Essays on labour markets and pensions

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Essays on Labour Markets and Pensions

B. Bonthuis
ESSAYS ON LABOUR MARKETS AND PENSIONS

ACADEMISCH PROEFSCHRIFT

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aan de Universiteit van Amsterdam
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**Faculteit:** Economie en Bedrijfskunde
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The opinions expressed in this dissertation are those of the author, and do not necessarily reflect the views of the Deutsche Bundesbank or the Eurosystem.
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1 Introduction

In this dissertation we study labour markets, pension systems, and the interaction between the two. The Great Recession has hit euro area economies severely and both labour markets and pension systems have come under immense strain. Unemployment rose from 7.5% in 2007 to 12.0% in 2013. At the same time growth of social security spending outpaced growth of social security receipts two-to-one, with spending on old age benefits rising even faster. However, these headline figures do not tell the whole story. Employment in certain sectors, such as construction, dropped by much more than in the economy as a whole, while employment in for instance professional services rose over the same period. Employment of the young dropped dramatically while employment of the age group 50+ increased over the same period. And while the share of people at risk of old age poverty was higher than the poverty rate among working age people before the crisis, at the height of the crisis people over 65 were less likely to be at risk of poverty than the population in general.¹

This divergence of outcomes shows that the euro area is at risk of becoming a divided monetary union. The dividing lines do not only run between countries but also between citizens of the same country. Some workers from permanently downsized sectors with potentially obsolete skills might find it difficult to find employment in other sectors. Many younger workers postpone labour market entry or toil in temporary employment, earning low wages for a substantial part of their working lives. At the same time, other workers enjoy stable wages and protected, possibly unionised jobs in sectors that weathered the crisis relatively well. These labour market differences culminate at old age in stable generous pensions for some, while others need to scrape by on minimum pensions.

It is therefore important that we understand what is below the surface of aggregate figures. It is important that we zoom in on cohorts, sectors, worker types and pension types. And ultimately, it is important that we understand which policies can help to mitigate some of the negative effects of the most severe recession of a lifetime. In this dissertation we will therefore zoom in on some of the differences between and within countries, and in particular on differences relevant for labour markets and pensions. In each of the chapters differences in labour market status play an important role; whether that is temporary vs permanent employment, short- vs long-term unemployment or (voluntary) inactivity. In addition, in the theoretical chapters we focus on differences between cohorts and pension types. In the empirical chapters we will shift the attention to differences between sectors, worker characteristics, financial conditions and unionised, permanent and temporary jobs.

In more detail, the rest of the dissertation is structured as follows. In the second chapter we study the effects of fiscal changes in an overlapping generations model. The model features imperfect annuities (i.e. annuities not fully compensating for mortality risk), real world demographics and a realistic productivity profile. We simulate two types of tax hikes: a consumption tax increase and a labour income tax increase. We also investigate the effect of announcing the tax increase beforehand. Finally, we simulate a tax swap in

¹All figures are from Eurostat and relate to 2007 and 2013. Social security receipts: +5.4%; social security spending: +10.9%; spending on old age: +13.1%. Employment in construction: -20.6%; employment in professional, science, tech and admin services: -7.9%. Employment rate 15-24 year olds: -6.6%; employment rate of 50+: +2.5%. At risk of poverty 65+: 15.5% (2007), 17.5% (2013); at risk of poverty 65+: 19.1% (2007), 13.3% (2013).
which the labour tax is reduced but tax revenues are kept constant through a consumption tax increase.

The chapter is closely related to Heijdra and Mierau (2010), who investigate the effects of labour and consumption taxes in the steady state in a similar, albeit continuous-time model with endogenous growth. The type of tax reform presented in this chapter is similar to the tax reform conducted in Auerbach and Kotlikoff (1987), but they do not include imperfect annuities or life-time uncertainty.

We find that, even though tax revenue is redistributed in a lump sum fashion, both types of tax hikes lower lifetime utility for almost all cohorts. However, a labour tax increase that returns the same amount in discounted tax revenue as a consumption tax increase reduces welfare more. This confirms the notion that labour taxes are more distorting than consumption taxes. Announcing the aforementioned tax hikes before they are implemented reduces variation between cohorts. If the consumption tax increase is announced, workers can lower their labour supply and increase consumption before the shock, mitigating some of the negative effects. In the case of a labour tax increase, the working population can prepare for a higher labour tax by working more in the periods before the tax hike. This reduces the disparity in the effect of this tax increase between cohorts. However, even though differences between cohorts can be significant, social welfare does not differ significantly between announcing and not announcing the tax change. Finally, we find that a tax swap makes all newborn cohorts better off. However, during transition it opens up a welfare gap between the retired, who are worse off, and the working, who are better off. The negative effect on the retired is caused by the fact that since they are no longer working they do not reap the benefits from a lower labour tax. This negative effect can be offset by an appropriate redistribution of tax income (towards the old) by the government. Therefore, a tax swap in combination with a skewed redistribution scheme can be Pareto improving.

In the third chapter we study the intergenerational effects of unemployment caused by wage rigidity on the accumulation of pension entitlements. A negative shock combined with wage rigidity can lead to large groups of (mainly) young people being excluded from employment over the course of a crisis. Certain cohorts are therefore stuck with relatively low income and low pension entitlement accumulation for a large part of their lives. Other cohorts, on the other hand, are largely shielded from the shock, enjoying steady wages in combination with a sustained build up of pension rights. The disparity of pension systems and labour market institutions within the euro area prompts us to focus on a sub-set of euro area countries: Spain, Germany, France and Italy.

We start with an accounting exercise, much like the OECD (2015), in which we keep the wage profile fixed for three different skill levels and simulate three different employment histories: one with a delayed labour market entry of 10 years, one with a career cut short by 10 years and one full career. Because of the relatively generous pension system, unemployment has little effect on the pension entitlements in Spain since minimum required years of contributions for a maximum pension are still reached. However, in the other three countries not being employed for 10 years lowers pensions and replacement rates significantly. For France and Italy, there are large differences between the young unemployed and the old unemployed. This is because receiving unemployment benefits count towards pension entitlement accumulation and because unemployment benefits last longer for older workers in these countries. In Germany this effect is smaller because unemployment benefits run out quicker.

To further investigate these effects we build a theoretical model with three overlapping generations (two working and one retired) which are represented in the labour market by unions. This combines the basic elements of union models like Dunlop (1950) with the overlapping generations models à la Diamond (1965). The unions represent each genera-
tion sequentially, setting the wages for a certain generation before this generation enters the labour market. Firms pick the employment level once the state of the economy is known. The pension system has a significant effect on steady state outcomes of labour market variables. Employment is lower and wages and pensions are higher under both a funded system and a pay-as-you-go (PAYG) notional defined contribution system compared to our benchmark PAYG defined benefit system.\textsuperscript{2} The reason is that pensions in the aforementioned systems depend more on wages earned early on in life compared to the PAYG defined benefit system, making it relatively less important to work both periods and more important to earn higher wages early on in life. Pensions in our model are more equally distributed among people with different work histories under the funded system and the PAYG notional defined contribution system compared to the PAYG defined contribution and PAYG defined benefit system.\textsuperscript{3}

Because wages are pre-determined, pension systems matter less for the transitional dynamics. The shock is largely reflected in labour market outcomes; with higher unemployment because of fixed wages. These outcomes do not differ significantly across pension systems. Similar to our accounting exercise, for each pension system the utility of the unemployed at the time of the shock drops more than the utility of the employed, reflecting the importance of being employed in the first period of life.

The fourth chapter analyses euro area Beveridge curves over the past 25 years, at both the aggregate euro area level and at the country level, focusing in particular on Beveridge curve developments since the onset of the global financial crisis.\textsuperscript{4} The aim is to identify deviations from the pre-crisis Beveridge curves and to isolate salient structural factors influencing these movements. Distinguishing between high unemployment rates that are due to cyclical factors and a lack of labour demand, or to labour market mismatches, has important policy implications.

We apply an autoregressive distributed lag (ARDL) model to test for statistical significance of observed shifts and changes in the slope of the Beveridge curve for both the euro area aggregate and the individual countries. We find a significant shift and change in the slope of the euro area Beveridge curve since the onset of the crisis; raising the unemployment rate by 1.5% for any given vacancy rate and turning the negative slope of the Beveridge curve insignificant. At the country level we find considerable heterogeneity. At the extremes, country level differences include a significant deviation from the pre-crisis Beveridge curve for Spain (+6.8% unemployment) and France (offsetting the gains made after the introduction of the euro), but an inward shift for Germany (-2.6%).\textsuperscript{5} We then extend our analysis in order to examine factors underlying the observed developments. A range of country-specific factors—including labour force characteristics, sectoral employment composition and financial conditions—are tested using the local projections method. We find evidence for skill mismatch and tentative evidence for sectoral and geographical mismatch. A high share of low skilled workers, a high homeownership rate, high pre-crisis financial slack and a high share of workers (previously) employed in the construction sector tend to shift the Beveridge curve outward in case of a negative shock. A high share of female workers in the labour force on the other hand tends to mitigate these effects.

\textsuperscript{2}A PAYG defined contribution and a PAYG defined benefit system both return the same steady state in our model.

\textsuperscript{3}The maximum pension is 2.5 times higher than the minimum pension under both the PAYG defined contribution/benefit system whereas this ratio is 1.4 for both the funded system and the PAYG notional defined contribution system.

\textsuperscript{4}The Beveridge curve has raised a lot of interest in the literature lately, but with some exceptions (e.g. ECB (2002), European Commission (2011b), Hobijn and Sahin (2012) and Bouvet (2012)), most studies are country specific.

\textsuperscript{5}All figures are compared to the position of the Beveridge curve before the introduction of the euro.
In the fifth and final chapter we estimate wage equations to test for changes in the responsiveness of wages to unemployment using euro area panel estimates. The objective of this chapter is to improve our understanding of the effect of rising unemployment on the evolution of wages, and also of the possible causes behind changes in responsiveness during the recent crisis period. We estimate equations where wage growth is explained by inflation, productivity growth and unemployment, and test various hypotheses by extending this basic specification.6

Our empirical results suggest evidence of lower responsiveness of wages at high levels of unemployment in the euro area. The otherwise downward sloping wage Phillips curve becomes flat between 23% and 28% of unemployment. This result applies to all episodes of high unemployment, even though wage responsiveness has somewhat recovered as the recent crisis became more protracted. Additionally, we find that differences in bargaining position — in particularly differences between unionised vs non-unionised labour and permanent vs temporary jobs — potentially explain part of the downward wage rigidity. Perhaps surprisingly, a larger share of long term unemployment tends to decrease wages. However, this effect is reversed at high levels of unemployment. Other findings show that a higher share of temporary workers lowers overall wage growth but this effect is also partially reversed during downturns.

Taking these four chapters together will hopefully improve our understanding of labour markets and pensions on both a theoretical and empirical level. And while the scope of this dissertation is limited and clearly does not cover every aspect influencing labour markets or pension systems, hopefully it will allow the reader an insight into some of the challenges that policy makers face in this field in the years if not decades to come.

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6Our wage equation is closely related to the original (wage) Phillips curve described in Phillips (1958) and the New Keynesian Wage Phillips curve in Gali (2011).
2 The effects of fiscal policy on consumption, labour supply and retirement decisions in a general equilibrium life-cycle model

2.1 Introduction

In this chapter we investigate the effects of fiscal policy changes in an overlapping generations (OLG) model with lifetime uncertainty, studying the transitional dynamics of the economy through time. We are particularly interested in the difference in the impact of shocks on different generations alive at the time of the shock and during the transition.

We simulate two types of tax hikes: a consumption tax increase and a labour income tax increase. We also investigate the effect of announcing the tax increase beforehand. Finally, we simulate a tax swap in which the labour tax is reduced but tax revenues are kept constant through a consumption tax increase.

We find that, even though tax revenue is redistributed in a lump sum fashion, both types of tax hikes lower lifetime utility for almost all generations. A labour tax increase that returns the same amount in discounted tax revenue as a consumption tax increase, reduces welfare more. This confirms the notion that labour taxes are more distorting than consumption taxes.

Announcing the aforementioned tax hikes has a pronounced redistributational effect during the transition. An announcement reduces variation between variations. A consumption tax hike hits agents at the peak of their consumption profile more. Therefore, if this tax increase comes as a surprise, this tax cannot be dodged. However, if the tax increase is announced, workers can already lower their labour supply and increase consumption before the shock, mitigating some of the negative effects. In the case of a labour tax increase, the working population can prepare for a higher labour tax by working more in the periods before the tax hike. This reduces the disparity in the effect of this tax increase between generations. Even though differences between generations can be significant, social welfare does not differ significantly between announcing and not announcing the tax change.

Finally we find that a tax swap — replacing part of the labour tax with a higher consumption tax — makes all newborn generations better off. However, during transition it opens up a welfare gap between the retired, who are worse off, and the working, who are better off. This negative effect can be offset by an appropriate redistribution of tax income by the government. If redistribution is skewed towards the old for some time directly after the tax swap, the negative effects of a higher consumption tax on the retired are mitigated and their lifetime utility does not drop below the pre-tax-shock level, at the same time lifetime utility still increases for all other generations. Therefore, a tax swap in combination with a skewed redistribution scheme can be Pareto improving.

Our model extends the type of OLG models first introduced by Yaari (1965) and Blanchard (1985) by using real mortality rates to construct our demographics, incorporating a hump-shaped productivity profile and introducing imperfect annuities. This results in a model that reflects the core characteristics of an economy quite accurately.

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\(^1\) This chapter was written with the financial support of MN.
\(^2\) Only the very old might be slightly better off because of larger government redistribution.
CHAPTER 2. FISCAL POLICY IN A GENERAL EQUILIBRIUM LIFE-CYCLE MODEL

Our analysis is related to several other papers. Yaari (1965) and Davidoff et al. (2005) show it is optimal for agents to annuitise their wealth. However, annuitisation of wealth does not necessarily bring about the highest welfare (Heijdra et al. (2010)). Moreover, in reality the annuity market is very small and does not function perfectly. We therefore introduce imperfect annuities. That is, the interest rate is only partially corrected for lifetime uncertainty. Therefore, agents receive a slightly lower interest rate than the perfect annuity rate.

Heijdra and Mierau (2010) investigate the effects of taxes on the key elements in an economy in a similar, albeit continuous-time model with endogenous growth. They show that a consumption tax can increase growth through redistribution. In effect, resources are taken away from the dis-saving elderly and redistributed to the saving young. They also show that although labour taxation is detrimental to growth and consumption, growth can be restored if the right redistribution policy is implemented (i.e. a redistribution skewed towards the young).

Our steady state results resemble Heijdra and Mierau (2010) quite closely. A major difference, however, is that Heijdra and Mierau (2010) describe a steady state growth path, while we describe a steady state with a stable capital stock because of our neo-classical production function. Although the steady states in their paper can be determined accurately, the transitional dynamics from one steady state to the other cannot be determined analytically. Our solution to this problem is to rewrite the model in discrete time and simulate permanent shocks that induce transition to the other steady state. An advantage of simulating this model in discrete time is that we can actually use real mortality data, which adds a realistic tail of ten years to the demographic profile, inducing very old agents to borrow again at the end of their lives. Most importantly, in our simulation we can clearly see what the impact is of policy changes on the different generations alive during the transition. We can therefore identify which generations at what time are worse or better off.

Bouzahzah et al. (2002) investigate the transitional dynamics in a discrete OLG model with six cohorts. Apart from the number of cohorts, their model differs from ours in a couple of respects. It features exogenous labour supply for all periods in life except the first; there is no lifetime uncertainty; and it features endogenous growth through a human capital accumulation function much like Lucas (1988).² Even though their long run results are quite similar to ours, their transition paths differ quite significantly from ours. The simulated tax reform in their model (a temporary increase in the income tax to repay debt followed by a reduction in income tax) immediately reduces the interest rate, while in our model such a tax reform would result in an initial drop of the interest rate, then an overshooting, followed by a reduction to a lower steady state level. Moreover, their growth rate is hump shaped, while our growth rate would jump up straight away and then slowly decline. Both differences can be attributed to the difference in exogenous versus endogenous labour supply.

Heijdra and Lighthart (2010) study the transitional dynamics of a small open economy in an OLG setting. In their finite horizon scenarios the adjustment of aggregate variables is oscillating, whereas the infinite horizon case produces a monotonic adjustment, much like our results. In their paper three elements are explained to be the driving force behind the cycles; endogenous labour supply, finite horizons and the Ethier-productivity effect.³ The latter of these explains the difference between their results and ours.

Finally, the type of tax reform is similar to the tax reform conducted in Auerbach and Kotlikoff (1987) who also find that labour taxes are more distorting than consumption taxes but who do not include imperfect annuities or life-time uncertainty.

The remainder of this chapter is organised as follows. Section 2 presents the model. In

²In addition they investigate an exogenous growth scenario.
³The Ethier-productivity effect allows for external economies of scale through input diversity.
section 3 we calibrate the steady states of the model. Section 4 presents the simulation results of the policy shocks. In section 5 we draw conclusions.4

2.2 Model

In this section we define the model we use for our simulation. We broadly follow the structure of Heijdra and Mierau (2010). However, in addition to the transformation to discrete time some very important changes are made to production, demographics and the analysis of welfare.

2.2.1 Firms

The productive side of the economy is relatively straightforward and can be described as perfect competition with the existence of a representative, profit maximising firm with the following production function:

\[ Y_t = Z_0 K_t^{\epsilon K} N_t^{1-\epsilon K}, \]

in which \( Z_0 \) is a constant technology term, \( K_t \) is the amount of capital and \( N_t \) is the amount of efficiency units of labour used. The first-order conditions for profit maximisation can be written as:

\[ w_t = (1 - \epsilon_K) Z_0 \left[ \frac{K_t}{N_t} \right]^{\epsilon_K}, \]

\[ r_t + \delta = \epsilon_K Z_0 \left[ \frac{K_t}{N_t} \right]^{\epsilon_K-1}, \]

where \( w_t \) is the real wage rate wage, \( r_t \) is the interest rate and \( \delta \) is the depreciation rate.

2.2.2 Consumers

Agents are born at the beginning of period \( v \) and die with certainty at the end of period \( v + D \). Within a period the timing is as follows. First, an agent either dies or survives. If the agent survives, he/she receives interest. Then, the agents simultaneously receive government transfers and decide how much to work and consume. After that a new period starts.

Demographics

We define a population on a steady state growth path. The size of the population \( (P_v) \) at time \( v \) is:

\[ P_v = (1 + \pi) P_{v-1}, \]

or more generally:

\[ P_v = (1 + \pi)^{v-t} P_t, \]

in which \( \pi \) is the population growth rate. The size of a new born cohort at time \( v \) is:

\[ P_{v,v} = \beta P_v, \]

in which \( \beta \) is the crude birth rate. Between (birth at) time \( v \) and time \( t \) the size of the cohort decreases to:

\[ P_{v,t} = \beta (1 + \pi)^{v-t} P_t \prod_{i=1}^{t-v} [1 - \mu_i], \]

\( ^{4}\)The Appendix contains further technical detail.
where $\mu_i$ is the mortality rate, defined as the share of a generation aged $i = t - v$ that passes away at the beginning of period $t$.\(^5\) In the simulation we use Dutch mortality data for 2009.\(^6\) We can write the relative cohort size $p_{v,t} \equiv P_{v,t}/P_t$ as:

$$p_{v,t} = \beta (1 + \pi)^{v-t} \prod_{i=1}^{t-v} [1 - \mu_i],$$

$$= \beta (1 + \pi)^{-u} \prod_{i=1}^{u} [1 - \mu_i],$$

(2.10)

in which $u = t - v$ is age. We can see that the relative cohort size only depends on age ($u$), birth rate ($\beta$) and population growth rate ($\pi$). From equation (2.10) we can extract a more general survival function between time $t$ and time $\tau$ for an individual born at time $v$:

$$M_{t-v,\tau-v} = \begin{cases} 1, & \text{if } \tau \leq t, \\ \frac{\tau-v}{t-v+1} \prod_{i=t-v+1}^{\tau} [1 - \mu_i], & \text{if } \tau > t. \end{cases}$$

(2.11)

The first part states that an individual alive at time $t$ logically cannot pass away before or at time $t$. The second part takes into account the probability of survival between the periods $t$ and $\tau$.

