68%

³ Table 5 in Appendix A.1 provides all data sources, Figure 12 in Appendix A.1 presents a plot of the time series. All variables are seasonally adjusted.

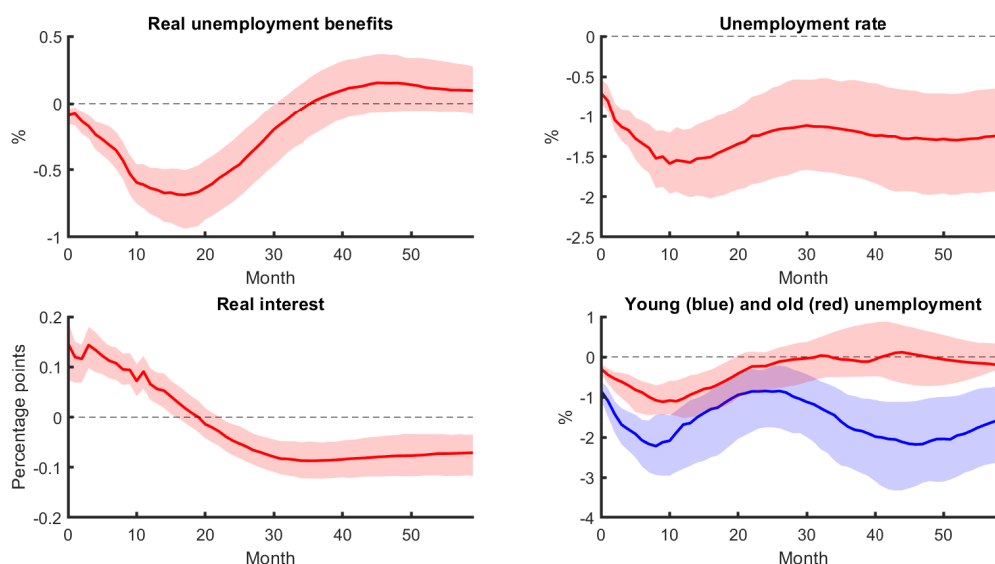


Figure 2: Impulse responses to a negative one-standard-deviation shock to unemployment benefit expenditures in baseline SVAR. Shaded areas: 68% highest posterior density (HPD) credible sets. Baseline SVAR: Real unemployment benefits, unemployment rate, real German 1-year bond yield; Extension (second row, second column): Instead of the unemployment rate, we use (i) young (15-24) unemployment (blue) and (ii) old (55+) unemployment (red).

credible sets. The median IRFs are computed based on 120,000 draws that satisfy the traditional sign restrictions. Of those, around 0.9% satisfy the narrative sign restrictions. Figure 2 documents that a policy that reduces unemployment benefit expenditures per unemployed significantly reduces the unemployment rate. The reduction in unemployment is very persistent and lasts for up to 5 years. The peak reaction is around -1.5%. The shock further leads to upward pressure on the real interest rate in the short run and reduces the real interest rate in the long run by up to 0.1 percentage points.

While the finding of lower unemployment is in line with theories that argue that lower benefits are expansionary as they reduce wages and stimulate job creation (Hagedorn et al., 2019), the intuition for the response of the interest rate is less obvious. In a larger VAR with the nominal interest rate and inflation (instead of the real rate) and industrial production as additional variables (see Figure 6 in the Appendix), we find that the shock is expansionary also in terms of production, while it does not significantly affect inflation. The short-run increase of the real interest rate is in line with a monetary policy tightening in response to the expansion in production. If the shock was deflationary, monetary policy should reduce the interest rate (Christiano et al., 2016). The long-run response of the interest rate is determined by multiple demand and supply channels. If the cut in benefits reduces government borrowing and, hence, bond supply, this generates downward pressure on the interest rate. If lower benefits incentivize precautionary savings, this additional bond demand would also put downward pressure on the interest rate. In the following, we will show that the effect on unemployment is heterogeneous by age, triggering changing patterns of intergenerational saving and borrowing that ra-

tionalize the reduced interest rate in the long run and imply amplification due to general equilibrium effects. We will further show that our model predicts a short-run increase in the real interest rate due to sluggish employment adjustment under frictions.

However, next, to provide some more intuition first, we analyze the responses of hourly wages relative to industrial production to an unemployment benefit shock.⁴ We can do so by simply adding the variable as a sixth variable to the baseline VAR. Figure 7 in Appendix A.1 shows the corresponding IRFs. In line with the intuition above, wages fall relative to production in response to a negative shock.

When we compare our result to the literature, Rünstler (2024) is the closest paper in terms of methods. He uses a panel-SVAR for European countries to identify the impact of unemployment benefit reforms using sign restrictions. For Germany, he uses only one narrative event for identification, namely the Hartz reform. Consistent with our findings, he documents that labor market reforms that reduce unemployment benefits increase output and employment.

Unemployment by age groups We will now document that unemployment benefit policies have heterogeneous effects across different age groups. To do so, we rerun the previous VAR, but instead of using the aggregate unemployment rate, we use (1) the unemployment level of young workers (15-24) and (2) old workers (55 and older) separately. Figure 2 shows the IRFs (second row, second column). The red line shows the reaction of the older workers' unemployment, the blue line shows the reaction of the younger workers' unemployment after an unemployment benefit shock.

Qualitatively, the results are similar to the analysis of the overall unemployment rate. In both cases, unemployment of both groups decreases after a negative unemployment benefit shock. However, the reaction of the unemployment of the young is stronger and much more persistent compared to the median IRF of the older unemployed. To analyze potential mechanisms and implications of this result, we construct a life-cycle search and matching model below.

2.6 Discussion and robustness

One may worry that the above results for young and older workers may be biased due to labor force adjustments. There are two main reasons: (i) older workers have the option of early retirement, which may lead them to exit the labor force if unemployment benefits are reduced, and (ii) younger workers may choose to pursue additional education or training instead of remaining in the labor force. In both cases, unemployment falls not because more people find jobs, but because people leave the labor force entirely, causing us to overestimate the true effectiveness of the policy change in terms of reducing

⁴ As the benefit cut is expansionary, higher production and higher labor demand put upward pressure on wages. We divide wages by industrial production to isolate the effect of lower unemployment benefits on the outside option of workers.

unemployment.

To address this concern, we focus our analysis on middle-aged workers (25-64) who lack the alternative options available to younger and older workers, namely, returning to education or taking early retirement. As documented in Appendix 9, the unemployment reduction for the middle-aged lies between those of the older and younger groups. Thus, middle-aged workers react more than older workers and less than younger workers. show a moderate response that falls between the stronger reaction of younger workers and the weaker response of older workers.

This implies that even when taking into account that we potentially overestimate the unemployment reduction of older workers, the gap between the responses of the middle-aged and the older workers would only go up. As a result, we argue that older workers indeed react less than middle-aged workers and we potentially estimate a lower bound here. Now consider the extreme case that the difference between the young and the middle-aged would be only explained by labor force exits of young workers. This would imply that the response of the youngest group would be identical to the one of the middle-aged when fixing labor force participation. However, even in this extreme scenario, older workers continue to see more moderate unemployment reductions compared to both younger age groups.

To remove potentially anticipated policy changes, similar to Mertens and Ravn (2013), we remove policies where the implementation lag is more than one quarter. This concerns the Hartz 4 reform implemented in 2004 and the law on integration opportunities in 2012. The IRFs are presented in Figure 10 in Appendix A.1. They are very similar to our baseline results. The additional restrictions primarily influence the response of the unemployment rate, making its effect somewhat more pronounced in the baseline.

We conduct several further robustness tests. First, our result does not depend on econometric specifications. Adding lags or using fewer lags does not change the result. Further, adding a linear time trend also does not change the result. Second, we obtain a similar result if we use unemployment (in log levels) or the unemployment rate not in logs.

For further robustness, we use the 2-year and 10-year German bond yields. Figure 8 in Appendix A.1 shows the impulse response function for different yields of German bond maturities. In principle, the shape of all three looks similar, but the longer the maturity, the smaller the reaction. Thus, short-term interest rates react more strongly to an unemployment benefit policy than long-term interest rates.

As a final robustness check, we examine net benefit payments, which include only unemployment benefits and exclude contributions to health, care, and retirement insurance. This limits our analysis to the period from 2003 to 2019, allowing us to consider only six out of the seven policy events that we previously used (one occurred in 2001). Figure 11 in Appendix A.1 presents the results. Generally, the results are consistent with our baseline findings. The shock leads to a reduction in net real unemployment benefits, the unemployment rate, and German one-year bond yields. In contrast, industrial

production increases, while inflation shows no significant response.

3 Model

The aim of this section is to develop an overlapping generations model with labor market frictions that will, first, rationalize a lower interest rate after a reduction in unemployment benefits in line with our empirical evidence above, and, second, show that the interest rate channel amplifies the responses of the benefits policy in general equilibrium.

The model consists of households, firms, and the government in a closed economy. We analyze three household types defined by age and work status: young non-participants, middle-aged workers, and elderly retirees. Depending on their type, households save and borrow in a one-period bond. Representative firms produce with labor input only, sell under perfect competition, and hire subject to search and matching labor market frictions. The model features steady-state unemployment and wage bargaining. For simplicity, all workers earn the same (union) wage. The government finances unemployment benefits using taxes (in an extension, using government debt). Our basic model does not have any nominal rigidities and has no role for a central bank.

3.1 Households

At each point in time, the model consists of twelve age-groups: one young, not yet working (indexed by y), ten middle-aged, i.e., of working age (indexed by m, a where $a = 1, \dots, 10$ refers to the age groups of the different middle-aged) and one old retired (indexed by o).⁵ There is no population growth, i.e., every newborn cohort has the same size.

Households live for twelve periods (this will correspond to 60 years in our calibration later), discount future utility from consumption with discount factor β when making their consumption, borrowing, and saving decisions. There is no labor supply decision. The representative household born at time t maximizes the following utility U

$$U_t = \max_{c_t^y, c_{t+1}^{m,a}, c_{t+a+1}^o, b_t^y, b_{t+a}^{m,a}} \left\{ \log(c_t^y) + \sum_{a=1}^{10} \beta^a \log(c_{t+a}^{m,a}) + \beta^{10+1} \log(c_{t+a+1}^o) \right\}. \quad (3)$$

When young, no household member works, but they apply for jobs for the next period. They finance their consumption (c^y) with debt (b^y). Their budget constraint reads as

$$c_t^y = b_t^y. \quad (4)$$

Each member of a middle-aged household is either employed (share n) and earns wage (w) or unemployed (share u) and gets unemployment benefits (b^u). They borrow in terms

⁵ Notation: $(m, a - 1) = (m, 0) = y$ if $a = 1$ and $(m, a + 1) = (m, 11) = o$ if $a = 10$.

of bonds, pay back last period's bonds or save in bond holdings ($b^{m,a}$). In each age-group household, employed and unemployed household members pool their consumption. Bonds return the gross interest $1 + r$ in the next period. Every working age-group pays a fraction of their labor income as taxes (τ) to finance unemployment benefits. The middle-aged earn profits of the firms. Profits are distributed proportionally to labor income among the working age-groups ($\Pi^{m,a}$). Hence, the budget constraint of middle-aged households is

$$c_{t+a}^{m,a} = (1 - \tau_{t+a})w_{t+a}n_{t+a}^{m,a} + u_{t+a}^{m,a}b_{t+a}^u - (1 + r_{t+a-1})b_{t+a-1}^{m,a-1} + b_{t+a}^{m,a} + \Pi_{t+a}^{m,a} \quad (5)$$

for $1 \leq a \leq 10$.