**Efficiency**

Although quite convenient for calculation purposes, the regular imposition of constant productivity throughout someone’s life is quite unrealistic. Instead, we use a hump shaped productivity function:

$$H_u = \alpha_0 \left[ \frac{1}{1 + \xi_0} \right]^u - \alpha_1 \left[ \frac{1}{1 + \xi_1} \right]^u.$$  

(2.12)

Using data of Hansen (1993) we can estimate the parameters for this equation using non-linear least squares. The parameters (and standard errors between brackets) are: $\alpha_0 = 19.805$ (fixed), $\alpha_1 = 19.248$ (0.064), $\xi_0 = 0.033$ (0.002) and $\xi_1 = 0.038$ (0.002) with an adjusted R-squared of 0.992. The maximum productivity is obtained at economic age 24 (42 in real life).

Because of this hump shaped productivity profile, agents face a labour market entry and retirement decision. A visual representation of efficiency and demographics is given in section 2.C.

\(^5\)The mortality rate is related to the birth rate and the population growth rate in the sense that the total population at time $t$ is comprised of the surviving fraction of the population of time $t - 1$ and the newborn generation $P_{t,c}$:

$$P_t = (1 - \bar{\mu})P_{t-1} + \beta P_t,$$

(2.8)

in which $\bar{\mu}$ is the average mortality rate. Using equation (2.4) this can be rewritten as:

$$\pi = \frac{\beta - \bar{\mu}}{1 - \beta},$$

(2.9)

which states that the population growth rate is equal to the birthrate minus the average mortality rate (corrected for the fact that the birth rate is measured as proportion of the population including the newborn cohort).

\(^6\)The maximum biological age at which mortality data are available by yearly age group is 98. Throughout this chapter age means the economic age which starts at 18. Therefore, the maximum age ($\bar{D}$) we use is 80. Hence, we have 81 cohorts; at the end of the 80th year before an agent turns 81 certain death occurs. We expect by using Dutch mortality to construct demographics data that resemble to a large extent the demographic profile of most western countries. Source mortality data: Statistics Netherlands (CBS).
The annuity market

The agents’ asset management in an OLG model with lifetime uncertainty is of particular interest. In our model agents fully annuitize their financial wealth for two reasons. First, annuities pay a higher interest rate than the market. Second, agents would not be allowed to be indebted if they took a regular capital market loan using the market interest rates.

Only allowing for regular capital market investment rules out the option to run a deficit, because agents have to meet a solvency condition upon death. Since it is uncertain when they will pass away they will have to meet the solvency condition at all time. The existence of an annuity market allows agents to borrow, as the annuity interest rate corrects for the probability of death. Agents pay a higher interest rate on debt depending on their age. On the other hand, all debt of agents who die indebted is cancelled. The higher interest rate can be calculated because the distribution of the probability of death for all cohorts is known.

For saving agents, the existence of an annuity market makes it possible to insure against longevity risk. Annuity firms invest the assets of agents in the capital market receiving the competitive interest rate $r_t$. Because a fraction of a cohort dies at the beginning of the period the annuity firms are able to pay a higher interest rate to the surviving fraction since all assets of the deceased accrue to the annuity firm.

More specifically, $(1 + r_t)A_{v,t-1}$ has been earned by the annuity firm on the assets of the cohort born at time $v$. A part of that cohort, $\mu_{t-v}$, passes away and a proportion $(0 \leq \lambda \leq 1)$ of the assets of the deceased is equally distributed among the surviving fraction $(1 - \mu_{t-v})$ of that cohort. Each member therefore receives $\lambda \mu_{t-v}/(1 - \mu_{t-v})$ of the assets of the deceased plus interest (on both their own assets and the redistributed assets), giving the annuity interest rate as: \footnote{$\lambda = 1$ is equivalent to perfect annuities, while $\lambda = 0$ is equivalent to the absence of an annuity market.}

$$(1 + r^A_{v,t})A_{v,t-1} = (1 + r_t)A_{v,t-1} + \frac{\lambda \mu_{t-v}}{1 - \mu_{t-v}}(1 + r_t)A_{v,t-1},$$

$$\Rightarrow r^A_{v,t} = r_t + \frac{\lambda \mu_{t-v}}{1 - \mu_{t-v}}(1 + r_t). \tag{2.13}$$

The profit made because of imperfect annuities ($\lambda < 1$) by annuity firms is taxed away by the government and redistributed to the surviving agents.

Individual behaviour

Agents maximise their expected remaining lifetime utility. At time $t$ the remaining lifetime utility of an agent born at time $v$ is:

$$EA_{v,t} = \sum_{\tau=t}^{\tilde{t}+v} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-t}} M_{t-v,\tau-v},$$

in which $\rho$ is the time preference parameter, $M_{t-v,\tau-v}$ is the survival function and utility is defined as:

$$U_{v,\tau} = \ln \left[ C_{v,\tau}^{e_v} [1 - L_{v,\tau}]^{1-e_v} \right]. \tag{2.15}$$

The budget identity at time $t$ is:

$$A_{v,t} = (1 + r^A_{v,t})A_{v,t-1} + w_{v,t}(1 - \theta_{L,t}) + TR_t - X_{v,t}, \tag{2.16}$$

where total consumption $X_{v,t}$ is defined as:

$$X_{v,t} = (1 + \theta_{C,t})C_{v,t} + w_{v,t}(1 - \theta_{L,t})[1 - L_{v,t}], \tag{2.17}$$

The budget identity at time $t$ is:

$$A_{v,t} = (1 + r^A_{v,t})A_{v,t-1} + w_{v,t}(1 - \theta_{L,t}) + TR_t - X_{v,t}, \tag{2.16}$$

where total consumption $X_{v,t}$ is defined as:

$$X_{v,t} = (1 + \theta_{C,t})C_{v,t} + w_{v,t}(1 - \theta_{L,t})[1 - L_{v,t}], \tag{2.17}$$
in which \( \theta_{L,t} \) and \( \theta_{C,t} \) are taxes on labour income and consumption respectively and \( TR_t \) are government transfers.\(^8\) Agents are born without assets and they are neither allowed to die indebted when death is certain (at the maximum attainable age), nor is it efficient to die in surplus when death is certain (therefore, \( A_{v,v-1} = 0 \) and \( A_{v,v+D} = 0 \)). Finally, individual wages evolve according to:

\[
w_{v,t} = H_{t-v} w_t. \tag{2.18}
\]

We use two-stage maximisation to determine the consumption, asset and labour supply path. The first stage, the intratemporal maximisation stage, optimally chooses between consumption and leisure. It maximises equation (2.15) subject to equation (2.17) and the non-negativity constraint on labour supply:

\[
\begin{align*}
\max_{C_{v,t},1-L_{v,t}} & \quad U_{v,t} = \ln \left[ C^{\sigma_c}_t [1 - L_{v,t}]^{1-\epsilon_c} \right] \\
\text{s.t.} & \quad X_{v,t} = (1 + \theta_{C,t}) C_{v,t} + w_{v,t}(1 - \theta_{L,t})[1 - L_{v,t}] \\
& \quad L_{v,t} \geq 0.
\end{align*}
\]

The first order conditions are:

\[
\begin{align*}
\frac{\epsilon_C}{C_{v,t}} &= (1 + \theta_{C,t}) \lambda_1, \tag{2.19} \\
\frac{1 - \epsilon_C}{1 - L_{v,t}} &= w_{v,t} (1 - \theta_{L,t}) \lambda_1 + \lambda_2, \tag{2.20} \\
X_{v,t} &= (1 + \theta_{C,t}) C_{v,t} + w_{v,t} (1 - \theta_{L,t})[1 - L_{v,t}], \tag{2.21} \\
L_{v,t} &\geq 0, \quad \lambda_2 \geq 0, \quad \lambda_2 L_{v,t} = 0. \tag{2.22}
\end{align*}
\]

in which \( \lambda_1 \) and \( \lambda_2 \) are the Lagrange multipliers of the respective constraints. For \( \lambda_2 = 0 \) the marginal rate of substitution between consumption and leisure is:

\[
\frac{1 - L_{v,t}}{C_{v,t}} = \frac{1 - \epsilon_C}{\epsilon_C} \frac{1 + \theta_{C,t}}{(1 - \theta_{L,t}) w_{v,t}}. \tag{2.23}
\]

The case in which \( L_{v,t} = 0 \) describes the corner solutions brought about by the hump shaped productivity profile. This induces a clear entry and retirement decision. However, because of imperfect annuities individuals would want to start working again at the end of their lives.\(^9\) But we do not allow re-entry into the labour market, working life should be a continuous period in our model. Therefore, we impose exogenously that the last ten years of the maximum life span must be spent in retirement \( (L_{v,t} = 0 \text{ for } t - v > 70) \).

Using (2.17) and (2.23) we can express “expenditure on leisure” expressed as leisure time multiplied by forgone wages in terms of total consumption:

\[
w_{v,t} (1 - L_{v,t}) = X_{v,t} \frac{1 - \epsilon_C}{(1 - \theta_{L,t})}, \tag{2.24}
\]

and we can express expenditure on consumption in terms of total consumption:

\[
C_{v,t} = X_{v,t} \frac{\epsilon_C}{1 + \theta_{C,t}}. \tag{2.25}
\]

\(^8\)In the benchmark model, government transfers are assumed to be equal between generations. This assumption will be relaxed later on in this chapter.

\(^9\)Agents discount the future more heavily because of imperfect annuities and lifetime uncertainty. They are therefore not willing to work more earlier on in life to save for later because they are unsure they will live until that age. However, once (and if) they reach a high age they still value consumption and are therefore willing to give up leisure to attain this consumption. Therefore, they would want to start working again.
The second stage of maximisation, the intertemporal stage, optimally smooths total consumption over lifetime. Using (2.24) and (2.25) in (2.15) we create the indirect utility function:

\[ U_{v,t} = \ln \left[ X_{v,t} Q_{v,t} \right], \tag{2.26} \]

in which:

\[ Q_{v,t} = \left( \frac{\epsilon C}{1 + \theta_{C,t}} \right)^{\epsilon C} \left( \frac{1 - \epsilon C}{w_{v,t}(1 - \theta_{L,t})} \right)^{1 - \epsilon C}, \tag{2.27} \]

is the "price index" at time \( t \) of total consumption reflecting the maximum attainable utility given wages and the budget constraint on total consumption.

The maximisation problem becomes:

\[ \max_{X_{v,t}} \space E \sum_{v} \ln \left[ X_{v,t} Q_{v,t} \right] M_{t-v,t-v}, \]

\[ s.t. \quad A_{v,t} = (1 + r_{v,t} A_{v,t-1} + w_{v,t}(1 - \theta_{L,t}) + TR_{t} - X_{v,t}. \]

The total consumption Euler equation becomes:

\[ \frac{X_{v,t+1}}{X_{v,t}} = \frac{1 + r_{v,t+1}}{1 + \rho} (1 - \mu_{t-v+1}). \tag{2.28} \]

Using (2.13) in (2.28) we get:

\[ \frac{X_{v,t+1}}{X_{v,t}} = \frac{1 + r_{t+1}}{1 + \rho} [1 - (1 - \lambda)\mu_{t-v+1}]. \tag{2.29} \]

The consumption Euler equation can be constructed using (2.25) in (2.29):

\[ \frac{(1 + \theta_{C,t+1}) C_{v,t+1}}{(1 + \theta_{C,t}) C_{v,t}} = \frac{1 + r_{t+1}}{1 + \rho} [1 - (1 - \lambda)\mu_{t-v+1}]. \tag{2.30} \]

If the consumption tax is kept constant (or for unexpected increases in the consumption tax) the tax rates drop out of the Euler equation.

For our purpose we do not need to analytically determine the steady state any further. Knowledge of the consumption path, the labour supply condition, the budget constraint, and the restrictions on assets at birth and certain death, is sufficient to numerically obtain the steady state values. In Appendix 2.Ba the microeconomic part of the model is summarised.

**Aggregate behaviour**

We aggregate over all agents alive at time \( t \) using (2.10), the aggregate per capita variables \( (c_t, n_t, a_t) \) are defined as:

\[ c_t = \sum_{v=t-D}^{t} p_{v,t} C_{v,t}, \tag{2.31} \]

\[ n_t = \sum_{v=t-D}^{t} p_{v,t} N_{v,t}, \tag{2.32} \]

\[ a_t = \sum_{v=t-D}^{t} p_{v,t} A_{v,t}, \tag{2.33} \]

in which \( N_{v,t} = H_{t-v} L_{v,t} \) is efficient labour supply.
2.2.3 Government

Tax hike announcements will take place at the beginning of the period; before agents make decisions on labour supply and consumption. The government balances its budget at all time, equalising redistributions and income. The income of the government consists of taxes from consumers and the profit of the annuity firms:

$$TR_t = (1 - \lambda)(1 + r_t) \sum_{v=t-D}^{t} \frac{\mu_{t-v}}{1 - \mu_{t-v}} p_{v,t} A_{v,t-1} + \theta_{C,t} c_t + \theta_{L,t} w_t n_t.$$  \hspace{1cm} (2.34)

in which we have transfers on the left hand side and profits of the annuity firms as the first term on the right-hand side.\(^{10}\) Using (2.34) we can calculate net transfers for agents:

$$NTR_{v,t} = TR_t - w_t N_{v,t} \theta_{L,t} - C_{v,t} \theta_{C,t} - (1 + r_t)(1 - \lambda) \frac{\mu_{t-v}}{1 - \mu_{t-v}} A_{v,t-1}$$

$$= w_t \theta_{L,t} (n_t - N_{v,t}) + \theta_{C,t} (c_t - C_{v,t}) + (1 + r_t)(1 - \lambda) \left( \sum_{v=t-D}^{t} \frac{\mu_{t-v}}{1 - \mu_{t-v}} p_{v,t} A_{v,t-1} - \frac{\mu_{t-v}}{1 - \mu_{t-v}} A_{v,t-1} \right).$$  \hspace{1cm} (2.35)

In this expression we have incorporated the loss agents make because of imperfect annuities, which could be interpreted as an indirect capital tax. Equation (2.35) shows that agents receive more in labour income tax than they spend on labour income tax if they supply fewer efficiency units of labour than the per capita level in the economy (first expression in brackets in the equation). Similarly, we can see that agents gain more in consumption tax than they pay if they consume less than the per capita level of consumption (second expression in brackets). The last term in brackets is a bit more difficult to evaluate, but intuitively this term is positive early in life and turns negative later on. This is because of two reasons. First, the death rate early on in life is low, which means that \(\mu_{t-v_1}/(1 - \mu_{t-v_1}) < \mu_{t-v_2}/(1 - \mu_{t-v_2})\) for \(v_1 > v_2\). Second, assets are low for early ages, rising only later on.

2.2.4 Change in lifetime utility and social welfare

To assess the change in both lifetime utility and social welfare we express this change in terms of consumption equivalence. We compare the post-shock expected remaining lifetime utility with the pre-shock expected remaining lifetime utility and calculate how much more (or less) consumption an individual should have in every remaining period given pre-shock consumption to end up with a post-shock lifetime utility. Using equations (2.14) and (2.15) we define the following relation between post-shock and pre-shock expected remaining lifetime utility:

$$E\Lambda_{v,t}^{new} = \sum_{\tau=t}^{\bar{D}+v} \ln \left[ \left(1 + \gamma_1 \right) C_{v,\tau}^{old} \epsilon_c \left[ 1 - L_{v,\tau}^{old} \right] \right] \frac{1}{(1 + \rho)^{\bar{D}-t}} M_{t-v,\tau},$$  \hspace{1cm} (2.36)

in which \(\gamma_1\) is additional (or reduction in) consumption needed to equalise both remaining lifetime utilities. Since we use log-utility we can rewrite this expression as:

$$E\Lambda_{v,t}^{new} - E\Lambda_{v,t}^{old} = \sum_{\tau=t}^{\bar{D}+v} \frac{\epsilon_c \ln(1 + \gamma_1)}{(1 + \rho)^{\bar{D}-t}} M_{t-v,\tau},$$

$$E\Lambda_{v,t}^{new} - E\Lambda_{v,t}^{old} = \ln(1 + \gamma_1) \sum_{\tau=t}^{\bar{D}+v} \frac{\epsilon_c}{(1 + \rho)^{\bar{D}-t}} M_{t-v,\tau},$$  \hspace{1cm} (2.37)

\(^{10}\) Transfers are equal on the individual and aggregate per capita level since: \(TR_t = \sum_{v=t-D}^{t} p_{v,t} TR_v\).
therefore the adjustment in consumption needed to go from pre-shock to post-shock expected remaining lifetime utility is:

$$
\gamma_1 \approx \frac{\Delta E \Lambda_{v,t}}{\sum_{\tau=t}^{\tau+D} \frac{e_c}{(1+\rho)^{\tau-v}} M_{t-v, \tau-v}}.
$$

(2.38)

The government in our model does not optimise social welfare but checks the effects of fiscal changes on it. We define social welfare as follows: \(^{11}\)

$$
SW_t = \sum_{\tau=t}^{\infty} \left( \frac{1+\pi}{1+\rho} \right)^{\tau-t} \sum_{v=\tau}^{\tau-D} U_{v, \tau}p_{v, \tau},
$$

(2.39)

in which \(\rho > \pi\) to ensure convergence. Otherwise, future generations will always be valued more than current ones. The social welfare function is a summation of utilities of different generations weighted by the generations shares of total population at a certain point in time. This is then summed over time and discounted by the rate of population growth over the rate of time preference.

For the change in social welfare expressed in consumption equivalents we can conduct a similar transformation as for individual welfare:

$$
\gamma_2 \approx \frac{\Delta SW_t (\rho - \pi)}{\epsilon_c (1+\rho)},
$$

(2.40)

in which we have used the fact that \(\sum_{\tau=t}^{\infty} \left( \frac{1+\pi}{1+\rho} \right)^{\tau-t} = \frac{1+\rho}{\rho - \pi}.\)

The macroeconomic part of the model is summarised in Appendix 2.Bb.

### 2.3 Steady state

In order to examine the transitional dynamics in this model we need to define a benchmark steady state. Once we have defined this steady state we can also calculate the steady states of the different scenarios after the shocks. We calibrate the model for 81 cohorts, each cohort resembling one year, which quite conveniently allows us to use annualised parameters.

First, we calculate the different cohort sizes relative to the total population since this is exogenous to the rest of the system. Using equation (2.10), setting \(\pi = 0.01\) and using the mortality data mentioned before, we find that \(\beta = 0.0217.\)

In our benchmark calibration for the rest of the model we set \(\rho = 0.035, \delta = 0.1, \lambda = 0.7, \theta_{C, t} = 0.2\) and \(\theta_{L, t} = 0.4.\) The tax rates are chosen to be close to OECD average tax rates.\(^{12}\) Furthermore, we let \(\epsilon_K\) adjust to ensure \(r = 0.04\) \((\epsilon_K = 0.294)\), we set \(Z_0\) to provide a capital effective-labour ratio of 0.5 \((Z_0 = 0.292)\) and we set \(\epsilon_C\) to induce a retirement age of 45, again the OECD average \((\epsilon_C = 0.228).\)<sup>13</sup> Using the benchmark parameters we can calculate the steady states of the different scenarios we want to investigate. We calculate 5 steady states, including the benchmark steady state d:

(a) No taxes

(b) Consumption tax

\(^{11}\)For a derivation of the social welfare function see appendix 2.A.

\(^{12}\)The OECD average value-added tax in 2009 was 17.6, the OECD average tax wedge on labour in 2009 was 36.4%. These averages have been fairly stable throughout the last decade (source: OECD).

\(^{13}\)Remember that we use economic age, starting at 18. OECD average retirement age between 2002 and 2007 was 63.5 for men and 62.3 for women (source: OECD).
Table 2.1: Comparative statics

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)*</th>
<th>(e)</th>
</tr>
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<td></td>
<td></td>
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<td></td>
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<td>Entry age</td>
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<td>6</td>
<td>6</td>
<td>6</td>
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<tr>
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<td>46</td>
<td>45</td>
<td>46</td>
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<td>-23.80</td>
<td>-24.17</td>
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<td></td>
<td></td>
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</tr>
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<td>$c_t$</td>
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<td>0.0395</td>
<td>0.0305</td>
<td>0.0262</td>
<td>0.0291</td>
</tr>
<tr>
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<td>0.0511</td>
<td>0.0394</td>
<td>0.0340</td>
<td>0.0377</td>
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<tr>
<td>$n_t$</td>
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<td>0.2142</td>
<td>0.1658</td>
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<td>0.1583</td>
</tr>
<tr>
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<td>0.1081</td>
<td>0.0825</td>
<td>0.0713</td>
<td>0.0794</td>
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<tr>
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<td>-37.52</td>
<td>-38.22</td>
<td>-37.70</td>
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</tbody>
</table>

Note: * Benchmark steady state

(c) Labour tax

(d) Consumption tax and labour tax

(e) Same tax income as (d), but a lower labour tax and a higher consumption tax

In Table 2.1 the core characteristics of all scenarios are summarised and in Graph 2.1 the steady states corresponding to situation (a) and (d) are presented. The movements of variables are very similar to Heijdra and Mierau (2010). Focusing first on the case without taxes (the dotted lines), we can see that in the first part of an individual’s life we have an increasing consumption profile dominated by the ratio of the market return on assets over the time preference. However, planned consumption decreases rapidly at the end of someone’s life. The reason is that if annuities are perfect, lifetime uncertainty can be eliminated completely from consumption planning. The annuity interest rate makes up for the probability of passing away. Therefore, agents can insures themselves against longevity by investing their wealth in annuities. However, with imperfect annuities, agents have to take into account that they might pass away sometime in the future and therefore discount consumption at higher ages more heavily. This makes the tail of graph a) slope downward.

Agents balance leisure and consumption, taking wages and taxes into account (equation (2.23)). They supply more labour when wages are high (i.e. when productivity is high). Due to the hump shaped productivity profile we therefore also get a hump shaped labour supply curve. Before entering the labour market wages are too low for individuals to be willing to work. At some point, as wages increase by age, agents are indifferent between working and not working given a certain consumption level. This can be verified by setting $L_{w,t} = 0$ in equation (2.23). It could of course be that, since we are dealing with discrete time, this point lies in between two generations. As wages increase further, more labour is supplied. Labour supply drops when productivity declines. At some point wages become so low that agents decide to retire. Because of imperfect annuities the model predicts that,

---

14This is because the term within brackets of equation (2.30) is close to 1 if mortality rates are close to 0.
if consumption at ages close to certain death becomes low enough, agents would want to re-enter the labour market. However, we do not allow for that in this model since this is clearly not supported by the data. In our model working life must be a continuous period.

The asset profile describes the budget identity over time as given in equation (2.16) in combination with equation (2.17), substituting the optimised values for consumption and labour supply. Individuals, logically start with zero assets. In the first phase of their lives they only consume and do not work. The only income that they receive consists of the transfers by the government. Assets initially drop as individuals consume more than they receive. On this debt they pay the annuity interest rate (which is at that point in life close to the market interest rate). As they start working the drop in assets decelerates and eventually as labour income increases assets move into positive territory. The peak in assets is reached when total income (labour income, capital gains and government transfers) equals consumption. After that assets drop off since consumption keeps increasing while income falls. Eventually at certain death no assets are left.

The effect of taxes is represented by the solid line. Consumption levels are decreased when labour and consumption are taxed (40% and 20% respectively). We see both an income effect (consumption becomes more expensive and working becomes less profitable) and a substitution effect (consumption is substituted for leisure). The asset profile becomes less pronounced compared to the scenario without taxes for two reasons. First, individuals work and consume less and second government transfers are higher, which dampens debt accumulation at the first phase of people’s lives. Because of a higher interest rate (lower capital-labour ratio), debt holding are more expensive, creating an in-
centive to reduce debt in the first phase of agents’ lives. We can also see that if taxes exist and are reasonably high, agents start borrowing again at the end of their lives. Adding the realistic tail to the demographic structure (ages 70 to 80) has this effect on the asset profile. Transfers in the last few years of life are high enough and consumption low enough for agents to be able to meet the solvency condition upon certain death.

Table 2.1 shows that a 20% consumption tax is welfare deteriorating, (b) compared to (a). The positive effect of the drop in labour supply plus the redistribution effects (resources are taken away from the dissaving old and redistributed to the saving young) cannot outweigh the loss of consumption and the loss of savings. A 40% labour tax however is even more welfare deteriorating, see situation (c). Logically, a tax swap - lower labour tax and higher consumption tax - increases welfare (see situation (e) compared to (d)).

2.4 Simulation

In this section we simulate fiscal policy shocks using the model described in the previous sections. For each scenario steady state (d) is chosen as starting point. We simulate three scenarios:

1. Permanent consumption tax increase
2. Permanent labour income tax increase
3. Tax swap: permanently lower labour tax, permanently higher consumption tax

For scenario 1 and 2 we also investigate the effect of announcing the shock beforehand. The tax increase is announced 10 years before it takes effect. The length of the announcement period is chosen for illustrative purposes, a shorter horizon gives qualitatively similar but less pronounced results. For scenario 3 we also investigate the effect of a tax swap in combination with a skewed redistribution of tax income.

The set-up of the experiment is as follows. Under scenario 1 the government simply raises the consumption tax with five percentage points. Under scenario 2 the aim of the government is to collect the same amount of discounted tax income as under scenario 1, but this time raising the labour income tax. To match the same discounted tax income as under scenario 1 we need a labour tax increase of 13.5 percentage points. Finally, the goal of the tax swap is to reduce the labour tax by ten percentage points but to keep tax revenue constant. In order to keep tax revenue stable we eventually need a consumption tax increase of 3.2 percentage points. However, during transition the consumption tax will be much higher. Even though, quite unrealistically, the tax shocks in each scenario are large, the transitional dynamics are shown clearly in these cases, which is what we are particularly interested in. Smaller, more realistic tax increases have logically similar but smaller effects.

There are a couple of technical issues we need to address during the simulation. Certain anticipated shocks induce young agents to enter the labour market in the last period before the shock, then exit the labour market at shock impact only to re-enter later in life.

---

15Moreover, as Altit et al. (2001) show if diversity of earnings within a generation is taken into account, an increase in consumption tax will deteriorate the lifetime utility of the worker with the lowest pay the most.

16It can even be shown that this holds with a labour tax that returns the same tax revenue.

17Keep in mind, however, that an implicit long term announcement of tax hikes, considering a scenario with a declining population (or a drop in population growth), is not completely unrealistic. As the population declines the tax burden on the working population has to rise to be able to pay for a collective social security system. Since population trends are generally perceived to be known, agents can expect taxes to rise under this scenario, even though these tax increases are not formally announced. This is a phenomenon that can be seen in many western countries with ageing populations.
2.4. SIMULATION

Figure 2.2: Consumption tax increase: Aggregated variables
(a) Consumption ($c_t$)  
(b) Labour supply ($n_t$)  
(c) Assets ($a_t$)  
(d) Welfare ($E_{\Lambda_{v,t}}$) in consumption equivalent:

Unanticipated (---), anticipated (-----)

Note: Changes compared to benchmark steady state

In our model we exclude the possibility of re-entering the labour market altogether; the working life of an agent should be a continuous period. We do not allow agents to re-enter at high ages and we do not allow young agents to "pre-enter" the labour market before the shock lest they decide to quit at impact.\(^\text{18}\)

2.4.1 Scenario 1: consumption tax increase

First, we investigate an unanticipated consumption tax increase from 20% to 25% at time $t = 1$. For consumption there are two noticeable effects. First, consumption drops almost across the board because it becomes more expensive (see figure 2.2a).\(^\text{19}\) Second, consumption drops more for the working population — workers substitute consumption for leisure, even reducing the retirement age by one year (see figures 2.2b and 2.3) — this creates a discrepancy between those who can adjust labour supply and those who are already retired.\(^\text{20}\) This effect is expressed by the hump in consumption for agents who are already retired at shock impact (see figure 2.5). Aggregate labour supply briefly undershoots its ultimate value because transfers are relatively high directly after the shock compensating

\(^{18}\)Additional graphs can be found in the Appendix.
\(^{19}\)Consumption rises slightly for the very old for whom government transfers offset dearer consumption.
\(^{20}\)The reduction of labour supply is also visible in the asset profile, even though assets fall across the board, assets of the retired do not fall as rapidly as the assets of the working (see figures 2.2c and 2.4)
partly for lost labour income.

Figure 2.2d shows that life-time utility (expressed in consumption equivalents) deteriorates for all agents alive during or after the shock except the very old. However, the drop in social welfare is relatively modest, compared to the benchmark scenario social welfare in consumption equivalents (as calculated by equation (2.40)) drops 1.64%.

Now we turn to the anticipated shock. At time $t = 1$ the government announces a consumption tax increase of 5 percentage points taking effect at time $t = 11$. Both older workers and the recently retired initially increase consumption since it is relatively cheap prior to the shock (see figure 2.2a and 2.5b). The older working generation does this while decreasing labour supply (keeping the marginal rate of substitution constant), thus running down assets (see figures 2.2b and c). Labour supply no longer undershoots the new steady state after the shock. Both the very young (those with negative assets) and the very old cut back consumption. There are two reasons for this. First, because assets decrease interest rates increase, making borrowing more expensive. Second, because labour supply is decreased, labour tax income decreases as well reducing transfers. Figure 2.5 for consumption shows that the hump shape for retired agents, which appeared under the unanticipated scenario, has vanished. Additionally, the announcement allows working agents to smooth consumption better.

Social welfare drops by 1.35% which is slightly lower than with no announcement, this is mainly caused by discounting later generations heavier (if we start counting in both cases ten years before the shock). However, the announcement has significant redistributational effects between generations. Agents with positive assets who will still be alive to see the tax increase have slightly higher lifetime utility than people who are at the beginning of
Figure 2.4: Consumption tax increase: Assets $A_{u,t}$

(a) unanticipated

(b) anticipated

(c) zoom of a)

(d) zoom of b)
Figure 2.5: Consumption tax increase: Consumption $C_{v,t}$

(a) unanticipated

(b) anticipated

(c) zoom of a

(d) zoom of b
their working lives or the very old (see figure 2.2d). Older workers and the retired benefit from rising interest rates, while the very young and the very old suffer from rising interest rates and/or decreased transfers (the latter do not gain enough from rising interest rates to offset the negative effects from falling transfers). The drop in lifetime utility seems much smoother than before. The reason for this result is that a consumption tax affects every agent in a similar way. Therefore, if this tax increase comes as a surprise nobody can dodge it. Those who would be consuming the most in their life at the time of the shock are disproportionately hit. If the tax increase is announced, however, they can anticipate the shock and adjust their labour supply in advance thus more optimally smoothing consumption and labour supply.

From a social welfare point of view it does not matter that much whether a consumption tax hike is announced or not. If the government cares about reducing the variation in lifetime utility between adjacent generations the tax hike should be announced.

### 2.4.2 Scenario 2: labour tax increase

The second scenario examines the effect of a labour tax increase from 40\% to 53.5\%. Again, we start with an unanticipated shock at time $t = 1$. This unanticipated labour tax increase collects exactly the same amount of discounted tax income as under scenario 1 without anticipation.
At shock impact labour supply is reduced drastically. All working agents cut back their labour supply, the entry age rises to 7 and the retirement age falls to 38 (see Figures 2.6b and 2.7). The reason for this large shift in retirement age is that working becomes relatively unrewarding and the government transfers are very high directly after the shock. Therefore, labour supply can be cut back while consumption does not have to fall dramatically for people close to retirement. After the shock a minor counter reaction can be seen; the retirement age slowly rises again to its new steady state level of 42 and labour supply of younger agents increases slightly compared to other generations. This is because the young are most indebted at shock impact and have to work more to make up for the difference. Since the final retirement age has dropped the peak in assets shifts to earlier ages (see figure 2.8). Looking at the consumption side of the economy we see a clear redistribution effect. At shock impact working agents reduce consumption because of reduced labour income which is not entirely compensated by higher government transfers. For retired agents consumption rises; those who would have worked, had there been no shock, are more than compensated for their loss of income. Figure 2.9 shows a clear saddle-like dip in consumption for those agents who are still in the labour force. The most noticeable effects of the shock fade out with the last surviving agent alive at the time of the shock.

Lifetime utility for agents who are retired at shock impact stays more or less constant, because the increase in redistribution offsets the decrease in the interest rate (see figure 2.6d). All working agents are logically worse off. However, there is a slight blip for agents who are born at shock impact. This is because they fully benefit from high redistributions and high wages when they enter the labour market. Wages are high because of the relatively high capital stock in combination with low labour supply (see figures 2.6b and 2.6c).
Social welfare drops 11.09% (in consumption equivalents).

Now we turn to the anticipated shock. At time $t = 1$ a labour tax increase of 13.5 percentage point taking effect in period $t = 11$ is announced. Older working agents start cutting back their labour supply prior to the shock (see Figures 2.6b and 2.7). They are compensated for their loss in labour income by relatively high redistribution after the shock. Young agents generally supply more labour before the shock benefiting from the low tax rate. Older agents who start cutting back their labour supply early logically find their assets decreasing more rapidly than before (see figure 2.8). For individuals who increase labour supply the reverse obviously holds. Agents who postpone labour market entry at shock impact see their asset level deteriorate as they were indebted before the shock on which they had to pay a relatively high interest rate, a situation from which they recover by supplying relatively much labour after the shock compared to other generations. The most striking effect of the announcement for consumption is that the hump shape exhibited under the unannounced shock is less pronounced (see figure 2.9). Individuals can smooth consumption more optimally because of the announcement.

A remarkable effect of the announcement is that lifetime utility has become smoother between subsequent generations — i.e. the variance in life-time utility has decreased (see figure 2.6d). Instead of creating more dispersion among the population, which is the case under the announcement of a consumption tax increase, the announcement of a labour tax hike decreases the lifetime utility differences between generations. In contrast to the consumption tax, the labour tax only hits the working population directly. Hence, announcing the tax hike enables people to adjust their plans for both working and consuming already before the shock hits. Therefore, it is not just the working population that takes the biggest
hit when the new tax rate takes effect. Lifetime utility still decreases for all agents. However, the blip exhibited under the unannounced scenario is no longer there. Announcing the shock beforehand shifts lifetime utility from the working old to the working young compared to the scenario without announcement. This of course makes sense since the working old receive large redistributions in the first periods after the shock under the unannounced scenario, while supplying no labour at all. Overall, total social welfare drops by 8.83% which is 0.14% lower compared to the scenario without announcement (if we start counting ten years before the shock). From a social welfare point of view it again hardly matters whether a labour tax hike is announced or not. However, if the government want to collect the highest discounted tax flow and/or cares about equality of adjacent generations it should announce the tax hike.

### 2.4.3 Scenario 3: tax swap

This scenario examines the effect of a tax swap, starting at situation (d) and ending up at situation (e). The goal of the government is to keep tax revenue (and therefore redistribution) stable while at the same time lowering the labour income tax, this results in an upward adjustment of the consumption tax. Using equation (T12) of the model summary:

$$
TR = (1 - \lambda)(1 + r_t) \sum_{v = t - D}^{t} \frac{\mu_{t-v}}{1 - \mu_{t-v}} p_{v,t} A_{v,t-1} + \theta_C c_t + \theta_{L,0} w_t n_t
$$

Keeping $TR$ constant on the left hand side and decreasing the labour tax (from $\theta_{L,0} = 0.4$ to $\theta_{L,1} = 0.3$) on the right hand side has to result in either an upward adjustment of the
consumption tax or an upward movement in the profit that is taxed away from the annuity firm. However, the increase in profits of the annuity firm is relatively small and cannot be controlled by the government.\textsuperscript{21} It is therefore clear that the bulk of the adjustment has to come from adjusting the consumption tax.

We abstract in this scenario from anticipation effects since this would dominate the transitional dynamics and would blur our view of what we are really interested in. At time $t = 1$ the government lowers labour income tax with 10 percentage points (from 40\% to 30\%). To keep tax revenue stable it increases consumption tax to 26.0\% at first. The consumption tax gradually falls back to 23.2\%, due to rising labour supply and therefore rising labour tax revenue (see Figures 2.10b and 2.11). A striking result is that the young only increase their labour supply gradually; for these agents lower wages (because of increased labour supply by others) partially offset the effect of a lower labour tax, additionally a higher consumption tax makes consumption relatively expensive compared to leisure. However, the cost in terms of total future consumption does not increase as dramatically for young agents as it does for older agents. Older agents face a relatively high consumption tax for the period in which they were planning to consume the most. These agents will directly increase their labour supply. The labour tax cut ultimately results in a rise in retirement age to 46, overshooting at first to 50 for the generation that

\textsuperscript{21}The profits of the annuity firm will rise, since, as we will see later, the total amount of assets will rise, offsetting the modest fall in the interest rate.
was planning to retire at the time of the shock. After the first surge in labour supply after the shock it slowly rises further as the consumption tax drops slowly. Even though the agents born at shock impact supply relatively much labour they see their assets decline more rapidly at first since they face a relatively high interest rate for the first (borrowing) part of their lives (see figure 2.12). The working (saving) population on the other hand has rising assets. All retired agents do not have increasing assets since they cannot adjust labour supply; they can therefore only adjust consumption to meet the solvency condition in the end. Figure 2.13 clearly shows the redistribution effect of a tax swap. We see a sharp decrease in consumption for the retired but also a decrease for agents who are at the end of their career. Apparently the lower income tax for the short remainder of their working life does not neutralise the higher consumption tax. All younger agents increase consumption.

For lifetime utility we see a drop for those who are already retired at the time of the shock and those who are close to retirement (see figure 2.10d). We see a rise in lifetime utility for the working population who see their labour become more lucrative. But for younger agents alive at the time of the shock lifetime utility drops compared to adjacent generations because they face a relatively high interest rate in the phase of their lives in which they borrow. They have to compensate for this by supplying relatively much labour at a low wage while facing a relatively high consumption tax. But still they have a higher lifetime utility than in the absence of the tax policy change. Post-shock agents’ lifetime utility rises steadily as consumption tax decreases and the interest rate and wages stabilise. Total social welfare rises with 4.47% in consumption equivalents.

The big question facing policy makers is: can we introduce a tax swap and at the same
time make everybody better off? One possible way to do this is to redistribute more of tax income to older agents to compensate for dearer consumption. Instead of a flat redistribution the government changes its redistribution to:

\[ TR_{v,t} = z [1 + \phi_t]^{(t-v)/\bar{D}} , \]

in which \( \bar{D} \) is the maximum attainable age and \( \phi_t \) is defined as an AR(1) process, \( \phi_t = \rho \phi_t + \eta \) in which \( \rho = .975 \) and the shock term \( \eta = .2 \) in the first period of the tax hike. This results in a redistribution that is skewed towards the elderly. In the period of the shock the oldest person therefore receives a 20% higher redistribution than the youngest person. Furthermore, \( z \) is adjusted to balance the government budget.\(^{22}\)

With this new redistribution scheme in place consumption of the retired no longer drops as dramatically as before (see Figure 2.13). It actually rises quickly after the shock takes place, which is why the consumption tax does not have to increase as much as before to collect the same amount of taxes. Labour supply rises much quicker since the working young have to compensate for lower government transfers (see figures 2.11 and 2.10b). This is why lifetime utility for younger generations drops quite significantly compared to the tax swap with flat redistributions. However, lifetime utility is still increasing for young generations while at the same time it is also increasing for older generations (see figure

\(^{22}\)We now can define the government budget constraint as:

\[ \sum_{t-v=0}^{\bar{D}} p_{v,t} TR_{v,t} = (1 - \lambda)(1 + r_t) \sum_{t-v=0}^{\bar{D}} \frac{\mu_{t-v}}{1 - \mu_{t-v}} p_{v,t} A_{v,t-1} + \theta_{C,t} c_t + \theta_{L,t} w_t n_t . \]
2.10d). This redistribution scheme therefore brings about a Pareto improvement. But lifetime utility takes much longer to reach the new (higher) steady state level. Social welfare rises with 4.51% which is even slightly higher compared to the flat-redistribution case. However, it is important to keep in mind that in this model the population distribution is assumed to be constant. Therefore a fixed, rather small proportion of the population (the retired) needs to be compensated. However, in most modern day western countries the proportion of retired people is rising. Therefore, compensating these cohorts would either demand more from government finances or would lead to a even more skewed or persistent redistribution.