When old, households retire, do not work anymore and finance their consumption (c^o) with bond holdings from the previous period.

$$c_{t+10+1}^o = -(1 + r_{t+10})b_{t+10}^{m,10} \quad (6)$$

Households' optimal behavior yields the following Euler equations

$$\frac{1}{c_t^y} = (1 + r_t)\beta \frac{1}{(c_{t+1}^{m,1})} \quad (7)$$

$$\frac{1}{c_t^{m,a}} = (1 + r_t)\beta \frac{1}{(c_{t+1}^{m,a+1})} \quad \text{for } 1 \leq a \leq 9 \quad (8)$$

$$\frac{1}{c_t^{m,10}} = (1 + r_t)\beta \frac{1}{(c_{t+1}^o)} \quad (9)$$

which implies that in equilibrium, the following relationship holds:

$$\frac{1}{\beta} \frac{(c_{t+1}^{m,1})}{c_t^y} = \frac{1}{\beta} \frac{(c_{t+1}^{m,a+1})}{c_t^{m,a}} = \frac{1}{\beta} \frac{(c_{t+1}^o)}{c_t^{m,10}} = 1 + r_t. \quad (10)$$

This relation states that the discounted next-period consumption relative to the current-period consumption equals the real interest rate, and this relation holds for all periods and all age groups.

3.2 Borrowing and saving

We assume that young households face a borrowing constraint that depends on an exogenous collateral constraint (d_t) and the real interest rate (r_t).

$$b_t^y = \frac{d_t}{1 + r_t} \quad (11)$$

By including the real interest rate in the borrowing limit, the ability to pay back loans influences the consumption behavior of young households.

Without government debt, the bond market equilibrium requires that total borrowing

by young and middle-aged households exactly equals the savings of middle-aged households. This implies that

$$b_t^y + \sum_{a=1}^{10} b_t^{m,a} = \frac{d_t}{1+r_t} + \sum_{a=1}^{10} b_t^{m,a} = 0. \quad (12)$$

3.3 The labor market, firms, and wages

The labor market is subject to search and matching frictions and determines employment of each age group ($n_t^{m,a}$). Firms offer vacancies, and workers search for jobs. If a job seeker and a vacancy lead to a match, the job seeker is hired (employed and productive) in the next period. Firms cannot discriminate in their hiring choice between different age groups. In every period, a fixed share of jobs is separated with rate Γ , and these households search for jobs again in the same period.

Thus, members of young households, newly separated and the unemployed in each middle age-group (except for the oldest one) search for jobs. Thus, total job seekers (s_t) are given by

$$s_t = s_t^y + \sum_{a=1}^9 s_t^{m,a} = 1 + \sum_{a=1}^9 s_t^{m,a} \quad (13)$$

$$\text{with } s_t^{m,a} = (1 - (1 - \Gamma)n_t^{m,a}) \quad \text{for } 1 \leq a \leq 9. \quad (14)$$

Matches are formed randomly according to a Cobb-Douglas matching function

$$m_t = \eta^m s_t^\mu v_t^{1-\mu} \quad (15)$$

where v_t is the number of job vacancies in the economy, η^m the matching efficiency and μ defines the elasticity on job seekers. Let labor market tightness $\theta_t = \frac{v_t}{s_t}$ be the number of vacancies relative to job seekers. Then, the job finding rate follows as $p_t(\theta_t) = \frac{m_t}{s_t} = \eta_t^m \theta_t^{1-\mu}$ and the worker finding rates as $q(\theta_t) = \frac{m_t}{v_t} = \eta_t^m \theta_t^{-\mu}$. The law of motion for employment from the perspective of households is defined as follows. The employment rate of the youngest middle-aged group is only determined by the matching process and defined as employment relative to the age-group size.

$$n_{t+1}^{m,1,household} = p_t \quad (16)$$

The employment rate of every following working period depends on the matching process, employment of the previous period, and the separation rate (Γ).

$$n_{t+1}^{m,a,household} = (1 - p_t)(1 - \Gamma)n_t^{m,a-1,household} + p_t \quad \text{for } 2 \leq a \leq 10 \quad (17)$$

The total employment rate (N) follows as

$$N_t = \frac{\sum_{a=1}^{10} n_t^{m,a,household}}{\sum_{a=1}^{10} 1} \quad (18)$$

From the perspective of firms, the employment rate of each age group depends on the number of vacancies (v).

$$n_{t+1}^{m,1,firm} = \frac{q(\theta_t)v_t}{s_t} s_t^y \quad (19)$$

$$n_{t+1}^{m,a,firm} = (1 - \Gamma)n_t^{m,a-1,firm} + \frac{q(\theta_t)v_t}{s_t} s_t^{m,a-1} \quad \text{for } 2 \leq a \leq 10 \quad (20)$$

In equilibrium, the employment of the firms and households are equal.

$$n_t^{m,a,household} = n_t^{m,a,firm} = n_t^{m,a} \quad \text{for } 1 \leq a \leq 10 \quad (21)$$

Firms produce with workers from all working age groups. We assume that firms cannot differentiate between workers from different age groups when hiring and that different age groups are similar in terms of productivity a and wages w . The production function is linear in labor input

$$y_t = a_t \left(\sum_{a=1}^{10} n_t^{m,a} \right) = a_t N_t^{total}. \quad (22)$$

Firm profits (Π) are equal to production (y) minus wage costs minus vacancy posting costs (χ).

$$\Pi_t = y_t - \sum_{a=1}^{10} n_t^{m,a} w_t - \chi v_t \quad (23)$$

Profits are distributed proportionally to labor income among the working-age groups.

$$\Pi_t^{m,a} = \frac{w_t n_t^{m,a}}{w_t \sum_{j=1}^{10} n_t^{m,j}} \Pi_t \quad \text{for } 1 \leq a \leq 10 \quad (24)$$

Firms maximize the firm's net present value of a job J over the number of vacancies v_t

$$J_t = \max_{v_t} y_t - \sum_{a=1}^{10} n_t^{m,a} w_t - \chi v_t + \left[\frac{1}{1 + r_t} J_{t+1} \right], \quad (25)$$

subject to the constraints (19), (20), (22) from above. Future profits are discounted with the discount factor and the marginal utility of consumption using Equation (10).

From the first-order condition follows the job creation condition as

$$\frac{\chi}{q(\theta_t)} = \left\{ \sum_{a=1}^{10} \frac{s_t^{a-1}}{s_t} \left[\sum_{j=0}^{10-a} \left(\prod_{h=0}^j \frac{1}{1+r_{t+h}} \right) (1-\Gamma)^j (a_{t+1+j} - w_{t+1+j}) \right] \right\} \quad (26)$$

Firms create vacancies as long as the cost of hiring is lower than the benefits. As job creation is a forward-looking decision, it depends on the real interest rate. If the real interest rate increases, this increases the opportunity cost of hiring, decreases the future value of jobs, and, in turn, job creation. Higher productivity increases job creation; higher wages decrease job creation as employees become more expensive. A higher separation rate decreases job creation as employees are expected to stay a shorter period in the firm. In our model, these terms are weighted by the shares of each age group among the job seekers. Intuitively, firms care about the age of the worker that they hire, as older workers have a shorter expected remaining working period.

The real wage w is determined via Nash bargaining over the mutual surplus of a match between workers and firms

$$\max_{w_t} \left(\underbrace{\sum_{a=1}^{10} \frac{\partial J_t}{\partial n_t^{m,a}}}_{\text{Firm surplus}} \right)^{1-\gamma} \left(\underbrace{\sum_{a=1}^{10} \frac{\frac{\partial U_{t-a}}{\partial n_t^{m,a}} - \frac{\partial U_{t-a}}{\partial w_t^{m,a}}}{\lambda_t^{m,a}}}_{\text{Worker surplus}} \right)^{\gamma},$$

where γ is the workers' bargaining power. We assume that all workers are represented by a union. Thus, all workers earn the same wage irrespective of their age.⁶ The worker surplus is defined as the difference between the net present value of all employed workers and the net present value of all unemployed workers. For that purpose, define $\lambda^{m,a}$ the Lagrange multiplier for each age group's budget constraint. The firm's surplus is equal to the profit surplus that firms obtain for a new worker.

The wage then follows as

$$w_t = \left\{ \frac{\gamma}{\gamma + (1-\gamma)(1-\tau_t)} \left[a_t + \sum_{j=1}^9 \left(\frac{\sum_{a=1}^{10-j} 1}{\sum_{a=1}^{10} 1} \left(\prod_{h=1}^j \frac{1}{1+r_{t+h-1}} \right) (1-\Gamma)^j (a_{t+j} - w_{t+j}) \right) \right] \right. \\ \left. + \frac{1-\gamma}{\gamma + (1-\gamma)(1-\tau_t)} \left[b_t^u + \sum_{j=1}^9 \left(\frac{\sum_{a=1}^{10-j} 1}{\sum_{a=1}^{10} 1} \left(\prod_{h=1}^j \frac{1}{1+r_{t+h-1}} \right) \right. \right. \right. \\ \left. \left. \left. (1-\Gamma)^j \left(\prod_{i=1}^j (1-p_{t+i-1}) \right) (b_{t+j}^u - (1-\tau_{t+j})w_{t+j}) \right) \right] \right\}. \quad (27)$$

The wage w is a weighted average of the firm's surplus that depends on current and future productivity and wages and the worker's surplus that depends on the unemployment benefit b^u as the outside option in the bargaining. Higher unemployment benefits b^u lead to direct upward pressure on the wage according to this wage setting scheme, as

⁶ Age-groups have no incentive to leave the union because the discounted lifetime utility is at least as high with the union as without the union for each age-group at a specific point in time.

this improves the outside option of workers. The higher the worker's bargaining power γ , the higher the share of the firm profits that the workers receive in the form of wages. Compared to a representative agent setting, in our OLG model, the surpluses are finite according to the remaining working life of each age group and are not evaluated for an infinite time horizon. An increase of the separation rate Γ decreases the future value of a job and thus decreases the wage. A higher job-finding rate $p(\theta)$ decreases the future worker surplus of the current job because households will find a new job easier. Lastly, a higher contemporaneous labor tax rate (τ) increases the wage as workers are able to pass on part of the tax burden to firms.

3.4 Taxes and resource constraint

When unemployment benefits are financed by taxes and the government runs a balanced budget in every period

$$\sum_{a=1}^{10} n_t^{m,a} w_t \tau_t = \sum_{a=1}^{10} u_t^{m,a} b_t^u, \quad (28)$$

then, the tax rate follows from the costs for unemployment benefits relative to the labor income of all age groups

$$\tau_t = \frac{b_t^u \left(\sum_{a=1}^{10} u_t^{m,a} \right)}{w_t \left(\sum_{a=1}^{10} n_t^{m,a} \right)}. \quad (29)$$

The model is closed with the aggregate resource constraint

$$y_t = c_t^y + \sum_{a=1}^{10} c_t^{m,a} + c_t^o + \chi v_t. \quad (30)$$

Lastly, we normalize the total population size to one.