2.5 Conclusion

Every tax increase, decrease or swap has a very different impact on different agents participating in the economy. After the change in taxes, it is always labour supply that adjusts the quickest. This quick adjustment in the end brings about an adjustment in consumption and assets.

A consumption tax increase decreases lifetime utility for almost all agents alive during or after the shock. However, the drop in social welfare is relatively modest, compared to the benchmark scenario. Announcing the shock has the effect that agents who have positive assets (and are still alive after the shock) will increase consumption and decrease their labour supply before the shock, therefore mitigating some of the negative effects of the tax hike. The announcement decreases variation in lifetime utility of adjacent generations.

A labour tax increase logically has the biggest impact on the working population. Every
working agent cuts back labour supply in the face of the shock. Older agents may even decide to retire at shock impact. A labour tax increase shifts resources away from the working population towards the retired. They increase their consumption because of the large redistributions floating their way. A labour tax increase is in the end detrimental for social welfare. An announcement of the shock mitigates the negative effect for the working population. An interesting result is that the announcement has a clear smoothing redistributional effect.

A tax swap ultimately has a positive impact on lifetime utility. It replaces a highly distorting tax (labour tax) by a slightly less distorting tax (consumption tax). However, at first this tax swap has a negative impact on the retired. They face dearer consumption for the rest of their lives while not being able to benefit from lower labour taxes. All retired agents therefore cut back consumption. The tax swap has the clear redistribution effect of benefiting the young at the expense of the old. This effect can however be offset by an appropriate redistribution. If the retired receive a larger share of total redistribution they can be made better off than before the tax swap. A tax swap in combination with this redistribution scheme is therefore Pareto improving.

Overall, for all fiscal changes we always see a clear discrepancy between the retired, the working population and the non-working young. Therefore, apart from their permanent effect, fiscal changes and the choice of announcement also have a clear redistribution effect for the population alive at the time of the shock and/or at the time of the announcement.

Appendix

2.A Social welfare

We define social welfare for time $t$. The expected lifetime utility an individual in a future generation born at time $v \geq t$:

$$E_{v,v}^{new} = \sum_{\tau=v}^{v+D} \frac{U_{v,\tau}}{(1+\rho)^{\tau-v}} M_{0,\tau-v},$$

(2.44)

The government discounts (for simplicity) with $\rho$ — just like individuals — and takes into account the relative size of the cohort. The social welfare for newborn generations is:

$$SW_t^{new} = \sum_{v=t}^{\infty} p_{v,t} E_{v,v}^{new},$$

(2.45)

$$SW_t^{new} = \sum_{v=t}^{\infty} \beta \frac{1+\pi}{1+\rho} \sum_{\tau=v}^{v+\hat{D}} \frac{U_{v,\tau}}{(1+\rho)^{\tau-v}} M_{0,\tau-v},$$

(2.46)

The expected remaining lifetime utility of an individual in the old generations $v < t$ is equivalent to equation (2.14):

$$E_{v,v}^{old} = \sum_{\tau=t}^{\hat{D}+v} \frac{U_{v,\tau}}{(1+\rho)^{\tau-t}} M_{t-v,\tau-v},$$

(2.47)

The government does not need to discount since all older agents are already alive at time $t$, however, the government needs to take into account the relative size of the cohort.\footnote{For individuals the only thing that matters is the fact that they are alive at a certain point in time and whether they had a certain probability to pass away before is none of their concern anymore. Therefore, they disregard all past $\mu$’s. But the government should take into account that some people of the cohort were on the unfortunate side of $\mu$ and it should also keep in mind that the population is growing.}
Therefore, social welfare for old generations is:

\[
SW_{t}^{old} = \sum_{v=t-D}^{v=t-1} p_{v,t}E\Lambda_{v,t},
\]

\[
SW_{t}^{old} = \sum_{v=t-D}^{v=t-1} \beta(1 + \pi)^{v-t} M_{t-v,t-v} \sum_{\tau=t}^{\bar{D}+v} \frac{U_{v,\tau}}{(1 + \rho)^{t-\tau}} M_{t-\tau-v,t-\tau-v}.
\]

\[
SW_{t}^{old} = \sum_{v=t-D}^{v=t-1} \beta(1 + \pi)^{v-t} \sum_{\tau=t}^{D+v} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-t}} M_{t-\tau-v,t-\tau-v},
\]

(2.48)

Which can be rewritten as:

\[
SW_{t}^{old} = \sum_{v=t-D}^{v=t-1} \beta \left(1 + \frac{\pi}{1 + \rho}\right)^{v-t} \sum_{\tau=t}^{D+v} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-t}} M_{t-\tau-v,t-\tau-v}
\]

(2.49)

Total social welfare is:

\[
SW_{t} = SW_{t}^{old} + SW_{t}^{new}
\]

(2.50)

\[
SW_{t} = \sum_{v=t-D}^{v=t-1} \beta \left(1 + \frac{\pi}{1 + \rho}\right)^{v-t} \sum_{\tau=t}^{D+v} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-t}} M_{t-\tau-v,t-\tau-v} + \sum_{v=t}^{\infty} \beta \left(1 + \frac{\pi}{1 + \rho}\right)^{v-t} \sum_{\tau=v}^{\bar{D}} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-t}} M_{t-\tau-v,t-\tau-v}
\]

(2.51)

If we reverse the summation we see that equation (2.51) can be written as:

\[
SW_{t} = \sum_{\tau=t}^{\infty} \beta \left(1 + \frac{\pi}{1 + \rho}\right)^{\tau-t} \sum_{v=t-D}^{v=v-\tau} \frac{U_{v,\tau}}{(1 + \rho)^{\tau-v}} M_{t-v,t-v}
\]

(2.52)

Which is equivalent to:

\[
SW_{t} = \sum_{\tau=t}^{\infty} \beta \left(1 + \frac{\pi}{1 + \rho}\right)^{\tau-t} \sum_{v=t-D}^{v=v-\tau} p_{v,\tau} U_{v,\tau}
\]

(2.53)
2.B Model summary

a) Microeconomic relationships:

\[ A_{v,t} = (1 + r_{v,t}^A)A_{v,t-1} + w_t H_{t-v} (1 - \theta_{L,t}) L_{v,t} + TR_t - (1 + \theta_{C,t}) C_{v,t} \]  \hspace{1cm} (T1)

\[ A_{v,v} = 0 \quad \text{and} \quad A_{v,v+D} = 0 \]  \hspace{1cm} (T2)

\[ \frac{C_{v,t+1}}{C_{v,t}} = 1 + \frac{\theta_{C,t}}{1 + \theta_{C,t+1}} \frac{1 - (1 - \lambda)\mu_{t-v+1}}{1 + \rho} \]  \hspace{1cm} (T3)

\[ 1 - L_{v,t} = \frac{1 - \epsilon_C (1 + \theta_{C,t}) C_{v,t}}{(1 - \theta_{L,t}) w_t H_{t-v}} \]  \hspace{1cm} (T4)

b) Macroeconomic relationships:

\[ c_t = \sum_{v=t-D}^t p_{v,t} C_{v,t} \]  \hspace{1cm} (T5)

\[ n_t = \sum_{v=t-D}^t p_{v,t} H_{t-v} L_{v,t} \]  \hspace{1cm} (T6)

\[ a_t = k_t = \sum_{v=t-D}^t p_{v,t} A_{v,t} \]  \hspace{1cm} (T7)

\[ y_t = Z_0 k_t^{\epsilon_K} n_t^{1-\epsilon_K} \]  \hspace{1cm} (T8)

\[ w_t = (1 - \epsilon_K) Z_0 \left( \frac{k_t}{n_t} \right)^{\epsilon_K} \]  \hspace{1cm} (T9)

\[ r_t = \epsilon_K Z_0 \left( \frac{k_t}{n_t} \right)^{\epsilon_K-1} - \delta \]  \hspace{1cm} (T10)

\[ 1 + r_{v,t}^A = (1 + r_t) \frac{1 - (1 - \lambda)\mu_{t-v}}{1 - \mu_{t-v}} \]  \hspace{1cm} (T11)

\[ TR_t = (1 - \lambda)(1 + r_t) \sum_{v=t-D}^t \frac{\mu_{t-v}}{1 - \mu_{t-v}} p_{v,t} A_{v,t-1} + \theta_{C,t} c_t + \theta_{L,t} w_t n_t \]  \hspace{1cm} (T12)

\[ SW_t = \sum_{\tau=t}^{\infty} \left( \frac{1 + \pi}{1 + \rho} \right)^{\tau-t} \sum_{v=\tau-D}^{\infty} U_{v,\tau} p_{v,\tau} \]  \hspace{1cm} (T13)
2.C Efficiency and demographics

Figure 2.14: Efficiency profile and demographics  
(a) Efficiency ($E_u$)  
(b) Relative cohort size ($p_u$)  
(c) Mortality rate ($\mu_u$)  
(d) Surviving fraction of cohort  
($\Pi_{t=0}^{u}[1 - \mu_i]$)

2.D Variation parameters

In this section we will briefly describe the effect of varying the main parameters and some functions in our model. In the main text of the paper this is ignored because we are ultimately interested in fiscal policy changes in that specific model. However, for completeness we describe here what difference it would make to change parameters and functions in the model.

2.D.1 Annuities

First we look at differences between perfect and imperfect annuities ($\lambda = 1$ vs. $0 < \lambda < 1$ respectively, see figure 2.15). As shown in Heijdra and Mierau (2010) under perfect annuities the consumption growth path is increasing at a constant rate. The reason for this is that agents can perfectly insure themselves against longevity risk by buying annuities, the full probability of passing away is in this case incorporated in the annuity interest rate. Therefore, the mortality rate drops out of the Euler equation and consumption increases according to; $C_{v,t+1}/C_{v,t} = (1 + r_{t+1})/(1 + \rho)$; which is a constant in a steady state economy. Transfers are now completely determined by consumption and labour taxes. Over-
2.D. VARIATION PARAMETERS

Figure 2.15: Annuities

(a) Consumption ($C_u$)  
(b) Labour supply ($L_u$)  
(c) Assets ($A_u$)  
(d) Net transfers ($NTR_u$)

Perfect annuities ($\lambda = 1$) (---) and imperfect annuities ($\lambda = 0.7$) (....)
all consumption and lifetime utility are higher in an economy with perfect annuities even though slightly more labour is supplied. We can therefore infirm that imperfect annuities are a source of imperfection and a more efficient allocation can be reached if annuities are perfect.

2.4.2 Population growth

Comparing the scenario with and without population growth, there is a shift in the distribution of the population. Generations younger than 31 with a 1% population growth are larger relative to the case without population growth. Generations older than 31 are subsequently smaller. We see that on an individual level not much happens, the consumption profile becomes slightly flatter compared to the growth case because of a decreased interest rate and agents save slightly less throughout their working life (see figure 2.16). On an aggregate level the changes are bigger since the population distribution changed. Social welfare is difficult to compare to other scenarios since population shares are directly used in this measure. However, we see that expected lifetime utility is slightly smaller than under the benchmark scenario.

2.4.3 Technology

Next we consider a scenario under which the production side of the economy is characterised by multiple perfectly competitive firms with a productivity externality. The firms exhibit the following individual production function:

$$Y_{i,t} = Z_t K_{i,t}^{\epsilon K} N_{i,t}^{1-\epsilon K},$$

(2.54)

$Z_t$ is the technology at time $t$, $K_{i,t}$ is the amount of capital and $N_{i,t}$ is the amount of efficiency units of labour used. The first-order conditions of profit maximisation can be
Figure 2.16: Population growth

(a) Consumption ($C_u$)  (b) Labour supply ($L_u$)

(c) Assets ($A_u$)  (d) Net transfers ($NTR_u$)

No population growth ($\pi = 0$) (---) and population growth ($\pi = 0.01$) (-----)

written as:

$$w_t = (1 - \epsilon_K)Z_t \left[ \frac{K_i,t}{N_i,t} \right]^{\epsilon_K},$$

(2.55)

$$r_t + \delta = \epsilon_K Z_t \left[ \frac{K_i,t}{N_i,t} \right]^{\epsilon_K - 1},$$

(2.56)

$w_t$ is the real wage rate, $r_t$ is the interest rate and $\delta$ is the depreciation rate. The capital intensity is the same for every firm, therefore, $K_i,t/N_i,t \equiv K_i/N_t$, where $K_t$ and $N_t$ are the cumulative capital stock and cumulative efficiency units of labour in the economy respectively.

We define the technology function as follows:

$$Z_t = Z_0 \left[ \frac{K_t}{N_t} \right]^{\eta}.$$  

(2.57)

We can therefore rewrite (2.54)-(2.56) as:

$$Y_t/N_t = Z_0 \left[ \frac{K_t}{N_t} \right]^{\epsilon_K + \eta},$$

(2.58)

$$w_t = (1 - \epsilon_K)Z_0 \left[ \frac{K_t}{N_t} \right]^{\epsilon_K + \eta},$$

(2.59)

$$r_t = \epsilon_K Z_0 \left[ \frac{K_t}{N_t} \right]^{\epsilon_K + \eta - 1} - \delta.$$  

(2.60)
CHAPTER 2. FISCAL POLICY IN A GENERAL EQUILIBRIUM LIFE-CYCLE MODEL

Figure 2.17: Technology externality

(a) Consumption ($C_u$) (b) Labour supply ($L_u$)

(c) Assets ($A_u$) (d) Net transfers ($NTR_u$)

Technology externality ($\eta = 0.1$) (——) and no technology externality ($\eta = 0$) (-----)

Note the difference of the equations above with equations T9 and T10 in the main text. Having $\eta > 0$ reflects an externality that could capture for instance human capital or knowledge. If $\eta \equiv 1 - \epsilon_K$ the model exhibits endogenous growth a la Romer (1989), the steady state is defined as a steady state growth path in which the capital stock rises at a constant rate and $r_t \equiv r$ is independent of time. In this section we focus on the case in which $\eta < 1 - \epsilon_K$. In the steady state the capital stock is still constant and the model only exhibits exogenous growth as under the benchmark scenario.

We see that this different technology function does not have an impact on labour supply. However, it lowers the aggregate capital stock again leaving interest rates unchanged. The reason for this is that the capital labour ratio is smaller than 1, a positive $\eta$ effectively lowers total production. Capital is more productive under this scenario but this effect is more than offset because of the decreased productivity of labour. Therefore, in steady state the marginal product of capital is still the same as under the benchmark scenario. Wages, however, drop as well as consumption. Therefore, life-time utility and social welfare are lower than under the benchmark scenario.

Finally, we did a quick investigation into the effect of the size of $\eta$ on the adjustment path. We find; the closer $\eta$ is to the knife-edge case the longer the adjustment path. Which makes sense since we get closer to the situation in which there is no steady state capital stock.
2.E Additional graphs

2.E.1 Consumption tax increase

(a) Interest rate \((r_t)\)

(b) Wage rate \((w_t)\)

(c) Production \((y_t)\)

(d) Tax revenue \((TR_t)\)

Unanticipated (—), anticipated (-----)

Note: Changes compared to benchmark steady state
Figure 2.19: Consumption tax increase: Net transfers $NTR_{u,t}$

(a) unanticipated

(b) anticipated

(c) zoom of a)

(d) zoom of b)
2.6.2 Labour tax increase

Figure 2.20: Labour tax increase: Aggregated variables
(a) Interest rate \((r_t)\)
(b) Wage rate \((w_t)\)
(c) Production \((y_t)\)
(d) Tax revenue \(TR_t\)

Unanticipated \(\)(—), anticipated \(\)(—–)

Note: Changes compared to benchmark steady state
Figure 2.21: Labour tax increase: Net transfers $NT R_{v,t}$

(a) unanticipated

(b) anticipated

(c) zoom of a)

(d) zoom of b)
2.E.3 Tax swap

Figure 2.22: Tax swap: Aggregated variables
(a) Interest rate \((r_t)\)
(b) Wage rate \((w_t)\)
(c) Production \((y_t)\)
(d) Consumption tax \((θ_t)\)

Flat redistribution \((\text{---})\), skewed redistribution (towards old) \((\text{-----})\)

Note: Changes compared to benchmark steady state
Figure 2.23: Tax swap: Net transfers $N TR_{u,t}$

(a) flat

(b) skewed

(c) zoom of a

(d) zoom of b

age(u)
time(t)
3 Intergenerational effects of unemployment on pensions

3.1 Introduction

In this chapter we study the intergenerational effects of unemployment caused by wage rigidity on the accumulation of pension entitlements. Our chapter is based on the situation in Southern Europe, for example Spain, where a negative shock combined with wage rigidity led to large groups of (mainly) young being excluded from employment over the course of the crisis. Certain cohorts are therefore stuck with relatively low income and low pension entitlement accumulation for a large part of their lives. Other cohorts on the other hand are largely shielded from the shock, enjoying steady wages in combination with a sustained build up of pension rights.

The Great Recession has made the problem described above more urgent in many European countries, with unemployment — and especially youth unemployment — rising substantially. A possible explanation for the sharp rise in unemployment can be found in the existence of wage rigidities. If wages do not adjust in a crisis it is likely that the adjustment is made through a reduction in employment. Part of the reason behind the rapid rise of youth unemployment follows from the fact that younger employees are likely to be the first ones to be fired (see for instance Scarpetta et al. (2010) and Carcillo et al. (2015)), while new labour market entrants will not be hired. Additionally, once stuck in long-term unemployment, workers are less likely to be rehired.

The protracted crisis with persistently high levels of (youth) unemployment leaves a significant portion of the labour market with no or limited pension entitlements accumulation. As the OECD (2015) notes: “Delaying entry into the labour market by five years for an average-wage worker implies a pension gap of 6% relative to full-career workers on average across [OECD] countries.” So even when the direct effects of high (youth) unemployment have died out and unemployment is back to normal levels the crisis will still have a delayed effect on the pension provisions of those who were unemployed in the past.

The disparity of pension systems and labour market institutions within the euro area prompts us to focus on a sub-set of euro area countries. To cover a large enough part of the euro area we focus on its four biggest countries: Spain, Germany, France and Italy.

We start by simulating different employment histories for our four euro area countries in a deterministic way. During this accounting exercise we keep the wage profile fixed for three different skill levels. We simulate a full career, a working life with 10 years of youth unemployment and finally a working life in which a worker becomes unemployed during the last 10 years of working age. We distinguish between unemployment at young ages and unemployment at older ages because the rules governing pension entitlement accumulation are very different for these two groups. Those who become unemployed directly after leaving education typically do not build up any pension rights while pension contributions are typically paid on regular unemployment benefits (regular unemployment).

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1 Scarpetta et al. (2010) add that the prevalence of youth on temporary contracts in some countries is another important reason behind the rapid rise in youth unemployment as it makes it relatively easy for employers to shed labour.

2 For regular unemployment this is 5%.
CHAPTER 3. INTERGENERATIONAL EFFECTS OF UNEMPLOYMENT ON PENSIONS

We find that the replacement rates in Spain are the highest (close to 100%). Because of the relatively generous pension system, unemployment has little effect on the pension entitlements since minimum required years of contributions for a maximum pension are still reached. High skilled workers always reach the maximum pension whereas medium skilled workers reach the maximum pension if they are employed for their entire working lives. In the other three countries being unemployed for 10 years has a larger impact. Pensions and replacement rates drop significantly and in Germany the pension entitlements of the young unemployed with low skills get close to the minimum pension. For France and Italy, there are large differences between the young unemployed and the old unemployed. This is because receiving unemployment benefits count towards pension entitlement accumulation and because unemployment benefits last longer for older workers in these countries. In Germany this effect is smaller because unemployment benefits run out quicker.

Next, we build an overlapping generations model with three generations (two working and one retired) in which unions, representing each generation sequentially, set the wages for a certain generation — both for when they are young and when they are old — before this generation enters the labour market. Firms pick the employment level once the state of the economy is known. This model is an overlapping generations extension of the classic union models of for instance Leontief (1946), Dunlop (1950), McDonald and Solow (1981) and Nickell (1982).

Since workers receive unemployment benefits when they are out of work, the union sets the wage above the market clearing rate. Because there are two possible labour market states (employed and unemployed), there are four different employment paths leading to four different pensions. The working young, experienced old (the previously employed) and the inexperienced old all receive a different wage and are employed by different firms. All people in the economy consume their after tax wage or benefit; there is no saving decision (hand to mouth economy). Finally, the government redistributes collected taxes to the unemployed and the retired, it always runs a balanced budget.

The interaction between the pension system and the labour market is limited in the event of a shock. The pension system has an effect on steady state outcomes of labour market variables but because wages are pre-determined pension systems matter less for the transitional dynamics.

In the steady state wages are higher and employment lower for the pay-as-you-go (PAYG) notional defined contribution pension system and the funded pension system compared to our benchmark PAYG defined benefit system. The reason is that pensions in these systems also depend on unemployment benefits and pensions depend more on wages earned early on in life compared to the PAYG defined benefit system, making it relatively less important to work both periods and more important to earn higher wages early on in life. Wages also rise (and employment drops) in case of a permanent negative technology shock under the PAYG defined contribution system. This is because contributions no longer adjust downward (as under the defined benefit system), to keep net wages — and therefore consumption — on the same level, gross wages need to rise further. Pensions are by construction more equally distributed under the funded pension system and the PAYG notional defined benefit pension system compared to the PAYG defined contribution and benefit system. The maximum pension under both the PAYG defined contribution/benefit system is 2.5 times higher than the minimum pension whereas this ratio is 1.4 for both the funded system and the PAYG notional defined contribution system.

We find that a technology shock is largely reflected in labour market outcomes which do not differ significantly across pension systems. A negative shock leads to higher unemployment because wages are pre-determined. Because unemployment rises, taxes to fund unemployment benefits must rise as well, leading to lower consumption. Those who
were employed at the time of the shock are more likely to be employed the next period than those who were unemployed. This is also reflected in the difference in the drop of utility for those who work when they are young compared to those who are unemployed, the utility of the latter drops more.

For the pension system itself the usual outcomes are found, with individual pensions fully stable under the PAYG defined benefit system, dropping under the PAYG (notional) defined contribution system and stable under the funded system (wages are stable and the interest rate is fixed in our model). On the aggregate we do find a belated drop in average pensions for the funded and the defined benefit system since fewer people build up high level pensions (i.e. more people have followed the less fortunate employment path). This effect is absent for the defined contributions systems since benefits are adjusted upwards once employment and thus social contributions bounce back.

There are few papers describing the effects of unemployment on pension provisions. Schreiber (2005) describes a very similar model to ours with 3 generations (2 working one retired). Young workers are outsiders, older workers are insiders or outsiders depending on their previous work experience. The model contains learning by doing and wages are set through a right to manage system. The existence of a defined contributions pay-as-you-go system leads to a larger entry of outsiders since there is a reward for insiders (higher contributions and therefore higher pensions).

Demmel and Keuschnigg (2000) also investigate a system quite similar to ours. However, their overlapping generations framework has only two generations (one working and one retired) and PAYG pensions do not depend on the wage but are the same for everyone. This lead to wages being a fixed markup over unemployment benefits as under the classic union model.\footnote{Ultimately they are interested in a switch from a PAYG system to a funded system. This switch reduces unemployment and boosts capital accumulation. A switch can yield positive welfare effects for both current and future generations.}

Corneo and Marquardt (2000) also investigate a two generation union model with wages set by the union. They find that contribution rates have no impact on unemployment. A PAYG system has negative effect on growth and an efficient transition to a funded system is possible.

Ono (2007) has a very similar setup as Corneo and Marquardt (2000) with the main difference being that labour efficiency depends on per capita capital rather than per worker capital and that the union objective function is a general CES function rather than Cobb-Douglas function. This time a higher contribution rate leads to a lower unemployment rate.

Finally, the OECD (2015) reports that delayed labour market entry of five years leads to losses of 10%, 7% and 0% and a gain of 3% in pensions compared to a regular working life in Italy, Germany, Spain and France respectively (our model predicts much larger losses).

The rest of this chapter is structured as follows in section 2 we describe pension systems and unemployment and wage dynamics in the four biggest euro area countries, in section 3 we conduct an intergenerational accounting exercise, in section 4 we set up an overlapping generations model, in section 5 we calibrate the model and report the comparative statics, in section 6 we report the dynamic results and finally in section 7 we conclude.

3.2 Descriptive analysis

3.2.1 Pension system

In order to describe the effects of unemployment on pensions accurately we first turn to the key characteristics of the public pension systems of the big four euro area countries
Table 3.1: Pensions systems

<table>
<thead>
<tr>
<th>Type of PAYG</th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
<th>IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pension age</td>
<td>65</td>
<td>65</td>
<td>62</td>
<td>66 m, 62 f</td>
</tr>
<tr>
<td>Contribution (% pension base)$^1$</td>
<td>9.5 w</td>
<td>4.7 w</td>
<td>6.8 w</td>
<td>11 w</td>
</tr>
<tr>
<td>Minimum contribution (years)</td>
<td>5</td>
<td>15</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Contributions regular unemployment (max duration)$^2$</td>
<td>Yes (12m)</td>
<td>Yes (24m)</td>
<td>Yes (24m)</td>
<td>Yes (24m)</td>
</tr>
<tr>
<td>Contributions unemployment without previous work experience</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ceiling pension base (% av. wage)</td>
<td>200</td>
<td>160</td>
<td>100</td>
<td>330</td>
</tr>
<tr>
<td>Gross replacement rate (%)$^3$</td>
<td>42</td>
<td>74</td>
<td>59</td>
<td>71</td>
</tr>
<tr>
<td>Targeted minimum pension (% av. wage)$^4$</td>
<td>23</td>
<td>19</td>
<td>26</td>
<td>22</td>
</tr>
</tbody>
</table>

1. w=worker, e=employer. 2. Max duration for workers under 50, for full table see appendix. 3. Replacement rate of mean earner. 4. Tested against means such as savings. All entries refer to 2013. Source: OECD (2013).

(see Table 3.1, or for a more extended overview Table 3.5 in the appendix). While all four countries have some form of a pay-as-you-go (PAYG) system, there are large differences in contributions, minimum years of contribution, base wages and replacement rates.

In Germany no specific replacement rate is promised, instead workers earn pension points, one point for each year contributed at the average wage, these points are multiplied with a pension point value at retirement. The value of pension points is linked to wages but also subject to financial sustainability.

In Spain on the other hand the objective is to provide a replacement rate of 50% of average earnings after 15 years of contributions. This can increase to a replacement rate of 100% after 35 years of contributions.$^4$ However, the actual replacement rate is usually lower since the maximum pension is limited at €30600 in 2014, which is around 15% higher than the average wage in Spain.

In France the replacement can reach 50% after a full career of 41.5 years. The replacement rate is based on the 25 best years of earnings. Pension entitlements are pro-rated for missing years of earnings (1.25% per missing year).

Italy introduced a notional defined contributions system in 2011. This means that even though the underlying mechanics still follow a pay-as-you-go system — the current workers pay for the current retired — the build up in entitlements mimic a funded system: contributions are added to a notional fund with a return equal to the 5 year moving average growth rate of the economy. At retirement this fund is divided by the expected remaining life-time.

While replacement rates are higher on average in Spain and Italy (compared to Germany and France), so are contribution rates. Both Spain and Italy also have the highest minimum years of contributions to be eligible for a public pension. Finally, in all four countries there are limits to the pension base wage. In France this is the most restrictive, only the part of the wage that is below the national average wage contributes to the public pension.

$^4$This is again based on the average earnings of the last 15 years of employment.
3.2.2 Unemployment

The ultimate level of a pension depends crucially on a person’s work history. Spells of unemployment for instance (and non-employment in general) can have a profound impact on individual pension entitlements. Pension entitlement accumulation will be absent or reduced during a period of unemployment. The build up of pension rights during unemployment will depend on the duration of unemployment and on whether social security contributions were paid in the past. The long term unemployed, the inactive and the unemployed without previous working experience (and therefore without previous social security contribution payments) do not build up any pension rights, they typically only receive social assistance (if any). Only persons receiving regular unemployment benefits generally accumulate pension entitlements (see Table 3.1).

In Germany a person receives unemployment benefits for 6 to 12 months after becoming unemployed (depending on the total time worked). The pension benefit accumulation during employment and unemployment is similar, the only exception being that the government pays the entire contribution for the unemployed. In Spain and France the years someone receives unemployment benefits count towards the total time “worked” but are not used to determine the reference wage. The maximum benefit duration in both countries for people under 55 is two years. The unemployed and the government pay pension contributions (the same shares apply as previously for the employed and the firm). Finally, in Italy the years during which someone receives unemployment benefits (maximum of 2.5 years for someone under 50) count towards the minimum years of contributions. Again the unemployed and the government pay for the pension contributions (in equal shares as previously the employed and the firm). The contributions are then added to the nominal account.

In addition to the direct effects of unemployment on pension entitlement accumulation it is likely that wages are lower once work is found compared to the wage under continuous employment, thus lowering pension entitlement accumulation further. Schmieder et al. (2013) show for instance that 1 month unemployment lowers wage offers by 0.8%. Gregg and Tominey (2005) show that a year of unemployment when young leaves a dent of 13-21% in wages at age 42.

Finally, being out of work for a longer period of time lowers the probability of finding work, which can lead to long-term unemployment and ultimately increasing the probability of getting stuck in a minimum pension. Even though persistent long-term unemployment is a problem in many European countries the drop in the job finding rate as unemployment drags on is generally found to be smaller in continental Europe compared to Anglo-Saxon countries (see Machin and Manning (1999), Elsby et al. (2008) and Hobijn and Sahin (2009)).

The effects of unemployment and non-employment on pensions described above can be sizable during normal times and individual pension provisions can be affected to a large extent but during crises more people will be affected and the effects generally last longer which can have serious macro-economic consequences.

As we can see in Figure 3.1(a) employment dropped substantially during the most recent crisis. Especially employment for the age group 15-39 decreased dramatically with Spanish employment rates dropping more than 20 percentage point between 2007 and 2013 (during the same period Spanish youth unemployment reached the 50% mark). Many of the unemployed and inactive in these countries have therefore experienced a considerable drop in both earnings and in pension accumulation.

Unfortunately, data on pension rights accumulation dependent on work history are difficult to come by. However, data exists on the share of the labour force that is eligible for a public pension dependent on age (see Figure 3.1(a)). Since age and work history are typically closely related — younger workers have shorter working histories — these data
provide an insight into the effects of working history on pension provisions. However, it is not possible to distinguish between the effects of unemployment and the effects of not having reached the minimum years of contributions.\footnote{The data in Figure 3.1(b) refer to 2010 in which the full effect of the crisis is not yet visible.}

### 3.2.3 Wages

While unemployment rises rapidly during crises wages tend to be relatively stable. Both downward nominal wage rigidity as well as downward real wage rigidity are common in Europe. Throughout the rest of the chapter we will focus on real rigid wages, since this is the more prevalent rigidity in Europe (see for instance Babecký et al. (2010)). Using survey evidence Druant et al. (2009) report that more than 70% of Spanish firms, 27% of the German firms, 33% of the French firms and 6% of the Italian firms have some kind of wage indexation which leads to rigid real wages. These results are in line with many other studies, for instance Messina et al. (2009) and Dickens et al. (2007). While the figures differ across studies, partly due to different methodologies, it is commonly found that real wage rigidity is high in Spain, moderate to substantial in Germany and France and low in Italy. Wage rigidity is likely to be part of the explanation behind rising unemployment during crises. If wage moderation is absent or insufficient, part of the adjustment will occur through lower employment.

The combination of both wage rigidity and high (youth) unemployment after negative shocks has profound implications for pension provisions. On the one hand the older generations are largely shielded from negative shocks. If they are retired they receive fixed pensions and if they continue to work they have stable wages and are therefore able to keep pension contributions largely at pre-shock levels. On the other hand, the unemployed are without work and do not build up pension entitlements and if work is found they are likely to sustain lower wages.

### 3.2.4 Labour market institutions

Labour market institutions can have a profound impact on wage setting and employment dynamics.
3.3. INTERGENERATIONAL ACCOUNTING EXERCISE

Union density (or coverage), employment protection, wage bargaining coordination and centralization, active labour market policies and the tax wedge are generally found to have a significant impact the flexibility (and level) of wages (Clar et al. (2007), Dessy (2004), Dickens et al. (2007), Babecký et al. (2010) Anderton and Bonthuis (2015)). In a standard wage bargaining framework the level of the wage depends (among other things) on the relative strength of the bargaining positions of the parties involved. For instance insiders have a more privileged position compared to outsiders (Lindbeck and Snower (1988)). This privileged position includes, but is not limited to, higher wages and better employment prospects.

In this chapter the bargaining strength of workers comes from unionisation. Even though classic union models (Leontief (1946), Dunlop (1950), McDonald and Solow (1981) and Nickell (1982)) differ in many respects, one commonality is that wages are typically higher and employment lower than under the competitive solution. In this framework wages are typically rigid, with employment taking part of the hit in case of a negative shock to the economy.

Even though union membership has been in steady decline during the last decades (from roughly 35% of the OECD work force in 1980 to 15% in 2014), unions still represent a large part of the work force during wage negotiations. This is reflected in the difference between union density (card carrying members of the union) and union coverage (all workers covered during the union's wage negotiations). In a lot of countries wage agreements negotiated by unions automatically extend to non-union members of the same industry. In the four countries covered in this chapter, union coverage ranges from 58% of the workforce in Germany to 98% of the workforce in France.6

3.3 Intergenerational accounting exercise

To investigate the possible effects of unemployment on pension entitlement accumulation we start by simulating different employment histories for our four euro area countries in a deterministic way. During this accounting exercise we keep the wage profile fixed as given by the EUKLEMS data set and assume that in the case of unemployment wages do not rise in line with the usual wage profile but instead are steady. Therefore, someone who is unemployed from age 20 to age 30 will earn the wage of a 20 year old at age 30.

First, we simulate a "regular" working life in which workers find a job at 20 and retire at 65. Second, we simulate a working life in which workers enters the labour market at 20 but do not find a job for the first 10 years after labour market entry, additionally they receive lower wages throughout the working life (retirement is still at 65). Finally, we simulate a working life in which a worker enters employment at 20 but becomes unemployed at 55 until retirement, this worker therefore also misses out on the highest wages in life.

We distinguish between unemployment at young ages and unemployment at older ages because the rules governing pension entitlement accumulation are very different for these two groups (as shown in the pension section). Those who become unemployed directly after leaving education typically do not build up any pension rights. They might receive social assistance but this does not count towards pension entitlement accumulation. Pension contributions are typically paid on regular unemployment benefits, i.e. benefits received after previously paying social security contributions (see Table 3.1). This means pension entitlements accumulate, albeit at a lower level. Additionally, in many countries becoming unemployed at high ages (55 and over) will result in longer lasting unemployment benefits and/or additional pension credits and therefore an extended accumulation of pension entitlements.

6Source: ICTWSS database.
Figure 3.2: Earnings simulation for young medium skilled unemployed

Source: EUKLEMS, OECD and own calculations. Relative earnings are defined as earnings relative to the average wage ($w_t/\bar{w}$). Periods of each 5 years are considered in the calculation. See Figure 3.3 for pension levels and replacement rates for all skill levels and all scenarios.

To make the results comparable across countries we take for all four countries the same wage profile. We calculate the replacement rate as the pension payments divided by the last working period’s wage (this wage is taken after pension contributions are paid, this causes some replacement rates to exceed 100%). In our calculations each discrete period is 5 years long.

As we can see in Figure 3.2 the replacement rate in Spain for medium skilled workers is indeed the highest, close to 100%. Because of the relatively generous pension system, unemployment early in the working life has little effect on the pension entitlements since minimum required years of contributions for a maximum pension are still reached. The only difference arises through having a lower reference wage (the highest part of the typical wage profile is not reached). In Spain it does not matter whether someone is unemployed early in working life or later in working life (Figure 3.3). High skilled workers always reach the maximum pension whereas medium skilled workers reach the maximum pension if they are employed for their entire working lives.

In the other three countries being unemployed for 10 years has a larger impact. Pensions and replacement rates drop significantly and in Germany the pension entitlements of the young unemployed with low skills get close to the minimum pension.
3.3. INTERGENERATIONAL ACCOUNTING EXERCISE

Figure 3.3: Pension levels and replacement rates by skill level

Source: EUKLEMS, OECD and own calculations. l: low skilled, m: medium skilled, h: high skilled.

For France and Italy, there are large differences between the young unemployed and the old unemployed. This is because receiving unemployment benefits count towards pension entitlement accumulation and because unemployment benefits last longer for older workers in these countries. In Germany this effect is smaller because unemployment benefits run out quicker.

Our results differ significantly from the OECD (2015), which reports that delayed labour market entry of five years leads to a -7%, 0%, +3% and -10% difference in pensions compared to a regular working life in Germany, Spain, France and Italy respectively (compared to our -26%, -9%, -13% and -26% for the medium skilled). There are two reasons for this. First, labour market entry in our model is delayed by 10 years compared to the 5 years for the OECD study.7 Second, we use a wage profile, whereas the OECD calculates the effect of unemployment on an average wage earner. In our model, part of the loss in pension comes from having a lower reference wage for pension calculations compared to the full career baseline. In the OECD study this effect is absent.8 The losses in replacement rates

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7Additionally, in OECD (2015) the relation between years of unemployment and pension loss seems to be nonlinear.

8For interrupted careers the results are slightly closer DE: -5% (-23%), ES: 0% (-9%), FR: +3% (0%), IT: -10% (-9%), with the OECD calculations without brackets and ours in brackets. The differences arise again through the reasons mentioned in the main text and because the OECD considers a career interruption rather than an early career end. However, this boosts the pensions in our calculations since pension
in our model are indeed smaller.

Differences between skills arise mainly through the differences in wage profiles. However, in the case of Spain some redistributions takes place since contributions are paid up to 160% of the average wage while the maximum payout is only 115% of the average wage. In France replacement rates drop rapidly for higher skill levels, this is caused by the relatively low pension base wage. However, this also means that higher wages have paid relatively less in contributions. These effects are absent for Germany and Italy since the maximum pension base wage is never reached in our accounting exercise.

3.4 Model

In the previous section we used the observed wage profile and hand picked employment. In this section we set up a general equilibrium life-cycle model in which wages and employment are determined endogenously. We introduce three generations of equal size (normalised to 1), of which two are of working age and one is retired. Both working periods and the retirement phase are 20 years long. Which means that someone can start working at 20, retire at 60 and will pass away at 80. Each period is relatively long, but since we are mainly interested in differences between the working young, the working old and the retired, it serves the purpose.

Since there are two possible labour market states (employed and unemployed) there are four different employment paths (see tree above). Someone can be employed (L) in both periods, earning \( w_y \) and \( w_l \) in the first and second period respectively and receiving a pensions of \( p_{ll} \) at retirement (R). Someone can be employed in the first period, earning \( w_y \), and unemployed (U) in the second period, receiving unemployment benefits \( b \). This person will receive a pension \( p_{lu} \). Someone can be unemployed in the first period and employed in the second, receiving/earning \( b \) and \( w_u \), respectively and receiving pension \( p_{ul} \) at retirement. And finally someone can be unemployed in both working age periods, receiving unemployment benefits in the first two period and a minimum pension \( p_{uu} \) at retirement.

Keeping the model as simple as possible; all people in the economy consume their after tax wage or benefit, there is no saving decision (hand to mouth economy). This way pensions are solely provided through the public pension system.

The three different possible wages (\( w_y \), \( w_l \) and \( w_u \)) are earned at three different firms. The reason to model it like this is to keep the interaction between generations limited to the social security system (both pensions and unemployment benefits). With fixed unemployment and pension benefits our model returns the classic union monopoly model

accumulation at the end of a career are generally more generous.
results.

The three different wages are set by unions but firms pick the employment level (right to manage). Workers of a certain cohort and work history are randomly picked to either work or not work. The unions represent each generation separately both for when they are young and when they are old. The unions set wages for each generation before the respective generation enters the labour market (i.e. wages are set at economic birth). Labour in this model is supplied inelastically but labour demand deviates from full employment because of the wages set by the unions.

Finally, the government redistributes collected taxes to the unemployed and the retired, it always runs a balanced budget.

For a person (economically) born at time $t$ we have the following sequence of events:

1. Using information available in period $t - 1$, labour unions representing the cohort born at time $t$ determine the wages this cohort wants to earn in periods $t$ and $t + 1$.