3.5 The equilibrium real interest rate

The equilibrium real interest rate follows from the bond market equilibrium as defined in Equation (12). Borrowing of the young is positive by definition as the young have no income and the borrowing constraint binds (see (11)). Retired old people without income do not borrow or lend, but consume all their previous savings. Borrowing or lending of the working-age groups is defined as the difference between the discounted income of the next period and the income of the current period.

$$\begin{aligned}
b_t^{m,a} &= \frac{1}{1+r_t} \frac{1}{1+\beta} \underbrace{\left[(1-\tau_{t+1})w_{t+1}n_{t+1}^{m,a+1} + u_{t+1}^{m,a+1}b_{t+1}^u + b_{t+1}^{m,a+1} + \Pi_{t+1}^{m,a+1} \right]}_{\text{Next period income}} \\
&\quad - \frac{\beta}{1+\beta} \underbrace{\left[(1-\tau_t)w_t n_t^{m,a} + u_t^{m,a}b_t^u - (1+r_{t-1})b_{t-1}^{m,a-1} + \Pi_t^{m,a} \right]}_{\text{Current period income}}
\end{aligned} \tag{31}$$

for $2 \leq a \leq 9$

If the difference is positive, the household borrows to shift income to the current period and consumes more in the current period. If the difference is negative, then the household lends and shifts income from the current to the next period. The last working-age group has to save because it has no other income than the return on saving during retirement in the next period.

$$b_t^{m10} = -\frac{\beta}{1+\beta} \left[(1-\tau_t)w_t n_t^{m10} + u_t^{m10}b_t^u - (1+r_{t-1})b_{t-1}^{m9} + \Pi_t^{10} \right]$$

The equilibrium real interest rate r can be derived by inserting these terms in the bond market equilibrium (12)

$$1+r_t = \frac{d_t + \sum_{a=1}^9 \frac{1}{1+\beta} \left[(1-\tau_{t+1})w_{t+1}n_{t+1}^{m,a+1} + u_{t+1}^{m,a+1}b_{t+1}^u + b_{t+1}^{m,a+1} + \Pi_{t+1}^{m,a+1} \right]}{\sum_{a=1}^{10} \frac{\beta}{1+\beta} \left[(1-\tau_t)w_t n_t^{m,a} + u_t^{m,a}b_t^u - (1+r_{t-1})b_{t-1}^{m,a-1} + \Pi_t^{m,a} \right]}. \tag{32}$$

This equation shows some interesting properties of our model. First, in this OLG setting, this equation implies that even in steady state the real interest rate depends on labor market characteristics, including the unemployment benefit replacement rate b^u .⁷

In contrast, in a representative agent setting, the steady-state interest rate would simply be determined by the discount factor according to $1+r = \frac{1}{\beta}$. In our model, the distribution of labor, unemployment, and profit income across age groups plays an important role as it affects the borrowing and saving behavior of the age groups. This distribution of income across age groups depends, among others, on unemployment benefits. For example, consider the steady-state effects of an increase in unemployment benefits b^u (holding all other variables constant, e.g. no feedback of other variables). Ceteris paribus this increases the bond holdings of all ten working-age groups in the denominator, weighted with their respective unemployment rates. Bond holdings in the nominator rise only for nine working age-groups (the last age-group before retirement only saves) again weighted with their respective unemployment rates. Bond supply of the young

⁷ The steady-state version of Equation (32) is

$$1+r = \frac{d + \sum_{a=1}^9 \frac{1}{1+\beta} \left[(1-\tau)wn^{m,a+1} + u^{m,a+1}b^u + b^{m,a+1} + \Pi^{m,a+1} \right]}{\sum_{a=1}^{10} \frac{\beta}{1+\beta} \left[(1-\tau)wn^{m,a} + u^{m,a}b^u - (1+r)b^{m,a-1} + \Pi^{m,a} \right]}.$$

is determined by their borrowing constraint and is not influenced by an unemployment benefit change. Because of that, *ceteris paribus*, an increase in unemployment benefits increases saving (the denominator) more than borrowing (the numerator), and the real interest rate falls. In equilibrium, as will be discussed in Section 4.1, wages and employment respond as well to the change in unemployment benefits, generating additional channels that affect the real interest rate in equilibrium. In particular, we will document that as employment and income fall with higher benefits, the real interest rate goes up.

3.6 Calibration

In the following, we propose a calibration that targets a stylized German economy in line with our empirical evidence. We investigate a US calibration in a robustness check (see Section 5). Table 2 summarizes the parameter values of our baseline calibration. Each household lives twelve periods and each period lasts for five years.

We set the discount factor to 0.99^5 to target a steady-state real interest rate of 2.4% for our five-year horizon. This value is determined from data prior to the Covid-19 crisis in Germany, when interest rates were low.⁸ In the robustness section, we will demonstrate that the primary mechanism remains valid even in a higher steady-state real interest rate scenario.

Additionally, the discount factor aligns with the relevant literature, which is usually assessed for the US and examines earlier periods.⁹ However, note that in our setting, the steady state real interest rate is not one-to-one related to the discount factor but also by labor market variables (see Section 3.5).

We set the collateral constraint such that it implies borrowing of the young relative to the average wage of 31% in steady state. This value is in line with Kaplan (2012) who estimate a borrowing constraint of 30% relative to the average wage income in the US. We follow OECD data for Germany and set unemployment benefits so that we achieve a 50% net replacement rate in steady state.¹⁰

The parameters for matching efficiency and vacancy posting costs target the average unemployment rate of Germany since 2000 (on average 7%, source: see Table 5 in Appendix A.1).

The bargaining power and the elasticity of matching with respect to vacancies have standard values with 0.5 each (see, for example, de La Croix et al. (2013)). For our five-year

⁸ The data on German bond yields and inflation is the same as in the empirical section, see Table 5.

⁹ de La Croix et al. (2013) and Ríos-Rull (1996) use quarterly values of 0.9901 and 1.011 respectively (annually 0.96 and 1.04), Gourinchas and Parker (2002) use an annual value of 0.96 and Constantinides et al. (2002) use an annual value of 0.96 and 1.04.

¹⁰ For the data source, see Table 5 in Appendix. There are different replacement rates, depending on family structure, previous wage and unemployment duration. For a single person with a 67% average wage and unemployment duration of 60 months, this value fluctuates between 47% and 51% since 2005. For a single person with an average wage between 34% and 38% and for a single person with minimum wage, this value was 74% in 2015. For couples, people with children, and other family structures, this value also differs. In our model, we use a single household with 67% previous wage and a 60-month unemployment duration as a proxy and thus a 50% replacement rate.

Name	Parameter	Value	Source/Target
Discount factor	β	0.99 ⁵	Steady state interest rate of $\approx 2.4\%$
Collateral parameter	d	0.25	31% of average wage
Unemployment benefits	b^{base}	0.40	$\frac{b}{w} \approx 0.5$
Matching efficiency	η^m	0.80	Employment rate of 93% and $p = 0.86$
Elasticity of matches	μ	0.50	De la Croix et al., 2013, p. 112
Bargaining power	γ	0.50	De la Croix et al., 2013, p. 112
Vacancy posting costs	χ	0.30	Employment rate of 93% and $p = 0.86$
Job separation rate	Γ	0.40	Annual job separation rate of $\approx 10\%$

Table 2: Model calibration for the baseline model. 5-year horizon.

time horizon, we use a 40% (10% in annual terms) job separation rate.¹¹ This number is in line with estimates for Germany. For example, Hobijn and Şahin (2009) find a monthly job separation rate of 1.06% (12% in annual terms), Bellmann et al. (2018) find an annual job separation rate of 10.3%. Table 6 in Appendix A.2 shows the implied steady-state values of the main model variables.

4 The effects of unemployment benefits

First, we discuss the steady-state properties of the model with different levels of unemployment benefits. Second, we analyze the dynamic adjustment of the model to a new steady state with lower unemployment benefits. Here, we provide a qualitative discussion. The quantitative results follow in Section 5.

4.1 Stationary equilibrium

Figure 3 documents steady-state consumption, bond holdings and income of each age group (blue lines, negative values of b denote lending). The youngest age group has no income and the borrowing constraint restricts their consumption. Income increases substantially over the life cycle. The reason is that the employment rate increases with age. Intuitively, because of the matching process, the young had fewer chances of getting a job offer compared to older workers. To smooth consumption over the life cycle, the youngest working-age group borrows the most in expectation of the future income increase and remaining lifetime income. The older the age groups, the lower their bor-

¹¹ We calculate the five-year rate as $1 - (1 - 0.1)^5$.

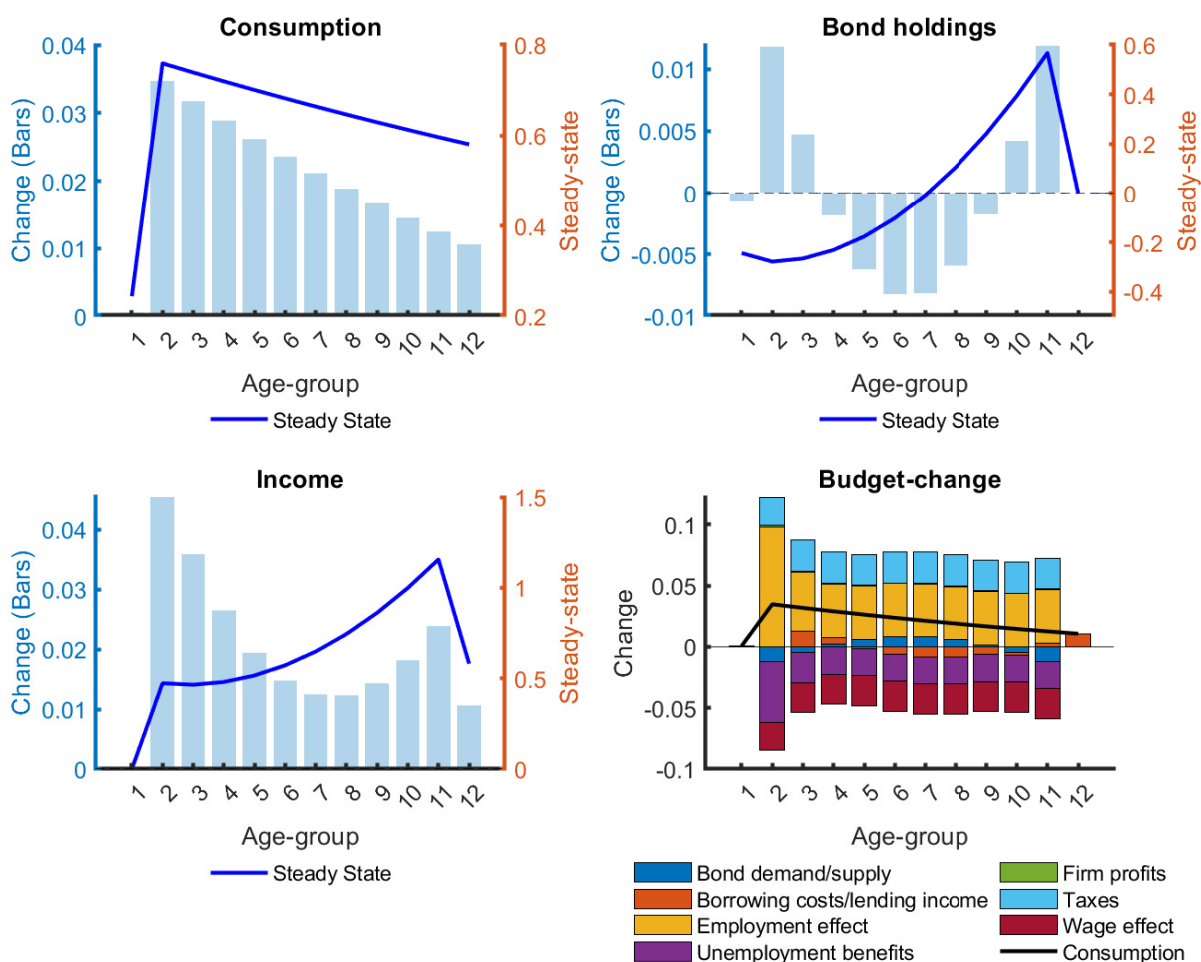


Figure 3: Consumption, bond holdings and income across age groups (1: young, 2-11: middle-aged, 12: old). Steady state in baseline model (blue lines) and level changes after a reduction in unemployment benefits (bars).

rowing. The turning point is for the seventh middle-aged group that begins to lend. As retirement approaches, these workers start to save for retirement, the more, the older they become. The oldest retired age group receives income from bond holdings only and consumes all of that.