2. At time $t$, aggregate productivity for this period ($A_t$) is revealed. Firms choose their labour demand given this aggregate productivity and wages set by labour unions in $t - 1$ (for the young) and $t - 2$ (for the old).

3. At time $t + 1$, aggregate productivity ($A_{t+1}$) is revealed. Firms again choose their labour demand given aggregate productivity and wages set by labour unions in $t$ (for the young in $t + 1$) and $t - 1$ (for the old in $t + 1$).

4. In period $t + 2$, the cohort born at time $t$ retires and consumes the pension they accumulated in periods $t$ and $t + 1$.

Our baseline pension system takes a defined benefit pay-as-you-go form, for the person born at time $t$ the state of technology at time $t + 3$ is therefore irrelevant. Later on we will relax this assumption.

### 3.4.1 Firms

In our model we have three types of firms, firms either hire young workers, experienced old workers or inexperienced old workers. The young firm will set labour demand for the young ($L_y$) in order to maximise profit:

$$\Pi_{y,t} = A_t A_y L_y^{1-\alpha_y} - w_{y,t} L_y^{\alpha_y}$$  \hspace{1cm} (3.1)

in which $1 - \alpha_y$ is the output elasticity of the young, $A_y$ is the technology parameter for the young and $A_t$ is aggregate productivity defined as $A_t = e^{\sigma_t}$ in which $\sigma$ has a normal distribution around mean 0. As mentioned above the wage ($w_{y,t}$) is set before the state of the economy ($A_t$) is known. Labour demand ($L_y$) dependents on the state of the economy and is adjusted by the firm such that the following first order condition (FOC) always holds:

$$w_{y,t} = (1 - \alpha_y) A_t A_y L_y^{-\alpha_y}$$  \hspace{1cm} (3.2)

The next period (when workers are old), workers are employed by two different firms depending on their work history. The optimisation for the firms employing old employees is similar. The firm employing experienced old employees (employees who were previously employed by the young firm) has the following profit function:

$$\Pi_{i,t} = A_t A_i L_i^{1-\alpha_i} - w_{i,t} L_i^{\alpha_i}$$  \hspace{1cm} (3.3)

and the firm employing inexperienced old workers has the following profit function:

$$\Pi_{u,t} = A_t A_u L_u^{1-\alpha_u} - w_{u,t} L_u^{\alpha_u}$$  \hspace{1cm} (3.4)
in which the $L$'s, $w$'s, $A$'s and $\alpha$ serve the same function as in the young firm. This will lead to the following FOCs:

\begin{align*}
w_{u,t} &= (1 - \alpha_u)A_u A_u L_u^{\alpha_u} \quad (3.5) \\
w_{l,t} &= (1 - \alpha_l)A_l A_l L_l^{\alpha_l} \quad (3.6)
\end{align*}

The three first order conditions above determine the labour demand curves for the three types of labour.

Since we have a diminishing returns production function the firms are making profits for positive values of $L$. We assume that these profits either flow abroad or are absorbed by capital holders who play no other part in the economy, therefore profits do not flow back into the (local) economy.

### 3.4.2 Households

Each household has four different possible paths at birth in this model (see tree at the beginning of this section). Someone can be employed (L) or unemployed (U) in the first two periods in which they earn $w_{k,t}$ (for $k = y, l, u$) or receive $b$ respectively. During the last period the agents are retired (R) and receive a pension of $p$, which is dependent on the work history.

We keep the modeling of the households very simple. Households live hand to mouth, consuming their after tax wages or unemployment benefits. Therefore, an unemployed worker will consume:

\[ c_{b,t} = (1 - \theta_t - \tau_t)b \quad (3.7) \]

in which $\theta$ is the contribution for the pension system and $\tau$ the contribution to fund the unemployment benefit system.\footnote{Under the PAYG defined benefit system consumption is history dependent because of the inclusion of pension contributions.} If a worker is employed he/she will consume:

\begin{align*}
c_{y,t} &= (1 - \theta_t - \tau_t)w_{y,t} \quad (3.8) \\
c_{l,t} &= (1 - \theta_t - \tau_t)w_{l,t} \quad (3.9) \\
c_{u,t} &= (1 - \theta_t - \tau_t)w_{u,t} \quad (3.10)
\end{align*}

Consumption returns the following utility (for $i = \{b, y, l, u\}$):

\[ u(c_{i,t}) = c_{i,t}^{1-\eta} - 1 \quad (3.11) \]

Throughout the exercise we assume that people also pay taxes on unemployment benefits (i.e. the same tax wedge is applied as for working people). The reason to model consumption like this is that wages become counter cyclical for most calibrations in the presence of constant unemployment benefits. As we will see below, the difference between $u(c_{y/l/u})$ and $u(c_b)$ plays an important role in the policy function of the unions. If consumption during unemployment is constant the unions will set wages slightly higher in case of a negative shock since being unemployed still returns a steady stream of consumption (see Appendix 3.B for a more detailed exploration of this effect). In reality letting net unemployment benefits vary with the state of the economy (low benefits in bad times and higher benefits in good times) does not seem unrealistic as governments will try to spread the burden of recessions over both working and unemployed workers.
3.4.3 Government

The only task of the government in our model is to collect taxes and redistribute these taxes to the unemployed and the retired. For unemployment benefits we set income from unemployment contributions equal to expenditure on unemployment benefits:

$$\tau_t (L_{y,t}w_{y,t} + L_{u,t}w_{u,t} + L_{l,t}w_{l,t}) = [2 - L_{y,t} - L_{u,t} - L_{l,t}] (1 - \tau_t) b$$

(3.12)

$\tau$ will be adjusted to balance the budget and is therefore dependent on the wage and employment levels. However, we assume that each union is too small to take into account the effect of the choice of the wage on $\tau$.

In our baseline model we introduce a defined benefit pay-as-you-go pension system. We need to take into account the effects of the level of the pension of the retired generation on the contribution rates for the working generations. Let’s first look at the total cost of the full pension system. In Germany, France, Italy and Spain the level of pensions depend on the past wage:

$$p_{ll,t} = \gamma_1 w_{y,t-2} + \gamma_2 u_{l,t-1}$$

(3.13)

$$p_{ul,t} = \gamma_3 w_{u,t-1}$$

(3.14)

$$p_{lu,t} = \gamma_4 w_{y,t-2}$$

(3.15)

$$p_{uu,t} = \gamma_5 b$$

(3.16)

in which $p_{ll}$ is the pension received by those who have worked both periods, $p_{ul}$ is the pension for working the first period, $p_{ul}$ is the pension received for working the last period and finally $p_{uu}$ is the pension for those who were unemployed for both periods. In each of the four countries $p_{uu}$ is also related to unemployment benefits. Because these unemployment benefits directly after becoming unemployed are related to the previous wage we incorporate this effect on the pension in $\gamma_4$. For now we assume that the parameters of the pensions are fixed (the pension for the permanently unemployed is fixed and linked to gross unemployment benefits). In reality this is not always the case. In Germany for instance the replacement rate is subject to financial sustainability of the system and in Italy the parameters depend on the growth rate of the economy.

Multiplying all pensions $p$ with the respective shares of the retired generation and adding up we get the total payout of the pension system at time $t$:

$$Benefits_t = p_{ll,t} L_{l,t} + p_{ul,t} L_{u,t-1} + p_{lu,t} [L_{y,t-2} - L_{l,t-1}] + p_{uu,t} [1 - L_{y,t-2} - L_{u,t-1}]$$

(3.17)

The total contributions to fund the pension system at time $t$ is equal to:

$$Contributions_t = \theta_t (L_{y,t}w_{y,t} + L_{l,t}w_{l,t} + L_{u,t} w_{u,t} + [2 - L_{y,t} - L_{u,t} - L_{l,t}] b)$$

(3.18)

it should be noted that these contributions are paid by two different generations. Again the government balances the pension budget setting total contributions equal to total benefits, $\theta$ adjusts to balance the budget:

$$\theta_t = \frac{p_{ll,t} L_{l,t-1} + p_{ul,t} L_{u,t-1} + p_{lu,t} [L_{y,t-2} - L_{l,t-1}] + p_{uu,t} [1 - L_{y,t-2} - L_{u,t-1}]}{L_{y,t}w_{y,t} + L_{l,t}w_{l,t} + L_{u,t} w_{u,t} + [2 - L_{y,t} - L_{u,t} - L_{l,t}] b}$$

(3.19)

We assume that unions are too small to take into account the effects of setting the wage on $\theta$ (i.e. they take $\theta$ and $\tau$ as given).

Later on in this chapter we consider variations of the pension system. We introduce for instance a pay-as-you-go defined contribution system (PAYG DC). This time it is the contribution rate that is fixed but the pensions are adjusted:

$$\theta = \gamma_t \frac{p_{ll,t} L_{l,t-1} + p_{ul,t} L_{u,t-1} + p_{lu,t} [L_{y,t-2} - L_{l,t-1}] + p_{uu,t} [1 - L_{y,t-2} - L_{u,t-1}]}{L_{y,t}w_{y,t} + L_{l,t}w_{l,t} + L_{u,t} w_{u,t} + [2 - L_{y,t} - L_{u,t} - L_{l,t}] b}$$

(3.20)
in which $\gamma_t$ is adjusted. Pensions are therefore:

\[
p_{ll,t} = \gamma_t \gamma_t w_{y,t-2} + \gamma_t \gamma_t w_{t-1} \\
p_{ul,t} = \gamma_t \gamma_t w_{u,t-1} \\
p_{lu,t} = \gamma_t \gamma_t w_{y,t-2} \\
p_{uu,t} = \gamma_t \gamma_t b
\]  

(3.21) (3.22) (3.23) (3.24)

in which gamma 1 to 5 are still defined as previously.

Alternatively we introduce a notional defined contribution pay-as-you-go system (PAYG NDC). Under this system people pay a fixed rate $\theta$ which is kept in a notional fund which grows at a fictive rate $r$ (also the contributions of the unemployed are kept in this fund). We consider the Italian case in which $r$ is the 20 year growth rate of the economy:10

\[
r_t = \ln \left( A_t \sum_i A_i L_{i,t}^{1-\alpha_i} \right) - \ln \left( A_{t-1} \sum_i A_i L_{i,t-1}^{1-\alpha_i} \right)
\]  

(3.25)

Pensions are therefore:

\[
p_{ll,t} = \frac{(1 + r_{t-1})(1 + r_t)\theta w_{y,t-2} + (1 + r_t)\theta w_{t-1}}{\gamma_t \gamma_t w_{y,t-2} + \gamma_t \gamma_t w_{t-1}} \\
p_{ul,t} = \frac{(1 + r_{t-1})(1 + r_t)\theta b + (1 + r_t)\theta w_{u,t-1}}{\gamma_t \gamma_t w_{y,t-2} + \gamma_t \gamma_t w_{t-1}} \\
p_{lu,t} = \frac{(1 + r_{t-1})(1 + r_t)\theta w_{y,t-2} + (1 + r_t)\theta b}{\gamma_t \gamma_t w_{y,t-2} + \gamma_t \gamma_t w_{t-1}} \\
p_{uu,t} = \frac{(1 + r_{t-1})(1 + r_t)\theta b + (1 + r_t)\theta b}{\gamma_t \gamma_t w_{y,t-2} + \gamma_t \gamma_t w_{t-1}}
\]  

(3.26) (3.27) (3.28) (3.29)

In equilibrium $r = 0$. Total benefits are still defined as previously:

\[
Benefits_t = p_{ll,t} L_{l,t-1} + p_{ul,t} L_{u,t-1} + p_{lu,t} [L_{y,t-2} - L_{l,t-1}] + p_{uu,t} [1 - L_{y,t-2} - L_{u,t-1}]
\]  

(3.30)

But the contributions rate to fund the pension system is now fixed so total contributions at time $t$ are now equal to:

\[
Contributions_t = \theta (L_{y,t} w_{y,t} + L_{l,t} w_{l,t} + L_{u,t} w_{u,t} + [2 - L_{y,t} - L_{u,t} - L_{l,t}] b)
\]  

(3.31)

Since $\theta$ is fixed in this case (as it is a defined contribution system) it can happen that total contributions and total benefits do not match and that there there is a gap:

\[
gap_t = Benefits_t - Contributions_t
\]  

(3.32)

since $r = 0$ in equilibrium the gap will also be 0 in equilibrium, people receive exactly what they paid while working. To close the gap of the pension system out of equilibrium we introduce a lump sum tax on all working generations $\theta_{lump}$:11

\[
\theta_{lump,t} = \frac{\gap_t}{2}
\]  

(3.33)

As we will see later it could be that $\theta_{lump}$ is negative.

Finally, we consider a funded system. All contributions are paid into a fund and invested abroad at fixed interest rate $r$:

\[
p_{ll,t} = (1 + r)^2 \theta w_{y,t-2} + (1 + r)\theta w_{l,t-1} \\
p_{ul,t} = (1 + r)^2 \theta b + (1 + r)\theta w_{u,t-1} \\
p_{lu,t} = (1 + r)^2 \theta w_{y,t-2} + (1 + r)\theta b \\
p_{uu,t} = (1 + r)^2 \theta b + (1 + r)\theta b
\]  

(3.34) (3.35) (3.36) (3.37)

We therefore do no longer need a government budget balance for the pension system. Contributions ($\theta$) are adjusted in the calibration to keep the average replacement rate equal to the replacement rate under the pay-as-you-go defined benefit system.

---

10In reality it is the average of 5 year growth rate in the case of Italy but since we have 20 year cohorts we cannot in that much.

11The gap is paid by 2 generations of size 1, hence the gap is divided by 2.
3.4.4 The unions

Households are represented by unions, which unilaterally set the wages for each generation before they enter the labour market. The unions maximise:

\begin{equation}
U_t = E_t[L_{y,t}V_{t,t} + (1 - L_{y,t})V_{u,t} | A_{t-1}] \tag{3.38}
\end{equation}

in which \(V_{t}\) is the value of being employed \(V_{u}\) is the value of being unemployed. \(L_y\) is labour demand for the young, which is equal to the probability of being employed, since the size of each generation is equal to 1. The unions therefore maximise the expected utility at birth. Both value functions in Equation 3.38 are defined as:

\begin{align}
V_{t,t} &= u(c_{t,t}) + \beta \left[ \frac{L_{t,t+1}}{L_{y,t}} V_{l,t+1} \frac{L_{y,t} - L_{t,t+1}}{L_{t,t+1}} V_{u,t+1} \right] \tag{3.39} \\
V_{u,t} &= u(c_{u,t}) + \beta \left[ \frac{L_{u,t+1}}{1 - L_{y,t}} V_{u,t+1} \frac{1 - L_{y,t} - L_{u,t+1}}{1 - L_{u,t+1}} V_{u,t+1} \right] \tag{3.40}
\end{align}

in which \(u(c_{t})\) is the utility for the young employed — which depends on the wage \((w_{t})\) — and \(u(c_{u})\) is utility of the unemployed. In which the value functions for the second period of life are defined as:

\begin{align}
V_{l,t+1} &= u(c_{l,t+1}) + \beta u(p_{l,t+2}) \tag{3.41} \\
V_{u,t+1} &= u(c_{b,t+1}) + \beta u(p_{u,t+2}) \tag{3.42} \\
V_{u,t+1} &= u(c_{u,t+1}) + \beta u(p_{u,t+2}) \tag{3.43} \\
V_{u,t+1} &= u(c_{b,t+1}) + \beta u(p_{u,t+2}) \tag{3.44}
\end{align}

in which \(V_{l}\) reflects the value function of the employed during the second period of life with a history of employment, \(V_{u}\) are the second period unemployed with a history of employment, \(V_{u}\) are the employed with a history of unemployment and finally \(V_{u}\) is the second period value function of the unemployed who were also previously unemployed. The first order condition for \(w_{t}\) is:

\begin{equation}
\frac{\delta U_t}{\delta w_{l,t+1}} = \beta E_t \left[ L_{t,t+1} u'(c_{l,t+1}) - u'(c_{b,t+1}) \right] + \beta \left[ L_{l,t+1} u'(p_{l,t+2}) + L_{u,t+1} u'(p_{u,t+2}) \right] = 0 \tag{3.45}
\end{equation}

The first line is the sum of an "employment effect" and a "wealth effect": on the one hand, an increase in the wage lowers union utility by reducing employment, because the utility from employment exceeds that of unemployment. On the other hand, the wage increase has a direct positive effect on the utility of those who work. In the absence of pensions these two effects need to be traded off. The second line shows that by reducing employment, a higher wage implies that fewer people enjoy the higher pension associated with working in their second period of life rather than not working. The final expression on the second line is the effect of the wage in the form of a higher pension benefit of those who work in the second period as well.

The first order condition for \(w_{u}\) is:

\begin{equation}
\frac{\delta U_t}{\delta w_{u,t+1}} = \beta E_t \left[ L_{u,t+1} u'(c_{u,t+1}) - u'(c_{b,t+1}) \right] + \beta \left[ L_{u,u+1} u'(p_{u,t+2}) + L_{u,t+1} u'(p_{u,t+2}) \right] = 0 \tag{3.46}
\end{equation}

as we can see the expression is very similar to the one for \(w_{l}\) only the parameters underlying the functions differ.
The equation for \( w_k \) is slightly more complicated because the young need to take into account the probabilities of employment in the next period as well:

\[
\frac{\delta U_t}{\delta w_{y,t}} = E_t \left[ L_{y,t} u'(c_{y,t}) + L_{y,t} u'(c_{b,t}) c_{y,t} + \beta^2 L_{y,t} u'(p_{u,t+2}) + L_{t,t+1} u'(p_{u,t+2}) p_{u,t+2} + [L_{y,t} - L_{t,t+1}] u'(p_{u,t+2}) p_{u,t+2}'] = 0
\]

again a similar choice is made, however, this time the effect of a higher pension needs to be weighted with the probabilities of being employed the next period or not.

For a investigation of the model characteristics see Appendix 3.B, for a model summary see Appendix 3.C.

### 3.5 Calibration and comparative statics

#### 3.5.1 Calibration

The replacement rates (\( \gamma \)) can be determined by looking at the different pension systems in Europe. We start with the simple cases, in France for instance the replacement rate is 50% after a full career.\(^{12}\) This replacement rate is based on the best 25 years of earning. This means that \( \gamma_1 = 0.1 \) and \( \gamma_2 = 0.4 \), \( \gamma_3 = 0.25 \) since the replacement rate is reduced to 25% with only 20 years of contributions. \( \gamma_4 \) is slightly higher since the time during which regular unemployment benefits are received count as contribution years. This means that instead of 20 missing years there are now only 18 missing years, because of two years of unemployment benefits. This means that \( \gamma_4 = 0.275 \).

For Spain the replacement rate can reach 100% after 35 years of contributions and is based on the last 15 years of earnings.\(^{13}\) This means that \( \gamma_1 = 0 \) and \( \gamma_2 = 1 \). After 20 years of contributions the replacement rate reaches 62.5% which means that \( \gamma_3 = 0.625 \). Again \( \gamma_4 \) is slightly higher at 0.675 since the two years of receiving unemployment benefits count as contributing years.

For Italy the benefits are calculated according to a notional fund. If we assume that the economy exhibits 0 growth (which is the case in equilibrium in our model) this means that the participants get exactly their contributions back. This means that for \( f = 1, 2, 3 \) is equal to the contribution rate which is 0.33 in Italy. For \( \gamma_4 \) we do not only have the regular contributions during the working period but also the contributions during the period in which unemployment benefits are received which raises the rate to 0.35. For Germany the calculation of the parameters is a bit trickier. For each year contributed at an average wage someone earns one pension point, therefore the number of points earned for contributing \( w_k \) for 20 years is:

\[
\text{points} = 20 \frac{w_k}{\bar{w}}
\]

in which \( \bar{w} = \frac{L_{y}w_y + L_{y}w_l + L_{y}w_u}{L_y + L_l + L_u} \). Each point results in a pension of around €336, to relate it to our model it is useful to note that this is around 1% of the average wage. In other words, after 20 years contributing at a wage of \( w_k \) someone earns a pension of:

\[
\gamma_f w_k = 0.2 \frac{w_k}{\bar{w}} = 0.2 w_k \quad \text{for} \quad f = 1, 2, 3, 4 \text{ and } k = y, l, u
\]

Therefore \( \gamma_f = 0.2 \) for \( f = 1, 2, 3 \) in Germany and \( \gamma_4 = 0.21 \) (again because of unemployment benefits). A pension received after working two periods in our model is roughly in line with the average replacement rate of 42% in Germany.

---

\(^{12}\) In reality this is 41.5 years, for simplicity we take it to be two working periods or 40 years.

\(^{13}\) This amount is capped around 115% of the average wage, which we assume will not be exceeded.
3.5. CALIBRATION AND COMPARATIVE STATICS

<table>
<thead>
<tr>
<th>Table 3.2: Steady state</th>
<th>Young ((y))</th>
<th>Previously employed ((l))</th>
<th>Previously unemployed ((u))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>1.601</td>
<td>2.313</td>
<td>0.960</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>0.300</td>
<td>0.513</td>
<td>0.242</td>
</tr>
<tr>
<td>(w)</td>
<td>1.228</td>
<td>1.365</td>
<td>1.228</td>
</tr>
<tr>
<td>(L)</td>
<td>0.760</td>
<td>0.700</td>
<td>0.120</td>
</tr>
<tr>
<td>Pensions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(p_{lu})</td>
<td>0.852</td>
<td></td>
<td>0.467</td>
</tr>
<tr>
<td>(p_{ul})</td>
<td>0.430</td>
<td></td>
<td>0.340</td>
</tr>
<tr>
<td>General parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\tau)</td>
<td>0.171</td>
<td>(\theta)</td>
<td>0.292</td>
</tr>
<tr>
<td>(b)</td>
<td>1</td>
<td>(\beta)</td>
<td>0.4</td>
</tr>
<tr>
<td>(\eta)</td>
<td>2</td>
<td>(\gamma_1)</td>
<td>0.16</td>
</tr>
<tr>
<td>(\gamma_2)</td>
<td>0.48</td>
<td>(\gamma_3)</td>
<td>0.35</td>
</tr>
<tr>
<td>(\gamma_4)</td>
<td>0.38</td>
<td>(\gamma_5)</td>
<td>0.34</td>
</tr>
<tr>
<td>(\text{rep}_b)</td>
<td>0.776</td>
<td>(\text{rep}_p)</td>
<td>0.556</td>
</tr>
</tbody>
</table>

Note: \(\text{rep}_b\) is the gross replacement rate for the unemployed \((b/w)\), \(\text{rep}_p\) is the average replacement rate for the retirement \(\bar{p}/w\).

On average the targeted minimum pension \((\gamma_5 b)\) in our four countries is around 22.5% of the average wage. It is difficult to reach exactly this level without setting values for other variables (like \(\alpha\) or \(\beta\)) to unrealistic levels. We therefore set \(\gamma_5\) equal to the average of all other gamma’s \((\gamma_5 = 0.34)\) and simply check if the value is roughly in line with the stylised facts. During the calibration we take the average of the four countries for each gamma, which means:

\[
\gamma_1 = \frac{1}{4} \left[ 0.1 + 0 + 0.33 + 0.2 \right] = 0.16 \quad (3.50)
\]

\[
\gamma_2 = \frac{1}{4} \left[ 0.4 + 1 + 0.33 + 0.2 \right] = 0.48 \quad (3.51)
\]

\[
\gamma_3 = \frac{1}{4} \left[ 0.25 + 0.625 + 0.33 + 0.2 \right] = 0.35 \quad (3.52)
\]

\[
\gamma_4 = \frac{1}{4} \left[ 0.275 + 0.675 + 0.35 + 0.21 \right] = 0.38 \quad (3.53)
\]

\[
\gamma_5 = 0.34 \quad (3.54)
\]

For the rest of the calibration we pick technology \(A\), such that employment for the young is at 76% and employment of the old is 82%, both numbers are close to the average employment rate over the period 2000-2007 in both the euro area and on average in our four countries. During this period inflation was around 2%, indicating that the period was neither excessively inflationary nor deflationary. It is therefore likely that the employment was also around the “natural rate”. The reason to focus on employment rates rather than unemployment rates is that we have rather large generations of 20 years. It is odd to speak of 20 years of unemployment; in this period someone is likely to have left the labour force. We therefore focus on employment versus non-employment (unemployment and inactivity). The 18% old non-employed is divided between 12 percentage point (ppt) previously non-employed and 6 ppt previously employed, this roughly corresponds to the shares of inactive and unemployed.

We set the output elasticity for the young to \(\alpha_y = 0.3\), in line with the share of total income going to capital (and therefore \(1 - \alpha_y\) in line with the share of income going to
Table 3.3: Comparative statics

<table>
<thead>
<tr>
<th></th>
<th>Baseline*</th>
<th>$A = 0.99$</th>
<th>diff (%)</th>
<th>$\eta = 1$</th>
<th>diff (%)</th>
<th>$\eta = 2.5$</th>
<th>diff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_y$</td>
<td>1.229</td>
<td>1.230</td>
<td>0.1</td>
<td>1.292</td>
<td>5.0</td>
<td>1.194</td>
<td>-2.9</td>
</tr>
<tr>
<td>$w_l$</td>
<td>1.365</td>
<td>1.370</td>
<td>0.3</td>
<td>1.516</td>
<td>10.5</td>
<td>1.295</td>
<td>-5.3</td>
</tr>
<tr>
<td>$w_u$</td>
<td>1.229</td>
<td>1.229</td>
<td>0.0</td>
<td>1.264</td>
<td>2.8</td>
<td>1.213</td>
<td>-1.3</td>
</tr>
<tr>
<td>$L_y$</td>
<td>0.760</td>
<td>0.732</td>
<td>-2.8</td>
<td>0.643</td>
<td>-11.7</td>
<td>0.837</td>
<td>7.7</td>
</tr>
<tr>
<td>$L_l$</td>
<td>0.700</td>
<td>0.682</td>
<td>-1.8</td>
<td>0.571</td>
<td>-12.9</td>
<td>0.776</td>
<td>7.6</td>
</tr>
<tr>
<td>$p_{ul}$</td>
<td>0.852</td>
<td>0.854</td>
<td>0.3</td>
<td>0.934</td>
<td>9.2</td>
<td>0.813</td>
<td>-4.8</td>
</tr>
<tr>
<td>$p_{ul}$</td>
<td>0.467</td>
<td>0.468</td>
<td>0.1</td>
<td>0.491</td>
<td>5.0</td>
<td>0.454</td>
<td>-2.9</td>
</tr>
<tr>
<td>$p_{uu}$</td>
<td>0.430</td>
<td>0.430</td>
<td>0.0</td>
<td>0.442</td>
<td>2.8</td>
<td>0.425</td>
<td>-1.3</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.171</td>
<td>0.192</td>
<td>2.1</td>
<td>0.270</td>
<td>9.9</td>
<td>0.107</td>
<td>-6.3</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.292</td>
<td>0.289</td>
<td>-0.3</td>
<td>0.279</td>
<td>-1.2</td>
<td>0.300</td>
<td>0.8</td>
</tr>
<tr>
<td>$rep_p$</td>
<td>0.556</td>
<td>0.548</td>
<td>-0.8</td>
<td>0.506</td>
<td>-5.0</td>
<td>0.584</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*Baseline: $A = 1, \eta = 2$, PAYG DB. Difference in wages and pensions in percentage change, labour demand and taxes in percentage point change.

We choose the output elasticity $\alpha_l$ to get a relative wage of the old vs the young ($w_y/w_l$) of 0.9. This is consistent with relative gross wages for the age groups 30-39 and 40-49. The reason to pick these two groups instead of the full 20-39 and 40-59 ranges is that part of the difference in wages in these age groups are driven by composition effects. In the age group 20-29 low skilled workers tend to be more dominant since they typically start working at an earlier age. The age group 50-59 is likely to include more high skilled workers since they tend to retire later. We therefore only use prime aged workers to avoid mixing up effects. We pick $\alpha_u$ to equalise wages between the young and the previously unemployed ($w_u/w_y = 1$). Since we do not have human capital depreciation there is no reason to pay young inexperienced workers differently from old inexperienced workers. Finally, we set risk aversion equal to $\eta = 2$, the unemployment benefits equal to unity ($b = 1$) and the rate of time preference to be $\beta = 0.4$ (this is 0.96 on an annual basis).

As we see in our calibration $\alpha_y$, $\alpha_l$ and $\alpha_u$ are on average close to 1/3. Furthermore, $b/\bar{w} = 0.78$, which is more than 10% higher than the observed replacement rate for the unemployed directly after losing a job of 65% of the four countries described in this chapter. The minimum pension is slightly higher than observed in the four countries, $\gamma_{12}b/\bar{w} = 0.26$ and the highest pension $p_{ul}$ in our model are 2.5 times higher than minimum pension. Finally, the pension loss from unemployment seems much larger than in the OECD (2015).\footnote{Our results: 50% and 45% loss for young unemployed and old unemployed respectively for 20 years unemployment. OECD results: 3.5% and 3% on average for our four countries resulting from 5 years of unemployment. However, it is of course not given that the relationship between years of unemployment and loss in pension needs to be linear.}

### 3.5.2 Comparative statics

If we introduce a permanent negative shock of 1% on technology ($A = 0.99$, see second column of Table 3.3). We see employment drop significantly in the steady state, wages rise slightly as do most pensions. This means that the wealth effect dominates the employment effect described in the model section. People rather have a higher wage and higher pension than a higher probability of being employed. Total taxes increase slightly since the
higher contributions to fund unemployment benefits outweigh the slightly lower pension contributions (less people receive high pensions).

Now we look at the situation in which the relative risk aversion is lower ($\eta = 1$, see fourth column of Table 3.3). Compared to the steady state described in the previous section. We see that wages increase while employment drops. Workers are less risk averse and therefore value a higher wage (wealth effect) more than higher job security (employment effect). Setting the risk aversion higher ($\eta = 2.5$, see sixth column of Table 3.3), we get the exact opposite with higher labour demand and lower wages and pensions.

If we introduce a pay-as-you-go defined contribution (PAYG DC) system the benefits are adjusted to balance the pension budget of the government as in Equation 3.20. If we feed in the steady state values of contributions of the defined benefit (DB) system we get the same steady state as the baseline. However, a shock has a different impact (see second column of Table 3.4). Wages increase more than before and labour demand therefore decreases more. This means that the wealth effect is even stronger than before under the DB system. This is because contributions no longer adjust downward. To keep net wages (and therefore consumption) on the same level, gross wages need to rise further.

Wages go up and employment down if we introduce a pay-as-you-go notional defined contribution (PAYG NDC) system with 0 notional return (see fourth column of Table 3.4). There are two effects at work. First, even when someone is unemployed a pension is build up (this is necessary to balance the government budget). This means that being unemployed has a smaller effect on pensions than previously and therefore workers prefer a slightly higher wage. Second, the weight on the last earned wage is smaller than under the DB and DC systems which means that it becomes less important to work both periods. Remember that the weight under the DB and DC system on $w_1$ is 0.48, under the NDC system the weight is reduced to 0.292 (which is equal to $\theta$).

Next, we introduce a funded (F) pension system (see sixth column of Table 3.4) in which the contributions are invested at a 10% interest rate (which is roughly 0.5% on an annual basis). We adjust contributions in such a way that the average replacement rate is stable. All contributions are invested in a fund (also the contributions of the unemployed). Both

### Table 3.4: Comparative statics

<table>
<thead>
<tr>
<th></th>
<th>Baseline* (level)</th>
<th>DC $A = 0.99$ (level)</th>
<th>dif (%)</th>
<th>NDC (level)</th>
<th>dif (%)</th>
<th>$F$ (level)</th>
<th>dif (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_y$</td>
<td>1.229</td>
<td>1.231</td>
<td>0.2</td>
<td>1.309</td>
<td>6.3</td>
<td>1.296</td>
<td>5.5</td>
</tr>
<tr>
<td>$w_l$</td>
<td>1.365</td>
<td>1.372</td>
<td>0.5</td>
<td>1.528</td>
<td>11.3</td>
<td>1.529</td>
<td>12.0</td>
</tr>
<tr>
<td>$w_u$</td>
<td>1.229</td>
<td>1.229</td>
<td>0.0</td>
<td>1.246</td>
<td>1.4</td>
<td>1.246</td>
<td>1.4</td>
</tr>
<tr>
<td>$L_y$</td>
<td>0.760</td>
<td>0.730</td>
<td>-3.0</td>
<td>0.616</td>
<td>-14.4</td>
<td>0.636</td>
<td>-12.4</td>
</tr>
<tr>
<td>$L_l$</td>
<td>0.700</td>
<td>0.680</td>
<td>-2.0</td>
<td>0.562</td>
<td>-13.8</td>
<td>0.562</td>
<td>-13.8</td>
</tr>
<tr>
<td>$L_u$</td>
<td>0.120</td>
<td>0.115</td>
<td>-0.5</td>
<td>0.113</td>
<td>-0.7</td>
<td>0.113</td>
<td>-0.7</td>
</tr>
<tr>
<td>$p_{ul}$</td>
<td>0.852</td>
<td>0.864</td>
<td>1.4</td>
<td>0.828</td>
<td>-2.9</td>
<td>0.868</td>
<td>1.9</td>
</tr>
<tr>
<td>$p_{ul}$</td>
<td>0.467</td>
<td>0.472</td>
<td>1.2</td>
<td>0.674</td>
<td>36.6</td>
<td>0.713</td>
<td>52.7</td>
</tr>
<tr>
<td>$p_{uu}$</td>
<td>0.430</td>
<td>0.434</td>
<td>1.0</td>
<td>0.655</td>
<td>42.1</td>
<td>0.690</td>
<td>60.4</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.171</td>
<td>0.194</td>
<td>2.3</td>
<td>0.282</td>
<td>11.1</td>
<td>0.274</td>
<td>10.3</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.292</td>
<td>0.292</td>
<td>0</td>
<td>0.292</td>
<td>0</td>
<td>0.267</td>
<td>-2.5</td>
</tr>
<tr>
<td>$rep_p$</td>
<td>0.556</td>
<td>0.552</td>
<td>-0.4</td>
<td>0.525</td>
<td>-3.2</td>
<td>0.556</td>
<td>0</td>
</tr>
</tbody>
</table>

*Baseline: $A = 1$, PAYG DB. DC=PAYG DC, NDC=PAYG notional DC, F=funded. Wages and pensions in log difference (percentage change), labour demand and taxes in difference (percentage point change).
wages and pensions go up significantly. There are two effects at work here. First, as under
the NDC system even during unemployment a private pension is build up. Second, contributions are invested and a return is earned on this investment. This increases the relative weight on wages earned early in life. This effect is stronger the higher the return, leading to even higher wages and lower employment.

Pensions are by construction more equally distributed under the funded pension system and the PAYG NDC pension system compared to the PAYG DC and PAYG DB. This is because the unemployed build up pension benefits under the former systems. The maximum pension under both the PAYG DB/DC system is 2.5 times higher than the minimum pension whereas this ratio is 1.4 for both the funded system and the PAYG NDC system.

3.6 Results

In this section we simulate a 1 period shock to aggregate technology \( A_{t+1} \) of -1% at time \( t+1 \). The technology shock dies out after 1 period since we do not have any persistence in technology shocks.

We consider four different pension systems: our baseline PAYG defined benefit system (from here on called DB), a PAYG defined contributions system (DC), a PAYG notional defined contribution system (NDC) and a funded system (F). For the moment we assume that the funded system has a return of 10% in 20 years or roughly half a percent per year.
Figure 3.5: Effects of technology shock on unemployment and labour market flows

Note: deviation from steady state. All in percentage point difference. Long-term unemployment ratio (LTU): long-term unemployed as share of total unemployed. Labour market flows: probability of moving from one state to the other.

However, it should be noted that the return mainly has an impact on the steady state but not so much on the dynamics.

Under each pension system labour demand drops immediately since this is the only variable that can adjust, wages were set before the shock (see Figure 3.4). The drop in labour demand is larger for the younger generation than for the older generation because of the higher output elasticity of labour. However, the relative drop of labour demand of the previously unemployed $L_u$ is larger than both others. In reality during a recession it is indeed more difficult for both the young and the long-term unemployed to find a job, whereas the previously employed are usually retained in larger numbers.

The period after the shock, levels of employment for the old working generation are back to the steady state level. However, given the employment composition in the previous period it means that those who already worked almost certainly find a job again (see panel working to working of Figure 3.5) and those who were unemployed are unlikely to find a job (see panel unemployed to working of Figure 3.5). Furthermore, we find the typical hump-shaped long-term unemployment ratio (LTU, those who are out of work for both periods as share of total unemployment). This ratio first drops because of the inflow of short-term unemployed but then peaks when the short-term unemployed become long-term unemployed. This typically happens only later in a recession which is matched by our model.
Figure 3.6: Effects of technology shock on wages, consumption, benefits and taxes

Wages are relatively rigid in our simulation just like the classic union monopoly model (see Figure 3.4). For wages set before the shock, the obvious reason is that they are predetermined and are therefore by construction fixed. Even if a worker would have liked to lower his/her wage to increase the probability of employment — i.e. to balance the employment and wealth effect described in the model section — this is no longer possible. The wages set after the shock has passed are rigid under the DC system and the funded system since distortionary taxes will no longer be adjusted once unemployment is back to pre-shock levels. However, under the DB system and the NDC system we see a slight drop in wages set in the first two periods after the shock (wages that hold for the young in $t + 1$, 2 and wages of the previously employed in $t + 2$, 3). For the DB system the reason is that workers know future pensions will be lower (the generations that worked during the shock have lower total pensions). This means that for a given wage and employment combination the contribution rate will be lower and net wages — and therefore consumption — will be higher (see Figure 3.6). Future generations exploit this drop in contributions and set lower wages to increase labour demand, thus rebalancing the wealth and employment effect.\footnote{For lower values of relative risk aversion $\gamma$ this effect is smaller, indeed in the case of log-utility this effect is absent because the wealth and employment effect cancel each other out (see Appendix)}

The reason wages drop under the NDC system is that notional pension growth is positive directly after the shock (see Figure 3.6), to fund this increase in pensions the lump sum tax
must be increased. Working generations react to this by lowering their wage, leading to increased labour demand and thus a higher probability of ending up employed. The higher lump sum tax has a lower proportional impact on consumption of the employed than on the unemployed and thus impacts $u(c_e) - u(c_u)$ in the first order conditions through taxes as well as wages.

The average wage rises slightly under all pension systems at the time of the shock.\footnote{This effect is relatively minor compared to the employment effect.} This is purely a composition effect as relatively more high wage ($w_h$) workers are employed than before. This effect is typically observed during recessions.\footnote{For instance between 2007 and 2013 the average wage in our four countries rose 3.5%. However, it is of course very difficult to extract the exact composition effect from this figure (see for instance Bernal-Verdugo et al. (2013) for a discussion).} The average wage falls under the DB and NDC systems after the shock dies out, which coincides with the adjustment of individual wages described above. Average consumption for working generations drops under all pension systems. This is both the effect of higher taxes and lower employment. Under the NDC system this drop is slightly less since pensions are adjusted by more than shock warrants (see average pension panel of Figure 3.6) and workers therefore receive a lump sum subsidy. However, later generations have to pay a lump sum tax to balance the pension budget, therefore, consumption stays depressed for longer. The way the fictional rate of return for the NDC system is calculated has a very large impact on the results. If average wage growth is taken as rate of return the effects are similar to the other pension systems but even more pronounced (since average wages rise slightly).

Average pensions drop at shock impact for both defined contributions systems. For the NDC system pensions overshoot the steady state after the shock, this is because the growth rate of the economy — and therefore the fictional rate of return on pensions — is positive after the technology shock dies out. For the DC system a larger share of the population builds up low level pensions ($p_{nu}$ and $p_{hu}$) during the shock. However, pensions after the shock has passed will be adjusted upward since contributions will have bounced back. Average pensions for the defined benefit and the funded system are lower after the shock because of composition effects, fewer people build up high pensions.