These life-cycle patterns are consistent with a large literature using micro data. For example, Gourinchas and Parker (2002) demonstrate that consumption patterns vary across different age groups throughout their life cycles. They identify the specific periods when generations save and borrow, noting that these decisions are influenced by age, education, and labor income. Our steady-state consumption distribution aligns well with their findings. Other studies demonstrate similar outcomes regarding consumption and savings in the US (see, for example, Fernandez-Villaverde and Krueger (2011)), or for income in Germany (see, for instance, Pollak (2013)). Moreover, there is a substantial body of literature discussing the factors contributing to inequality in consumption and income across the life cycle and among various generations. Examples include Kaplan (2012), Blundell et al. (2008), and Kaplan and Violante (2010).

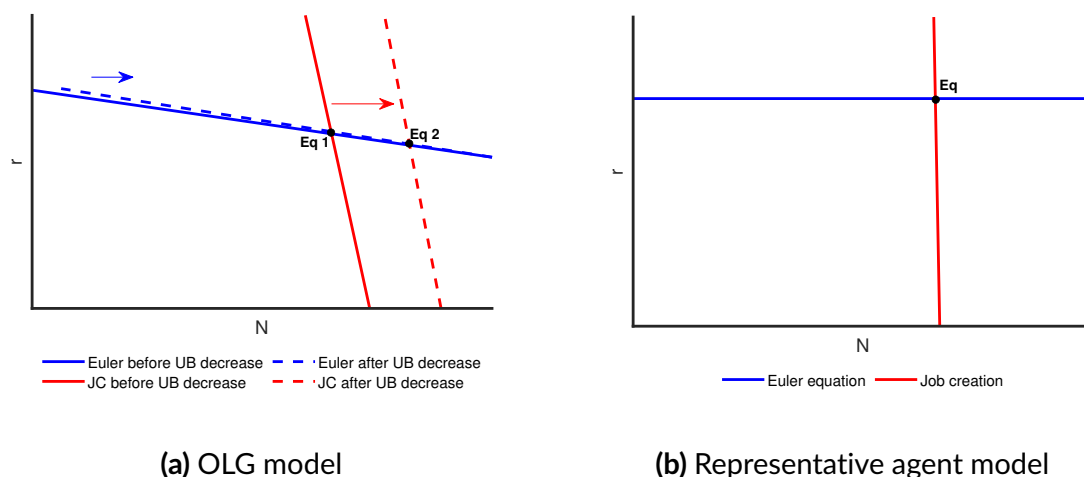


Figure 4: Steady state in real interest rate (r) - total employment rate (N) diagram. Left panel: Steady state effects of a decrease of unemployment benefits in the OLG model.

Panel (a) of Figure 4 illustrates the stationary model equilibrium in a real interest rate-employment diagram. Output comoves with employment because of the linear production function in labor input. As a point of comparison, we will use a representative agent (RA) model with search and matching frictions. The calibration of the RA model is equal to the OLG calibration with three exceptions. To target the same steady state real interest and employment rate as in the OLG model, we use $\beta = 0.9953^5$, $\eta_m = 2.1$ and $\chi = 0.069$. The model equations of the RA model are summarized in Appendix A.3. Panel (b) of Figure 4 shows the equilibrium of the RA model.

The equilibrium can be represented as the intersection of the job creation condition (red, Equation (26)) and the Euler equations (blue, Equation (10)). In our OLG model, the Euler equation curve slopes downward in the $r - N$ space. A lower real interest rate decreases savings and increases consumption and demand, and consequently employment. In contrast, in the RA model, the stationary real interest rate is only determined by the discount factor, and it is independent of labor market variables. Thus, the Euler equation curve is horizontal. The job creation curve is downward sloping in both models as a lower real interest rate increases the future value of jobs, firms offer more jobs, and employment increases. While the effect is small in the RA model (the curve looks almost vertical in panel b), the job creation curve is flatter in the OLG model. The reason is that employment of the youngest age group only depends on job creation, not on last period's employment. This makes overall employment more responsive in the OLG model than in the RA model. Both models define a unique stationary equilibrium of the real interest rate and employment.

Next, we will use the model to study the effects of a decrease in unemployment benefits. Figure 4 illustrates these effects in the $r - N$ space. First, as shown in the left panel, lower unemployment benefits shift the job creation condition curve to the right. Due to the wage bargaining process (see Equation (27)), lower unemployment benefits lead to lower wages and firms create more vacancies. Consequently, job matches, the job-finding rate,

and employment increase for a given real interest rate. Second, the Euler equation curve shifts slightly to the right as lower unemployment benefits imply lower taxes and higher firm profits. These effects are heterogeneous across age groups, conditional on their employment rates (a detailed discussion follows below). In the new steady state with lower unemployment benefits, employment is substantially higher, and, as there is more upward pressure on savings compared to borrowing, the real interest rate decreases compared to the previous steady state (see Equation (32)). The latter effect sets the OLG model apart from the RA model where the real interest rate would stay constant in steady state.

Figure 3 shows how the reform affects the age groups differently. The blue bars illustrate the changes in consumption, bond holdings and income across age groups that live at the time when the reform is implemented. The last panel decomposes the steady state change of consumption (black line) in how it is financed. The youngest age group that does not yet participate in the labor market is not affected at all. The exogenous borrowing limit constrains their bond demand. Thus, as long as the real interest rate does not yet adjust, their borrowing constraint does not change, and their consumption stays the same. The oldest retired age group is also not directly affected as it does not participate in the labor market either, but it increases their earlier savings.

The working (middle-aged) are affected by opposing effects. On the one hand, lower wages and lower unemployment benefits decrease their income (red and purple bars in the lower right panel). On the other hand, simultaneously, higher employment and lower taxation increase their income (yellow and blue bars). The younger the age group, the stronger the positive employment effect. Because employment of older age groups was higher before the reform, the increase in the job-finding rate due to the reform benefits younger age groups most. However, the younger age groups also lose the most because they depend more on unemployment benefits. In contrast, older age groups contribute relatively more to the financing of unemployment benefits via taxation. When unemployment benefits decrease, they pay relatively less in taxes. This pattern implies that the income increase is U-shaped across the age groups (see the lower right panel of Figure 3), with the largest income increases for the young and old working-age groups. The youngest working-age group experiences the largest increase overall. There are some additional effects because of changes in the profit distribution and the real interest rate, but these effects are quantitatively small.

In sum, all age groups see an increase in (life-time) income and consumption (see Figure 3) because the employment and tax effects outweigh the declines in wages and unemployment benefits.

Next, we will discuss how this affects their consumption-saving decisions over the life-cycle and the bond market equilibrium. Overall, the distribution of bond holdings over the life cycle changes with the reform. This is illustrated in the upper right panel of Figure 3. Generally, agents optimally shift some of the U-shaped income increase to their

prime age period to smooth consumption. This is illustrated by the dark blue bars in the lower right panel and the bond changes in the upper right panel of Figure 3. With lower unemployment benefits, the youngest working-age groups shift part of the income increase to consumption in later periods by borrowing less. In contrast, the prime-age working-age groups increase their borrowing/reduce their lending to consume more and save later. They shift consumption to an earlier phase in their life cycle as retirement is relatively far away and their future labor income is now high enough to save for retirement later.

This is reflected by the behavior of the oldest working-age groups who increase their savings. The higher labor income allows them to save and consume more and they smooth consumption between this period and retirement. The retired age group also benefits due to higher saving returns in age group 12. Overall, households increase bond holdings when their income increase is largest (during young and old working life) while they borrow more during prime age. On the bond market, overall, the bond demand increases by more than the bond supply, putting downward pressure on the real interest rate. A lower real interest rate leads to second-round effects on income, consumption, and saving of the different age groups. For example, it partly offsets the increase in bond demand of the older age groups

In sum, the reform creates opposing effects across working-age groups, with younger workers benefiting most from increased employment while older workers gain more from reduced tax burdens, leading to net income increases for all age groups. This implies heterogeneous borrowing and saving adjustments across age groups. In the bond market, older working-age groups increase their savings more than younger groups increase their borrowing, creating excess bond demand that drives down the real interest rate. We will call this adjustment of the real interest rate the real interest rate channel of the change in unemployment benefits in the following.

4.2 Dynamic adjustment to a temporary unemployment benefit shock

Next, in spirit of our SVAR exercise above, we study the dynamic adjustment to a one-time transitory decrease of unemployment benefits. We simulate a shock with autocorrelation of 0.5, which is in line with the shock persistence as implemented by Christiano et al. (2016) adjusted to our 5-year calibration. For the simulation, we use a perfect foresight setup, i.e., we implement a shock to unemployment benefits, but the future path is known by all agents. Interestingly, the short-term effects differ from the long-term effects in the sense that consumption decreases and the real interest rate increases in the short run. Intuitively, employment reacts with a lag to the reform due to the search friction, whereas unemployment benefits and wages respond immediately.

Figure 5 shows the dynamics of the OLG model in response to a temporary one percent cut in unemployment benefits. The red lines show the steady state before the shock and the blue lines show the impulse responses. In the OLG model, lower unemployment

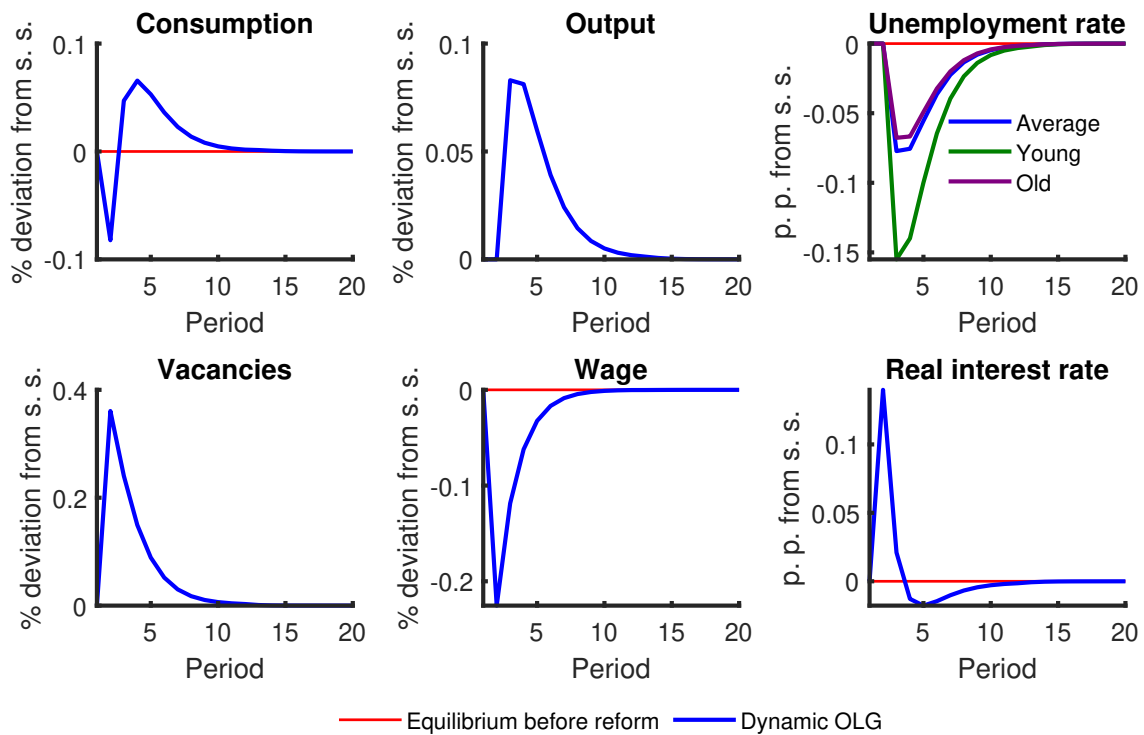


Figure 5: Impulse responses to a one percent negative temporary shock to unemployment benefits in OLG model (in period one). Five-year periods. Persistence parameter $\rho = 0.5$.

benefits trigger an immediate decrease in wages and an immediate increase in vacancies and job creation. But employment (and output) are predetermined and only react with a one period lag. With our calibration, this implies no response for five years. While this is an extreme case, the intuition would also hold for shorter periods. Before employment adjusts, households experience a short-term income decrease because of lower wages. This contrasts with the income increase in the long run.

Again, the income changes have different effects by age group. For example, the young non-working-age and the retired population experience no direct effects as they do not participate in the labor market. In the short run, lower incomes induce all working-age groups to consume less, while younger working-age groups also borrow less and older working-age groups save less. Saving decreases proportionally more than borrowing, because borrowing of the young not working-age group stays the same. This increases the real interest rate in the short run, triggering second-round effects on consumption, borrowing and lending. Firm profits decrease in the short run because firms pay higher vacancy posting costs due to higher job creation in the future. At the same time, output increases only in the medium run. In sum, there are short-term consumption losses due to higher real interest rates in the short run. In the long run, employment and output rise and the contractionary effects are reversed. The short-run increase and medium-run decrease of the real interest rate are in line with our empirical evidence from Section 2. The empirics further support that the unemployment rate of the young falls the most in response to the benefit cut (see Figure 5, upper right panel and Figure 2). Hence, the

model result that younger generations benefit most from the employment gains due to the benefit cut is in line with the data.

In the short run, the interest rate response will also be affected by monetary policy. While our model does not have nominal rigidities and focuses on life-cycle consumption-saving decisions, the New Keynesian model with search and matching frictions by Christiano et al. (2016) proposes the following short-run adjustment to unemployment benefit cuts: As in our case, the benefit cut reduces wages. With nominal rigidities, this creates deflationary pressure, inducing the central bank to cut interest rates and amplify the expansion. In the data, a mixture of both mechanisms will be at work, as illustrated in our empirical SVAR (Section 2). However, our SVAR does not provide strong evidence for deflationary tendencies, nor do we observe short-run interest rate cuts in the data.

However, we can use their results as a benchmark for the size of the effect. Christiano et al. (2016) find that a one percent reduction in unemployment benefits mildly decreases the unemployment rate by 0.22 percentage points at the peak. Our peak reduction in unemployment is even smaller with 0.075 percentage points. In the next section, we will show that the effects are substantially larger for permanent policy changes compared to temporary shocks.

In relation to the empirical literature that estimates the effects of temporary unemployment duration extensions during US recessions, our effects are larger. When making the assumption that extensions of unemployment benefit durations have similar effects to benefit level extensions, the estimates as reported by Acosta et al. (2023) imply that a one percent increase in duration results in a rise of only 0.017 to 0.024 percentage points in insured unemployment. There are two main reasons why we find larger effects: Our shocks are more persistent compared to the temporary increases in the empirical literature and the empirical results do not account for national general equilibrium effects (e.g., the interest rate channel that we discuss here).

5 Quantitative analysis of policy multipliers

Next, we illustrate how the real interest rate channel changes the quantitative model responses to a permanent change in unemployment benefits. To do so, we contrast the OLG and the RA model (where our interest rate channel is absent). Table 3 documents the quantitative steady-state effects on output for our baseline calibration (unemployment benefits financed by taxes) (panel A). Panel B shows the RA case. We will also discuss model extensions with government debt (Section 5.2) and physical capital (Appendix Section A.4). In the previous sections, we focused on employment rather than output. Because of the linear production function, employment and output respond similarly as productivity remains constant. Using output allows for a more direct comparison to unemployment benefit expenditures.

We investigate two measures. First, the elasticity of output concerning unemployment

(1)	(2)	(3)
Δ UB (in %)	Elasticity	Output multiplier
$\frac{\Delta b^u}{b_{base}^u} \times 100$	$\frac{\Delta y}{y_{base}} \frac{u_{base}^b}{\Delta b^u}$	$\frac{\Delta y}{\Delta \sum_{a=1}^{10} u^{ma} b^u}$
<i>Panel A: OLG, tax financing of unemployment benefits</i>		
-1.00	-0.40	-2.13
<i>Panel B: Representative agent model</i>		
-1.00	-0.03	-0.50
<i>Panel C: OLG, debt financing of unemployment benefits</i>		
-1.00	-0.29	-2.09

Table 3: Quantitative long-run effects of a one percent reduction in unemployment benefits (UB), steady state output comparison, two measures: elasticity of output concerning unemployment benefits and output multiplier (Euro change).

benefits, i.e., by how much output changes in percent in response to a one percent change in the unemployment benefit (column 2). This elasticity captures only part of the total cost for financing the unemployment benefit change; however, as total benefit expenditures change not only with the benefit itself (as captured by the elasticity), but also with the number of unemployed who receive the benefit. Second, we use an output multiplier that relates the output change to the overall change in unemployment benefit expenditures, taking into account the change in the number of benefit recipients (column 3). In the spirit of fiscal multipliers, the output multiplier measures the output change in Euros per Euro change in unemployment benefit expenditures. In all cases, we start with unemployment benefits equal to 0.4 as in our baseline calibration.

5.1 Baseline

In the baseline case, we use our OLG model with tax-financed unemployment benefits as presented in panel A. A one percent unemployment benefit cut leads to a moderate 0.4% output increase, i.e., an output elasticity of -0.4 (column 2). Taking into account the total change in unemployment expenditure, including the declining number of benefit recipients, gives a large output multiplier of -2.13, i.e., if total unemployment expenditures decrease by one Euro, output increases by 2.13 Euros (column 3). The elasticities and the output multipliers are very similar for a one percent increase in unemployment benefits or for a 5 percent change in unemployment benefits. In other words, non-linearities do not play a large role here (see Table 7 in the Appendix).

Panel B shows the results of the RA model. A one percent unemployment benefit decrease increases output by only 0.03%, i.e., leads to an elasticity of -0.03. The output elasticity is reduced by more than a factor of ten compared to the OLG model. The output multiplier is smaller by a factor of four in the RA agent model: if unemployment

expenditures decrease by one Euro, output increases only by 0.5 Euros.¹²

The intuition for this result is the same as described above in Section 4.1: because of the heterogeneous saving responses across age groups, the real interest rate falls. This incentivizes additional job creation by firms and substantially amplifies the employment and output increase.

It is not straightforward to compare our effect sizes to estimates from the literature as the existing literature mainly focuses on temporary benefit changes (see our discussion in Section 4.2). Our effects are larger compared to that literature as we study permanent policy changes here. Our finding that lower unemployment benefits reduce unemployment is in line with the literature that evaluates the effects of the Hartz labor market reforms (Hochmuth et al., 2021; Krause and Uhlig, 2012). Compared to the literature on fiscal multipliers (e.g., Ramey, 2019), the output multiplier of more than 2 seems large. Our model naturally makes a set of assumptions to illustrate the role of the interest rate channel. As we will document next, introducing public debt and capital into the model reduces the multiplier quantitatively. Further, our model abstracts from the insurance motive of unemployment benefits. With imperfect insurance, lower unemployment benefits may reduce aggregate demand (Kekre, 2023).

5.2 Financing with government debt

Instead of financing unemployment benefits with taxes, the government can finance them by public debt (b_t^g). Because of the finite planning horizon and the binding borrowing constraint for the young, public borrowing is an important source of bond supply that breaks Ricardian equivalence and potentially interferes with the real interest channel. We develop a model extension with government debt next. The following government budget constraint states that fiscal income (borrowing plus taxes) equals spending on the costs of unemployment benefits plus the repayment of government borrowing from the previous period plus real interest.

$$b_t^g + \sum_{a=1}^{10} n_t^{ma} w_t \tau_t = \sum_{a=1}^{10} u_t^{ma} b_t^u - (1 + r_{t-1}) b_{t-1}^g \quad (33)$$

Here, we assume that government debt is always repaid in full one period later by taxing the labor income of all working age-groups.

$$\sum_{a=1}^{10} n_t^{ma} w_t \tau_t = (1 + r_{t-1}) b_{t-1}^g \quad (34)$$

¹² The calibration between the OLG and RA model differs slightly as we target the same employment rate and real interest rate in both models. This implies that some labor market parameters differ. Alternatively, if we target a similar job-finding and worker-finding rate across both models (which implies a lower employment rate in the RA model), the RA model has somewhat higher elasticities and multipliers. However, they remain substantially lower compared to the values in the OLG model.

Bond market clearing now incorporates government borrowing next to private borrowing and lending. Thus, the bond market equilibrium implies that

$$b_t^y + \sum_{a=1}^{10} b_t^{ma} + b_t^g = 0. \quad (35)$$

Government debt is an additional source of bond supply and can influence the real interest rate via the bond market equilibrium. On the one hand, lower bond supply leads to downward pressure on the real interest rate, and *ceteris paribus* should amplify the real interest rate channel. On the other hand, if unemployment benefits are financed by debt, then taxes do not decrease immediately with lower unemployment benefits. Then, there is only the negative effect on income of lower unemployment benefits, while the positive effect of lower taxes is absent. With government debt financed by future taxes, the policy redistributes the costs of the unemployment benefits increase from the old to the young as the old retire and do not pay taxes anymore. Thus, in particular, the savings of the older working-age groups increase by less compared to the case with immediate tax financing (if unemployment benefits are decreased), putting upward pressure on the real interest rate. The second effect becomes stronger, the later the government debt is repaid.

Panel C in Table 3 shows output elasticities and multipliers of the OLG model when unemployment benefits are financed by debt. A one percent unemployment benefit decrease, increases output by 0.29%. This value is below the corresponding value of the tax-financed case. This suggests that the inter-generational redistribution channel that puts upward pressure on the real interest rate is the quantitatively dominating effect. Thus, the real interest rate channel becomes somewhat weaker with public debt.

Interestingly, when investigating the output multipliers that take the total response of unemployment benefit expenditures into account, there is only a small quantitative difference between the tax- and the debt-financed case. The reason is that unemployment decreases by less in the debt-financed case because of the weaker real interest rate amplification. This results in a smaller increase in output and a smaller reduction in total unemployment benefit expenditure. For the multiplier, both of these effects balance, leading to a multiplier similar to that in the tax-financed scenario.

5.3 Introducing capital as a production factor

Next, we introduce physical capital as a production factor in our baseline model. The model specification is described in Appendix A.4. Introducing physical capital as an additional production factor next to labor could influence our results as physical capital and investment is an alternative way to save next to bonds. Firms borrow from households. Thus, they are a potential competitor for households who borrow, and the firms' capital decisions can influence the real interest rate. A shock on the labor market, which influ-

(1)	(2)	(3)	(4)	(5)
Baseline	$\beta = 0.98^5$	US calibration	OLG with capital	d=0.4
-0.40	-0.50	-0.10	-0.30	-0.40

Table 4: OLG output elasticity with respect to a change in unemployment benefits. The table shows numbers for the baseline model, a lower discount factor, a US calibration, a model with physical capital, and a higher borrowing limit of the young.

ences the real interest rate, affects investments of the firms in the capital stock, which can feed back into the aggregate economy. Further, the firm’s capital demand decision also influences job creation and wages, as production not only depends on labor, but also on capital.

The results are shown in Table 4 and discussed in detail in Appendix A.4 and Table 7, Panel D in the Appendix. If unemployment benefits are decreased, output increases in this model as well. The elasticity is only slightly below the elasticity of the OLG without capital (in absolute terms), and the output multipliers are reduced substantially to around 1.5. Two effects now influence the adjustment of the interest rate to the benefit change. First, higher capital demand pushes interest rates up because lower unemployment benefits stimulate production. Second, the channel from the model without firm capital is still in place. Lower unemployment benefits increase employment and income, which leads to higher savings. Overall, the first channel partly dampens the role of the second channel.

5.4 Further robustness

We examine the robustness of our results with respect to different calibrations. For example, we decrease the discount factor to $\beta = 0.98^5$. This adjustment leads to an increase in the steady-state level of the real interest rate and a decrease in the steady-state employment rate. Further, we implement a US calibration.¹³ We calculate elasticities and multipliers as before.

A lower discount factor slightly increases the output elasticities of a change in unemployment benefits. The intuition behind this result is that a higher discount factor implies a higher real interest rate in steady state. This increases the costs of borrowing and decreases consumption, production and employment. With a lower labor market tightness, job creation becomes cheaper, and the labor market’s response becomes stronger to reform. This is a non-linearity of the model that is inherited from the non-linear matching

¹³We use $\beta = 0.98^5$, $d = 0.25$, $b^u = 0.1$, $\eta^m = 0.82$, $\Gamma = 0.91$ and obtain a unemployment rate of 4.25% and a real interest rate of 9% for our five year horizon. This is quite similar to US unemployment and real interest rate values since 2015. Net replacement rates are slightly above the rates of the US. Furthermore, we target a 96% job finding rate and a 91% job separation rate. For data sources, please view Table 5 in the Appendix.

function which feeds back into the real interest rate channel and intensifies this channel. Compared to the German calibration, the US calibration is characterized by larger labor market flows and a lower unemployment rate. This increases labor market tightness, job and worker finding rate in the US calibration, and limits the effect of unemployment benefit reforms on employment and output. Income is not that affected, and the real interest rate channel is weaker. Thus, the elasticity of the OLG model is not as much amplified compared to the elasticity of the RA model. The output elasticity increases to 0.1 in the OLG compared to only 0.01 in the RA model. This implies that the real interest rate channel interacts with the labor market friction such that more sclerotic labor markets have a higher amplification.

As another robustness check, we increase the borrowing limit of the young to the steady-state net replacement rate ($d = 0.4$; $\frac{d}{w} = 0.5$) and use the parameters from the baseline calibration for the other parameters. In steady state, this changes the life-cycle consumption-saving distribution as it shifts borrowing to an earlier stage in the life cycle. However, the borrowing limit of the young does not influence the effectiveness of our channel in response to a change in unemployment benefits. The output elasticity stays the same compared to the baseline calibration.

6 Conclusions

The impact of unemployment benefit policies remains a key topic in labor economics and macroeconomics. In this paper, we contribute to this debate by demonstrating that unemployment benefit policies have varying effects across different age groups, particularly regarding unemployment rates as well as consumption and saving behaviors. These variations trigger general equilibrium effects, notably affecting the real interest rate. Specifically, a reduction in unemployment benefits results in a lower interest rate, which in turn stimulates economic activity.

To illustrate these findings, we first analyze the effects of an unemployment benefit shock in a structural time series framework. Second, we rationalize our empirical results within a life-cycle model that integrates a search-and-matching labor market.

In our empirical approach, we employ a novel identification strategy that combines sign restrictions on the impulse responses with narrative sign restrictions on the structural shocks to identify the effects of unemployment benefit shocks. Our findings indicate that a benefit cut is expansionary, reduces unemployment and reduces the interest rate over the medium run. Notably, the unemployment rate of younger workers decreases more than that of older workers.

Within the life-cycle model, we illustrate that lower unemployment benefits increase income and savings, reducing the real interest rate in equilibrium. The lower interest rate amplifies the expansionary effects of the benefit cut. Quantitatively, we find that a one percent reduction in unemployment benefits results in a 0.4 percent increase in

output. These results represent long-run average effects. Short-run impacts and effects during periods of high economic slack or at the zero lower bound when demand effects are strong may differ. We leave an analysis of these channels for future research.

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A Appendix

A.1 Additional information about the NSVAR

A.1.1 Details about labor market reforms

The following list provides details about the labor market reforms that we use for our narrative identification as documented in Table 1 in the main text.

1. One-time payment regulation law ('Gesetz zur Neuregelung der sozialversicherungsrechtlichen Behandlung von einmalig gezahltem Arbeitsentgelt (Einmalzahlungs-Neuregelungsgesetz)'): From now on, one-time payments like bonuses will count towards calculating unemployment benefits.
2. Hartz I and II: Budget cuts for the Federal German Labor Agency. Hartz I focused on improving job placement services and created new employment agencies, while also introducing temporary work agencies and start-up subsidies for the unemployed. Hartz II established 'Mini-Jobs' (low-wage part-time work with reduced social contributions) and 'Midi-Jobs' for slightly higher earners, making it easier for employers to hire workers for smaller roles.
3. Hartz III and reforms on the labor market: Reorganization of the Federal German Labor Agency, including minor changes to unemployment benefits. The duration of unemployment benefits is reduced from 32 months to 12-18 months.
4. Hartz IV: Adjustment of the unemployment benefit duration in the unemployment insurance system to 12 months for everyone, except for individuals over the age of 45. Merger of unemployment assistance and social welfare into a single transfer system 'Arbeitslosengeld II' (unemployment benefit II). This reform significantly reduced long-term unemployment benefits and tightened eligibility requirements
5. Contribution rate change 2007 ('Gesetz über die Senkung des Beitrags zur Arbeitsförderung, die Festsetzung der Beitragssätze in der gesetzlichen Rentenversicherung und der Beiträge und Beitragszuschüsse in der Alterssicherung der Landwirte für das Jahr 2007 (Beitragssatzgesetz 2007)'): The contribution rate for unemployment benefits was reduced to 4.2%.
6. Contribution rate change, UB adjustments for older unemployed ('Sechstes Gesetz zur Änderung des Dritten Buches Sozialgesetzbuch und an derer Gesetze und im speziellen das Siebte Gesetz zur Änderung des Dritten Buches Sozialgesetzbuch und anderer Gesetze'): The contribution to unemployment benefits was reduced to 3.3%. The duration of unemployment benefits for older workers was extended to 24 months.

7. Law to Improve Integration Opportunities in the Labor Market ('Gesetz zur Verbesserung der Eingliederungschancen am Arbeitsmarkt'): Reduces payments to short-term unemployed to reintegrate them into the labor market.

A.1.2 Additional SVARs

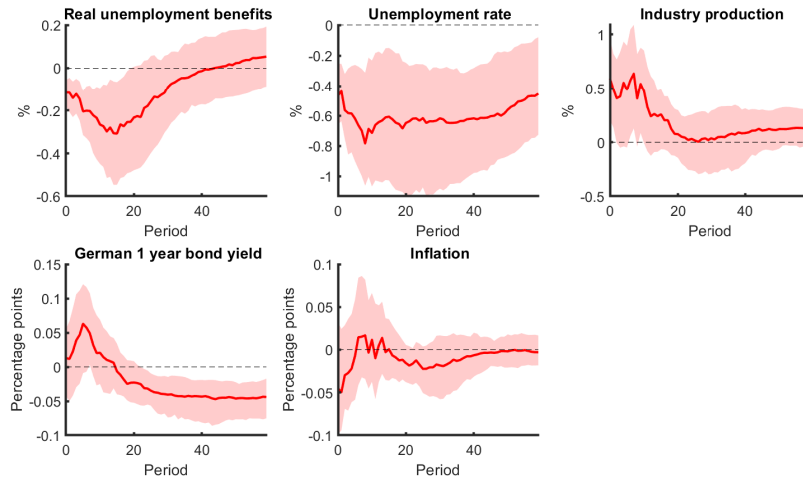


Figure 6: Impulse responses to a negative shock to unemployment benefit expenditures in baseline SVAR. Shaded areas: 68% highest posterior density (HPD) credible sets. Periods are months. Variables: Real unemployment benefits, unemployment rate, industrial production, German 1-year bond yield, inflation.

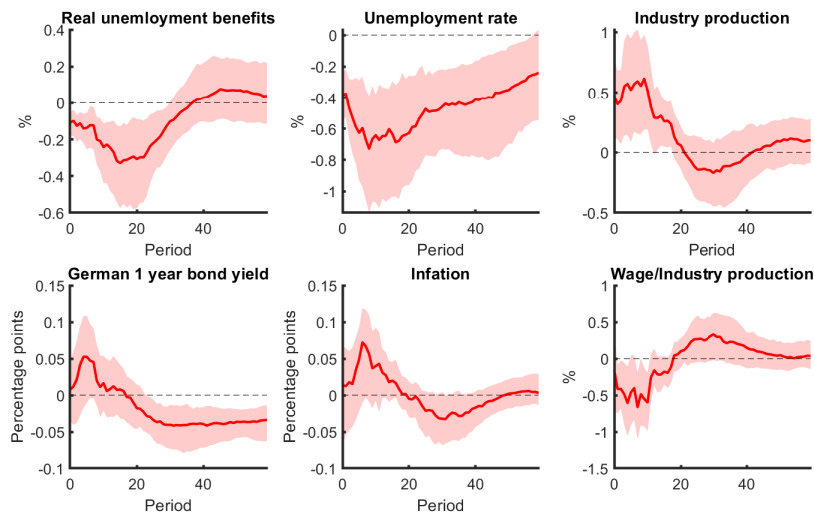


Figure 7: Impulse response functions of wages to a negative unemployment benefit shock. Baseline five-variable model plus wages relative to industrial production. Shaded areas: 68% HPD credible sets.

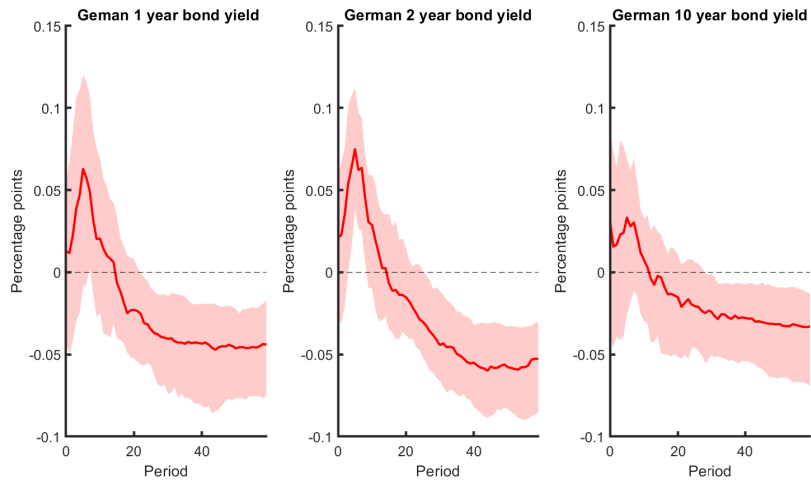


Figure 8: Impulse response functions to a negative unemployment benefit shock. Base-line 5 variable model with either 1-year, 2-year, or 10-year German bond yields. Shaded areas: 68% HPD credible sets.

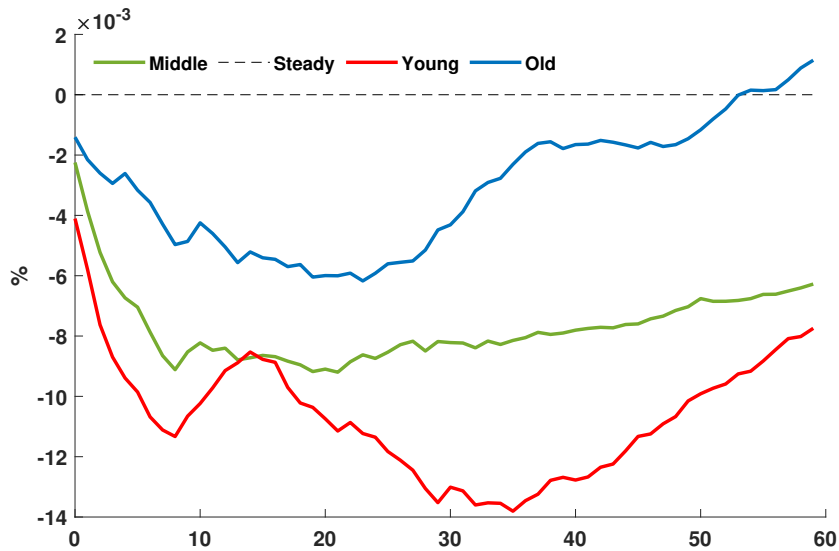


Figure 9: Impulse response functions to a negative unemployment benefit shock of the NSRVAR with youth unemployment (15-24, in logs) (red), middle-aged unemployment (25-54, in logs) (green) and elderly unemployment (55+, in logs) (blue).

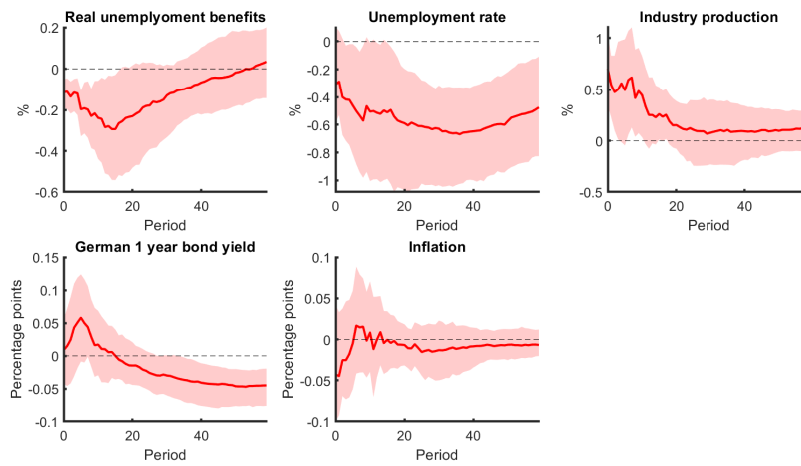


Figure 10: Impulse response functions of a negative shock to unemployment benefit expenditures, removing potentially anticipated policy changes. Shaded areas: 68% highest posterior density (HPD) credible sets.

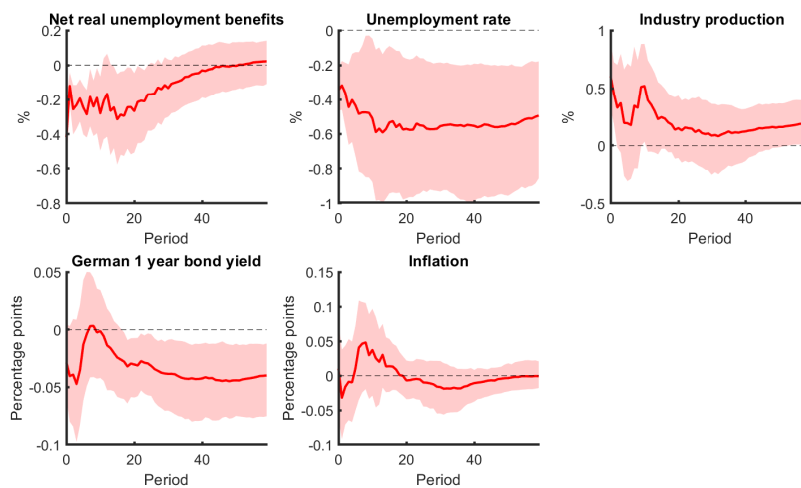


Figure 11: Impulse response functions of a negative shock to net unemployment benefit expenditures. Shaded areas: 68% highest posterior density (HPD) credible sets.

A.1.3 Data sources and overview

Data sources:

Data	Source
Expenditures on unemployment benefits	Bundesagentur für Arbeit (2023c)
Unemployment benefit recipients	Bundesagentur für Arbeit (2023b), Bundesagentur für Arbeit (2023a)
Unemployment and unemployment rate (seasonally adjusted)	Bundesagentur für Arbeit (2024)
CPI (base-year: 2020)	Statistisches Bundesamt (2023)
HCPI	Eurostat (2024a)
Industrial production (net turnover; nominal; seasonally adjusted; manufacturing, mining, quarrying)	Eurostat (2024b)
German bond yields (1, 2, 10 year maturity)	Deutsche Bundesbank (2025)
Gross wages per hour (nominal, seasonally adjusted)	Deutsche Bundesbank (2023)
Net replacement rate	OECD (2021)
US unemployment rate	U.S. Bureau of Labor Statistics (2022)
US interest rate (yield on U.S treasury securities at 5-year maturity)	Board of Governors of the Federal Reserve System (US) (2022)

Table 5: Data sources.

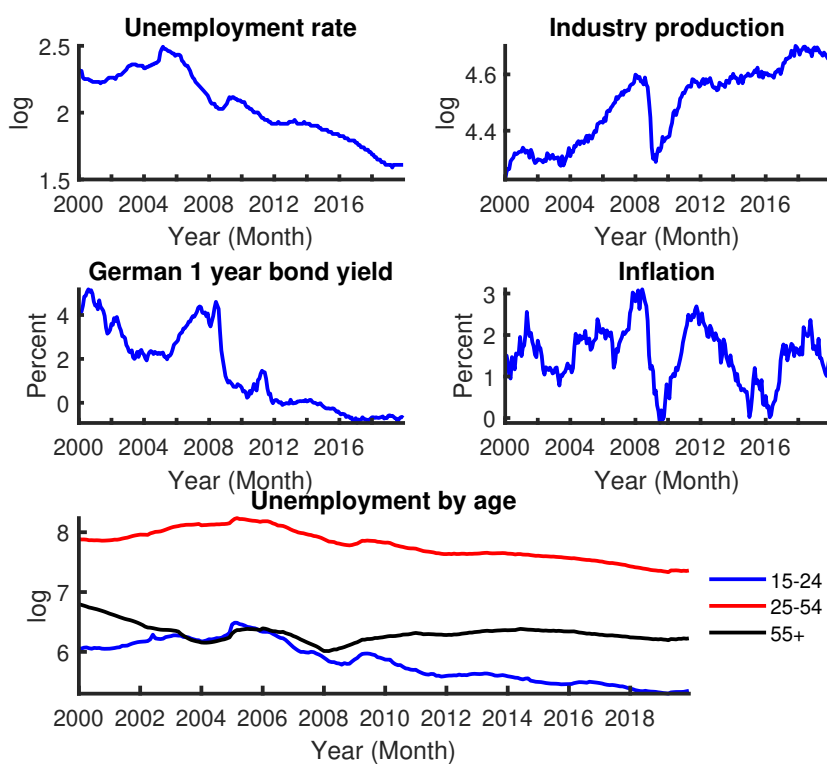


Figure 12: Data. All data series, except interest rates, are seasonally adjusted.

A.2 Additional information about the life-cycle search and matching model

Variable	Value	Variable	Value	Variable	Value	Variable	Value
b^y	0.2442	b^{m9}	-0.3938	n^{m8}	0.9389	θ	1.1558
b^{m1}	0.2787	b^{m10}	-0.5674	n^{m9}	0.9389	C	0.6313
b^{m2}	0.2662	n^{m1}	0.8600	n^{m10}	0.9389	b^u	0.4000
b^{m3}	0.2315	n^{m2}	0.9323	N	0.9303	y	0.7752
b^{m4}	0.1768	n^{m3}	0.9383	S	0.4151	U	0.0697
b^{m5}	0.1023	n^{m4}	0.9388	m	0.3570		
b^{m6}	0.0079	n^{m5}	0.9389	v	0.4798	w	0.8049
b^{m7}	-0.1062	n^{m6}	0.9389	p	0.8601	τ	0.0372
b^{m8}	-0.2401	n^{m7}	0.9389	$q(\theta)$	0.7441	r	0.0238

Table 6: Steady state values before unemployment benefit reform.

A.3 Summary of model equations for the representative agent model

Household budget constraint:

$$C_t = (1 - \tau_t)w_tN_t + u_t b_t^u + profit_t \quad (36)$$

Euler-equation:

$$\frac{1}{C_t} = \beta(1 + r_t)\frac{1}{C_{t+1}} \quad (37)$$

Labor market, firms, wages:

$$N_t = (1 - \Gamma)N_{t-1} + m_{t-1} \quad (38)$$

$$N_t = 1 - u_t \quad (39)$$

$$m_t = \eta^m v_t^{1-\mu} u_t^\mu \quad (40)$$

$$p(\theta_t) = \frac{m_t}{u_t} \quad (41)$$

$$q(\theta_t) = \frac{m_t}{v_t} \quad (42)$$

$$\theta_t = \frac{v_t}{u_t} \quad (43)$$

$$\frac{\chi}{q(\theta_t)} = \frac{1}{1 + r_t} \left((a_{t+1} - w_{t+1}) + (1 - \Gamma)\frac{\chi}{q(\theta_{t+1})} \right) \quad (44)$$

$$w_t = \gamma(1 + \theta_t \chi) + \frac{(1 - \gamma)}{(1 - \tau_t)} b_t^u \quad (45)$$

$$y_t = N_t \quad (46)$$

$$profit_t = y_t - w_t N_t - \chi v_t \quad (47)$$

Taxes:

$$\tau_t = \frac{b_t^u u_t}{w_t N_t} \quad (48)$$

Steady-State-Euler-Equation

$$1 + r = \frac{1}{\beta} \quad (49)$$

Steady-State-Job-Creation-Condition:

$$1 + r = (a - w)\frac{q(\theta)}{\chi} + (1 - \Gamma) \quad (50)$$

A.4 Extension: Introducing physical capital as a production input

In the baseline model, in Section 3, households only lend each other. In reality, firms also borrow to finance physical capital. As firms' capital demand decisions also depend on the labor market, introducing firm capital can influence our baseline result and the multipliers. The following channels could affect the result. First, as seen in the former sections, decreasing unemployment benefits makes labor input cheaper. Firms change their production factors from capital to labor. This reduces capital demand and decreases the real interest rate, making labor more attractive. Second, lower unemployment benefits increase demand. This increases production and the use of capital. Firms demand more capital, which increases the real interest rate. This lowers the future value of jobs and decreases our multiplier.

We introduce firm capital following de La Croix et al. (2013). Households hold either bonds, finance physical capital, or hold firm shares. We assume all assets are riskless, and households obtain the same interest rate for all. To do that, we introduce a non-arbitrage condition.

Capital changes the production function and the firms' maximization problem. We use a standard Cobb-Douglas production function with labor and capital inputs.

$$y_t = a_t k_t^\alpha \left(\sum_{a=1}^{10} n_t^{m,a} \right)^{(1-\alpha)} = a_t k_t^\alpha (N_t^{total})^{(1-\alpha)} \quad (51)$$

Profits depend on capital costs. Capital costs are the real interest rate and the capital depreciation rate (δ).

$$\Pi_t = y_t - \sum_{a=1}^{10} n_t^{m,a} w_t - \chi v_t - (r_t + \delta) k_t \quad (52)$$

Firms maximize the firm's net present value over the number of vacancies v_t and capital demand.

$$J_t = \max_{v_t, k_t} y_t - \sum_{a=1}^{10} n_t^{m,a} w_t - \chi v_t - (r_t + \delta) k_t + \left[\frac{1}{1 + r_t} J_{t+1} \right]. \quad (53)$$

The new production function leads to a modified job creation condition.

$$\frac{\chi}{q(\theta_t)} = \left\{ \sum_{a=1}^{10} \frac{s_t^{a-1}}{s_t} \left[\sum_{j=0}^{10-a} \left(\prod_{h=0}^j \frac{1}{1 + r_{t+h}} \right) (1 - \Gamma)^j ((1 - \alpha) \left(\frac{y_{t+1+j}}{N_{t+1+j}^{total}} \right) - w_{t+1+j}) \right] \right\} \quad (54)$$

Also, the wage bargaining process is altered slightly because the firm takes into account that the firm's surplus depends not only on labor but also on capital. Thus, in the bargaining process, the firm values the share of production that was produced because of

labor use (e.g., labor demand) compared to wages.

$$\begin{aligned}
w_t = & \left\{ \frac{\gamma}{\gamma + (1-\gamma)(1-\tau_t)} \left[(1-\alpha) \left(\frac{y_t}{N_t^{total}} \right) + \sum_{j=1}^9 \left(\frac{\sum_{a=1}^{10-j} 1}{\sum_{a=1}^{10} 1} \left(\prod_{h=1}^j \frac{1}{1+r_{t+h-1}} \right) \right) \right] \right. \\
& (1-\Gamma)^j \left((1-\alpha) \left(\frac{y_{t+j}}{N_{t+j}^{total}} \right) - w_{t+j} \right) \\
& + \frac{1-\gamma}{\gamma + (1-\gamma)(1-\tau_t)} \left[b_t^u + \sum_{j=1}^9 \left(\frac{\sum_{a=1}^{10-j} 1}{\sum_{a=1}^{10} 1} \left(\prod_{h=1}^j \frac{1}{1+r_{t+h-1}} \right) \right) \right. \\
& \left. \left. (1-\Gamma)^j \left(\prod_{i=1}^j (1-p_{t+i-1}) \right) (b_{t+j}^u - (1-\tau_{t+j})w_{t+j}) \right) \right] \left. \right\}. \tag{55}
\end{aligned}$$

The firms' demand for capital is derived from the firms' maximization problem. The first order condition is

$$(r + \delta) = \alpha a_t k_t^{\alpha-1} (N_t^{total})^{(1-\alpha)}. \tag{56}$$

The bond market is closed by formulating a non-arbitrage condition. Q is the financial value of firms. The financial value is linked to the value of a firm.

The financial value of firms in $t + 1$ plus the profits must be equal to the financial value of firms in t times the interest rate.

$$Q_{t+1} + \Pi_{t+1} = (1 + r_t)Q_t \tag{57}$$

The clearing of the bond market now incorporates the capital of the firms (k) and the financial value of the firms. One can think about this equation in the following way. Firms can either invest in other households, firm capital, or firm shares. All investments earn the same interest.

$$b_t^y + \sum_{a=1}^{10} b_t^{m,a} + k_{t+1} + Q_t = 0. \tag{58}$$

The model is closed with the resource constraint. It includes now consumption, the costs of vacancy postings, firm capital and the financial value of firms.

$$y_t = c_t^y + \sum_{a=1}^{10} c_t^{m,a} + c_t^o + \chi v_t + k_{t+1} - (1-\delta)k_t + Q_t - Q_{t-1}. \tag{59}$$

With these new equations, parameter values for $\alpha = 0.3$ and $\delta = 0.2$, and a steady state employment rate that is similar to the baseline model¹⁴, we can run an analysis that follows the one from the main text.

In a first step, we analyze the dynamic adjustment to the new steady state. Figure 13 shows the effects of a permanent one percent unemployment benefit increase. The

¹⁴ Because of this, parameter μ and χ are adjusted.

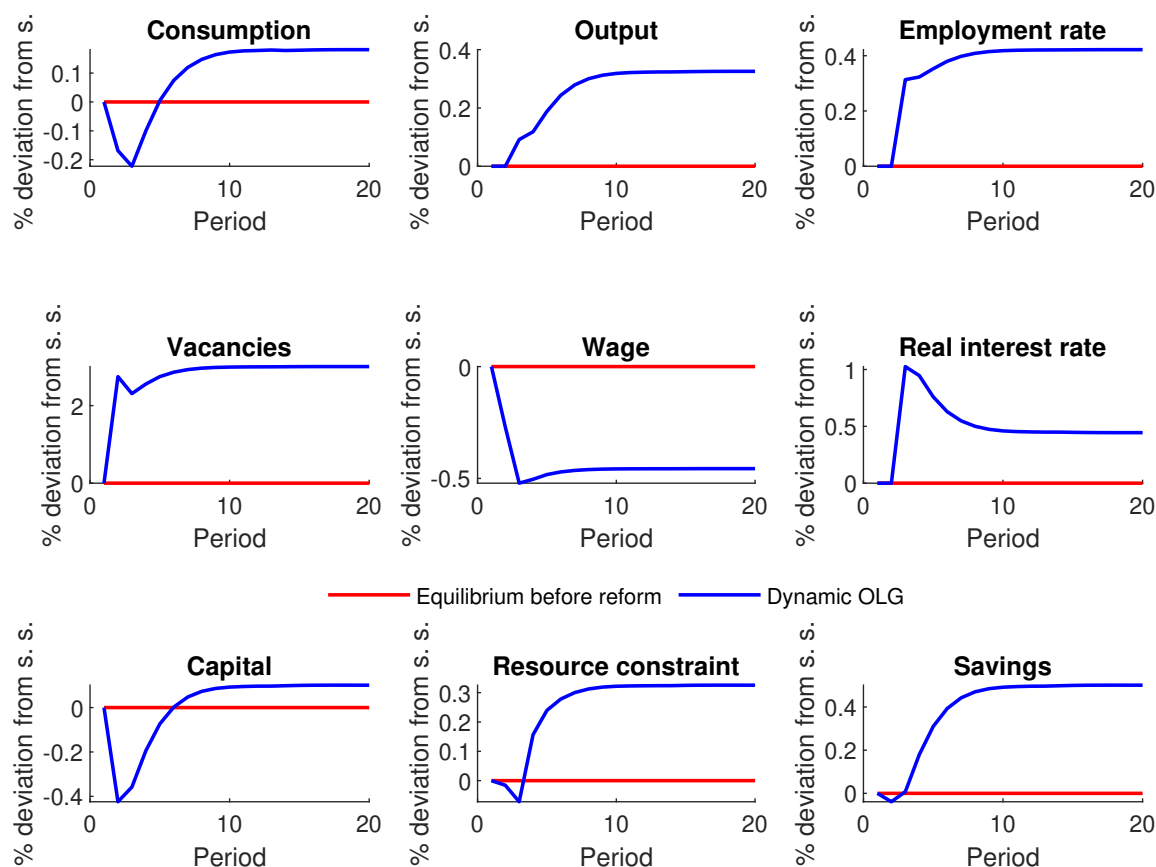


Figure 13: OLG model with capital dynamics to permanent one percent lower unemployment benefits. Five-year periods

directions of most dynamic adjustments are similar to the dynamic adjustments of the model without capital (see Figure 5), except for the real interest rate reaction. Now, two effects influence the dynamic adjustment. First, higher capital demand pushes interest rates up, because lower unemployment benefits stimulate production. Second, the channel from the model without firm capital is still in place. Lower unemployment benefits increase employment, which leads to higher savings.

Thus, after an initial peak increase of the real interest rate, the real interest rate decreases, but is still higher than before the reform. Thus, the first channel is stronger than the second one.

In the empirical section, we argue that the real interest rate decreases following the implementation of an unemployment benefit policy. How can we compare the empirical result with the result in this section? First, as previously mentioned, we do not incorporate precautionary savings. This would increase the savings channel, potentially leading to a decrease in the real interest rate. Second, the calibration used in this section is as close as possible to that in the former section. We only targeted a similar steady-state employment rate. The net replacement rate, wage, and other steady-state variables are different. It is relatively easy to find a calibration where the savings channel is stronger than the firm capital channel. Thus, the real interest rate decreases in response to permanently reduced unemployment benefits.

One way to achieve this is by adjusting the bargaining power of workers. The higher the bargaining power of workers, the more of the additional surplus is distributed to them, and their income and savings increase accordingly. At the same time, it increases labor costs, and the additional production is smaller; consequently, capital demand decreases. Both lead to downward pressure on the real interest rate, and eventually, the real interest rate decreases.

(1)	(2)	(3)	(4)	(5)	(6)
Δ UB (in %)	Δ Output (in %)	Elasticity	Δ Unemployment expenditures	Δ Output	Output multiplier
$\frac{\Delta b^u}{b_{base}^u} \times 100$	$\frac{\Delta y}{y_{base}} \times 100$	$\frac{\Delta y}{y_{base}} \frac{u_{base}^b}{\Delta b^u}$	$\Delta \sum_{a=1}^{10} u^{ma} b^u$	Δy	$\frac{\Delta y}{\Delta \sum_{a=1}^{10} u^{ma} b^u}$
Panel A: OLG, tax financed UB					
-5.00	1.900	-0.38	-0.0068	0.0150	-2.21
-1.00	0.400	-0.40	-0.0015	0.0032	-2.13
1.00	-0.400	-0.40	0.0015	-0.0032	-2.13
5.00	-2.200	-0.44	0.0084	-0.0173	-2.06
Panel B: Representative agent model					
-5.00	0.124	-0.02	-0.0017	0.0012	-0.71
-1.00	0.025	-0.03	-0.0004	0.0002	-0.50
1.00	-0.026	-0.03	0.0004	-0.0002	-0.50
5.00	-0.131	-0.03	0.0018	-0.0012	-0.67
Panel C: OLG, debt financed UB					
-5.00	1.409	-0.28	-0.0051	0.0111	-2.13
-1.00	0.289	-0.29	-0.0011	0.0023	-2.09
1.00	-0.292	-0.29	0.0011	-0.0023	-2.09
5.00	-1.499	-0.30	0.0059	-0.0118	-2.00
Panel D: OLG, with capital					
-5.00	1.400	-0.28	-0.0068	0.0099	-1.46
-1.00	0.300	-0.30	-0.0015	0.0022	-1.47
1.00	-0.300	-0.30	0.0016	-0.0024	-1.50
5.00	-2.100	-0.42	0.0096	-0.0143	-1.49

Table 7: Quantitative long-run effects of a change in unemployment benefits (UB), steady state comparison, full table.