Taxes to fund the unemployment benefit system ($\tau$) rise by roughly the same amount during the period of the shock in all four scenarios since wages are pre-determined and the drop in labour demand is similar (see Figure 3.6). The small differences are caused by differences in steady state values. Since labour demand rises slightly after the shock under both the DB scenario and the NDC scenario, $\tau$ can drop slightly. However, this is a relatively small decrease in taxes. Much smaller for instance than the drop in pension contributions after the shock under the DB scenario (following an initial first period rise). The temporary undershooting in contributions after the shock is caused by lower total pensions that were build up during the shock. For a DC system the benefits are adjusted and we see a mirror image from contributions under the DB system. Initially pensions drop under the DC system but after the shock dies out the pensions are adjusted upwards. However, the changes in pension contribution rates ($\theta$) or pension adjustment ($\gamma$) are in all cases but the NDC system dwarfed by the effects of contributions to fund unemployment benefits ($\tau$).

Life-time utility expressed in certainty equivalent consumption (CEC) drops severely once the shock hits but bounces back up quickly for most pension systems even overshooting slightly for the DB system (see Figure 3.7). Only the NDC system exhibits a smaller but more persistent drop.\footnote{This is because of the adjustment through the lump sum tax. Once the shock hits, pensions are adjusted by more than is warranted by lower contributions, this means that there is a pension contribution surplus, which is returned lump sum to workers. The period after the shock the growth rate of the economy is positive raising pension levels which means that the economy swings into a pension deficit resulting in a} This adjustment mechanism spreads the negative effects
of a recession over generations.

Regardless of the pension system there is a large difference in the adjustment of utility for those who work when they are young compared to those who are unemployed. The utility (in CEC) of the unemployed drops more than a half percent more than the utility of the employed. A large part of the reason is that those who have a job when they are young are more likely to be employed during the next period as well (see Figure 3.5).

If we look at the different paths someone can take through life we see very similar patterns across all possibilities for a given pension system (see Figure 3.8). This is because wages are very rigid and the effects are largely dominated by taxes and/or pension adjustments, which are the same for all agents. We see that for the generation which is retired during the shock \((s)\), both defined contribution systems deviate from the steady state. This is because total income from pension contribution falls and pensions need to be adjusted downward to balance the budget under the DC system. For the NDC system a negative rate of return is applied and pensions are adjusted down even more. For both working generations during the shock \((s + 1\) and \(s + 2\)) the both defined contribution systems are more beneficial since social security contributions do not rise as much as under the other scenarios (the NDC even returns a lump sum subsidy) and pensions even rise once the shock has past. For generations born after the shock the DB system is most beneficial since they can take advantage of lower pension contributions, higher net wages and higher employ-

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positive lump sum tax and lower utility.
Figure 3.8: Consumption paths for four scenarios

Note: percent deviation from steady state. Title of subplot reflects the time of retirement of a generation, \( s \) is time of the shock. \( l_t \); employed in both periods, \( lu_t \); employed in the first period of life but not the second, \( ul_t \); unemployed in the first period of life but employed in the second, \( uu_t \); unemployed in both periods. \( y \); young, \( o \); old, \( r \); retired.

A NDC system is not beneficial for generations born after the shock \((s + 1 \text{ and } s + 2)\) since they have to pay for higher pensions of the shock generation. However, the deviation is minor compared to deviation from the steady state for older generations.

We therefore see that the interaction between the pension system and labour markets in our model is relatively limited. There are some minor effects on wage setting and thus labour demand through adjustment of contributions. However, these effects are small compared to the direct labour market effects of the shock. The reason behind the limited interaction is the rigidity of the labour market. At first wages are predetermined and can by definition not be adjusted. By the time wages can be adjusted the system will have been pushed back (close) to the steady state. Additionally, the differences between working generations are not as pronounced as in reality. Typically, employment rates of the young drop much faster as employment rates of older workers. Between 2007 and 2013 employment rates in the euro area of 15-39 year olds dropped by 4.9% whereas employment rates of 40-59 year olds dropped “only” 2.4%. In our model the difference in the drop in employment is less pronounced (2.5% vs. 1.9%) — not fully capturing the relatively sheltered position of older workers — which in turn leads to less pronounced differences in all other variables as well.
CHAPTER 3. INTERGENERATIONAL EFFECTS OF UNEMPLOYMENT ON PENSIONS

Still, the type of pension system has some impact on which generation bears the brunt of the crisis. As is typical with pension systems the DC systems places a larger part of the burden of a shock on the retired compared to the DB system. The funded system removes the pension interaction between generation entirely and the only effect that is left is the labour market effect, which has a delayed effect on pension provisions.

3.7 Conclusion

In this chapter we investigated the effects of unemployment and rigid wages on pension provisions. First we used a generational accounting exercise to investigate these effects. We distinguished between unemployment at young ages and unemployment at older ages.

Because of the relatively generous pension system and because minimum required years of contributions for a maximum pension are still reached a spell of 10 years of unemployment has little effect on the pension entitlements in Spain (for both young and old unemployed). In Germany, France and Italy being unemployed for 10 years has a larger impact. Pensions and replacement rates drop significantly and in our exercise the German pension entitlements of the young unemployed with low skills barely exceed the minimum pension.

For France and Italy, there are large differences between the young unemployed and the old unemployed. This is because receiving unemployment benefits count towards pension entitlement accumulation and because unemployment benefits last longer for older workers in these countries. In Germany this effect is smaller because unemployment benefits run out quicker.

We also investigated an overlapping generations model with three generations (two working and one retired) in which unions, representing each generation sequentially, set the wages for a certain generation. Firms pick the employment level once the state of the economy is known.

We find that a technology shock is largely reflected in labour market outcomes which do not differ significantly across pension systems. A negative shock leads to higher unemployment since wages are pre-determined. Because unemployment rises, taxes to fund unemployment benefits must rise as well, leading to lower consumption. Those who were employed at the time of the shock are more likely to be employed the next period than those who were unemployed. This is also reflected in the difference in the drop of utility for those who work when they are young compared to those who are unemployed, the utility of the latter drops more.

The interaction between the pension system and the labour market is limited. The pension system has an effect on steady state outcomes of labour market variables but because wages are pre-determined pension systems matter less for the transitional dynamics.

For the pension system itself the usual outcomes are found, with individual pensions fully stable under the defined benefit system, dropping under the (notional) defined contribution system and stable under the funded system (wages are stable and the interest rate is fixed in our model). On the aggregate we do find a belated drop in average pensions for the funded and the defined benefit system since fewer people build up high level pensions (i.e. more people have followed the less fortunate employment path). This effect is absent for the defined contributions systems since benefits are adjusted upwards once employment and thus social contributions bounce back.
Appendix

3.A Pension systems

Table 3.5: Pensions systems extended table

<table>
<thead>
<tr>
<th></th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
<th>IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean wage (€)</td>
<td>36000</td>
<td>26800</td>
<td>35600</td>
<td>28900</td>
</tr>
<tr>
<td>Contribution (% of wages)</td>
<td>9.5 w</td>
<td>4.7 w</td>
<td>6.8 w</td>
<td>11 w</td>
</tr>
<tr>
<td>Contribution (% of average</td>
<td>9.5 e</td>
<td>23.6 e</td>
<td>8.45 e</td>
<td>22 e</td>
</tr>
<tr>
<td>Ceiling pension base (€)</td>
<td>72000 (200)</td>
<td>43000 (160)</td>
<td>36400 (102)</td>
<td>96000 (332)</td>
</tr>
<tr>
<td>Minimum contribution (years)</td>
<td>5</td>
<td>15</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Gross replacement rate (%)</td>
<td>42</td>
<td>8250 (23)</td>
<td>74</td>
<td>59</td>
</tr>
<tr>
<td>Targeted min. pension (%)</td>
<td>n.a.</td>
<td>8700 (32)</td>
<td>8200 (23)</td>
<td>5600 (19)</td>
</tr>
<tr>
<td>Minimum pension (€)</td>
<td>n.a.</td>
<td>3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>(as % of average)</td>
<td></td>
<td>8250 (23)</td>
<td>7000 (20)</td>
<td>5</td>
</tr>
<tr>
<td>Retired receiving minimum</td>
<td>n.a.</td>
<td>28</td>
<td>37</td>
<td>32</td>
</tr>
<tr>
<td>(as % of age)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent graduate without job</td>
<td>No (mandatory)</td>
<td>No contributions</td>
<td>No contributions</td>
<td>No contributions</td>
</tr>
<tr>
<td>Benefits for unemployed</td>
<td>8250 (23)</td>
<td>No</td>
<td>7000 (20)</td>
<td>5</td>
</tr>
<tr>
<td>(normal unemployment, after</td>
<td>Yes (proportional to benefits)</td>
<td>Yes (counts as years but not as reference wage). For 55+ contributions are paid until retirement</td>
<td>Yes (counts as 1-2 year(s) but not included in reference wage</td>
<td>Yes (counts as years and contributions based on benefits are added to notional account)</td>
</tr>
<tr>
<td>period of work)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions paid by</td>
<td>Government</td>
<td>Government and unemployed</td>
<td>Government and unemployed</td>
<td>Government and unemployed</td>
</tr>
<tr>
<td>Benefits (normal unemployment)</td>
<td>80% of previous salary</td>
<td>70% of average salary of last 6m, 50% thereafter</td>
<td>60% of previous salary</td>
<td>50% of previous salary 30% thereafter</td>
</tr>
<tr>
<td>Duration benefits (as % of</td>
<td>6-12 m, ½ of working time</td>
<td>1st phase 4-6m, 2nd phase 1-18m ½ of working time</td>
<td>2y (50-), 3y (50+)</td>
<td>1st phase: 12m (age 40-), 24 m (40-50), 36m (50+). 2nd phase: 6m</td>
</tr>
</tbody>
</table>

1. w=worker, e=employer. 2. Replacement rate of mean earner. 3. Tested against means. 4. Minimum pension requires social security contributions for a minimum period (see minimum contribution years). For France this is again pro-rated. 5. Only after 25 for France. In Italy and Spain benefits exist for individuals with family responsibilities, not considered here. 6. y=year, m=month. All entries refer to 2013
3.B Model characteristics

3.B.1 Assumption: the unemployed pay taxes

We start with the model without any pensions, just to see how wages, taxes and labour demand interact in the steady state (we therefore leave out the time index). We solve for \{w_y, w_u, w_l, L_y, L_u, L_i, \tau\}. The firms first order conditions are for \(i = y, l, u\):

\[ w_i = (1 - \alpha_i)AA_iL_i^{-\alpha_i} \quad (3.55) \]

the first order conditions for the unions for \(i = y, l, u\):

\[ L_i'(u(c_i) - u(c_b)) + L_iu'(c_i)c_i' = 0 \quad (3.56) \]

in which \(c\) is consumption, defined as:

\[ c_i = (1 - \tau)w_i \quad (3.57) \]

\[ c_b = (1 - \tau)b \quad (3.58) \]

with:

\[ c_i' = (1 - \tau) \quad (3.59) \]

since we start with the assumption that the unemployed also pay taxes, we get the following government budget constraint:

\[ \tau = \frac{[2 - L_y - L_u - L_i]b}{L_yw_y + L_uw_u + L_lw_l + [2 - L_y - L_u - L_i]b} \quad (3.60) \]

We use the following functions in the first order conditions:

\[ u(c_i) = \frac{c_i^{1-\eta} - 1}{1 - \eta} \quad (3.61) \]

\[ u'(c_i) = c_i^{-\eta} \quad (3.62) \]

\[ L_i' = -\frac{1}{\alpha_i} \frac{L_i}{w_i} \quad (3.63) \]

using these and the definitions for consumption in equation 3.56 and rearranging we get:

\[ w_i = \frac{b}{[1 - \alpha_i(1 - \eta)]^{1/(1 - \eta)}} \quad (3.64) \]

as in the “classic” union monopoly model we have completely rigid wages \(dw_i = 0\). Furthermore, taking the total derivative from equation 3.55 and rearranging:

\[ \frac{dL_i}{dA} = \frac{L_i}{\alpha_iA} > 0 \quad (3.65) \]

3.B.2 Assumption: the unemployed do not pay taxes

The firms first order conditions are still:

\[ w_i = (1 - \alpha_i)AA_iL_i^{-\alpha_i} \quad (3.66) \]

and the first order conditions for the union:

\[ L_i'(u(c_i) - u(c_b)) + L_iu'(c_i)c_i' = 0 \quad (3.67) \]
So far nothing changed, however, if the unemployed do not pay taxes consumption now becomes:

\[ c_i = (1 - \tau)w_i \quad (3.68) \]
\[ c_b = b \quad (3.69) \]

with:

\[ c_i' = (1 - \tau) \quad (3.70) \]

We get for \( \tau \):

\[ \tau = \frac{[2 - L_y - L_u - L_l]b}{L_y w_y + L_u w_u + L_l w_l} \quad (3.71) \]

We use the following functions in the first order conditions:

\[ u(c_i) = \frac{c_i^{1-n} - 1}{1 - \eta} \quad (3.72) \]
\[ u'(c_i) = c_i^{-\eta} \quad (3.73) \]
\[ L_i' = -\frac{1}{\alpha_i w_i} \quad (3.74) \]

Using these in equation 3.67 and rearranging we get:

\[ (1 - \tau)w_i = \frac{b}{[1 - \alpha_i(1 - \eta)]^{1/(1-\eta)}} \quad (3.75) \]

now we see that after tax wages are rigid. The total derivate from this expression is:

\[ w_i d\tau = (1 - \tau)dw_i \quad (3.76) \]

we therefore know that \( dw/w \) is equal for all wages. The total derivative for equation 3.66 now becomes:

\[ dw_i = \frac{w_i}{A} dA - \frac{w_i}{L_i} dL_i \quad (3.77) \]

taking the total derivative of the government budget balance:

\[ (L_y w_y + L_u w_u + L_l w_l) d\tau + \tau (L_y dw_y + L_u dw_u + L_l dw_l) + (\tau w_y + b) dL_y + (\tau w_l + b) dL_l + (\tau w_u + b) dL_u = 0 \quad (3.78) \]

Using equation 3.76 we can express everything in \( dL \) and \( dw \):

\[ L_y dw_y + L_u dw_u + L_l dw_l + (\tau w_y + b) dL_y + (\tau w_l + b) dL_l + (\tau w_u + b) dL_u = 0 \quad (3.79) \]

from equation 3.76 we know that the \( dw_i \)’s are of the same sign which means that the \( dL_i \)’s are of the opposite sign. Using equation 3.77 to replace \( dL_i \) we get:

\[ \left( \frac{w_y \tau + b}{\alpha_y} - w_y \right) \frac{L_y}{w_y} dw_y + \left( \frac{w_l \tau + b}{\alpha_l} - w_l \right) \frac{L_l}{w_l} dw_l + \left( \frac{w_u \tau + b}{\alpha_u} - w_u \right) \frac{L_u}{w_u} dw_u = \]
\[ \left( \frac{w_l \tau + b}{\alpha A} L_y + \frac{w_y \tau + b}{\alpha A} L_y + \frac{w_l \tau + b}{\alpha A} L_l \right) dA \quad (3.80) \]
we know from equation 3.76 that $d\omega_i/\omega_i$ is equal for all wages, therefore:

$$
\left[ \left( \frac{w_y \tau + b}{\alpha_y} - w_y \right) L_y + \left( \frac{w_l \tau + b}{\alpha_l} - w_l \right) L_l + \left( \frac{w_u \tau + b}{\alpha_u} - w_u \right) L_u \right] \frac{d\omega_i}{\omega_i} = \\
\left( \frac{w_y \tau + b}{\alpha_A} L_y + \frac{w_l \tau + b}{\alpha_A} L_l + \frac{w_u \tau + b}{\alpha_A} L_u \right) dA
$$

(3.81)

the sign of this expression depends on the sign of the sum in square brackets. If the following holds:

$$
\left( \frac{w_y \tau + b}{\alpha_y} - w_y \right) L_y + \left( \frac{w_l \tau + b}{\alpha_l} - w_l \right) L_l + \left( \frac{w_u \tau + b}{\alpha_u} - w_u \right) L_u > 0 \quad (3.82)
$$

then wages rise with a positive shock to technology $dw/dA > 0$. A sufficient condition is:

$$
\frac{w_i \tau + b}{\alpha_i} > w_i \alpha_i \quad (3.83)
$$

for each $w_i$, or:

$$
\frac{b}{w_i} > (\alpha_i - \tau) \quad (3.84)
$$

This tells us that wages are positively related to technology if the replacement rate $b/w$ is larger than the gap between the output elasticity and the tax rate. However, for many calibrated values of $\alpha$, $\eta$ and $b$ this is not the case.

### 3.3.3 Assumption: the unemployed pay unemployment and pension contributions

This time we introduce a pension system that is dependent on the wage. The firms first order conditions are still:

$$
\omega_i = (1 - \alpha_i) A_i L_i^{-\alpha_i} \quad (3.85)
$$

and the first order conditions for the union now become:

$$
L_y'(a(c_y) - a(c_b)) + L_y d'(a(c_y))c_y' + \beta^2 L_y'(u(p_{L}) - u(p_{u})) + \beta^2 L_y u'(p_{L})p_{L} + \beta^2 L_y c_y' c_u' + + \beta^2 L_y u'(p_{L})p_{L}' = 0 \\
L_i(u(c_y) - u(c_b)) + L_i u'(c_y)c_y' + \beta[L_i(u(p_{L}) - u(p_{u})) + L_i u'(p_{L})p_{L}^i] = 0 \\
L_u(u(c_u) - u(c_b)) + L_u u'(c_u)c_u' + \beta[L_u(u(p_{u}) - u(p_{L})) + L_u u'(p_{u})p_{u}^L] = 0
$$

(3.86) (3.87) (3.88)

If the unemployed pay unemployment and pension contributions we get for $\tau$ and $\theta$:

$$
\tau = \frac{[2 - L_y - \omega - L_i]b}{L_y w_y + L_a w_u + L_i w_l + [2 - L_y - \omega - L_i]b} \quad (3.89)
$$

$$
\theta = \frac{p_{L} L_i + p_{u} L_u + p_{L} u[2 - L_y - L_i] + p_{u} u[1 - L_y - L_u]}{L_y w_y + L_i w_l + L_u w_u + [2 - L_y - L_u - L_i]b} \quad (3.90)
$$

Consumption now becomes:

$$
c_i = (1 - \tau - \theta) \omega_i \quad (3.91)
$$

$$
c_b = (1 - \tau - \theta) b \quad (3.92)
$$

with:

$$
c_i' = (1 - \tau - \theta) \quad (3.93)
$$
We use the following functions in the first order conditions:

\[
\begin{align*}
    u(c_i) &= \frac{c_i^{1-\eta} - 1}{1 - \eta} \\
    u'(c_i) &= c_i^{-\eta} \\
    L_i' &= -\frac{1}{\alpha_i w_i} 
\end{align*}
\]  

(3.94)  

(3.95)  

(3.96)  

and for pensions:

\[
\begin{align*}
    p_{ll} &= \gamma_1 w_y + \gamma_2 w_l \\
    p_{ud} &= \gamma_3 w_u \\
    p_{lu} &= \gamma_4 w_y \\
    p_{wu} &= \gamma_5 \gamma_6 \\
    p'_{lt,1} &= \gamma_1 \\
    p'_{lt,2} &= \gamma_2 \\
    p'_{ud} &= \gamma_3 \\
    p'_{lu} &= \gamma_4 
\end{align*}
\]  

(3.97)  

(3.98)  

(3.99)  

(3.100)  

(3.101)  

(3.102)  

(3.103)  

(3.104)  

Starting with the first order condition of \( w_u \) we can write:

\[
w_u = \frac{b}{1 - \alpha_i (1 - \eta)} \left\{ \frac{(1 - \theta - \tau)^{1-\eta} + \beta \gamma_3^{1-\eta}}{(1 - \theta - \tau)^{1-\eta} + \beta \gamma_3^{1-\eta}} \right\}^{1/(1-\eta)} 
\]  

(3.105)  

If \( \gamma_3 = \gamma_5 \) we have exactly the same expression as before and a completely rigid wage. For \( w_l \) and \( w_y \) we do not get such a clean expression since both \( w_l \) and \( w_y \) are interdependent. However, in our calibration both wages are practically rigid.

3.C Model summary

We solve for \( \{w_y, w_u, w_l, L_y, L_u, L_t, \tau, \theta\} \). The first order conditions of the firms are:

\[
\begin{align*}
    w_{yt,t} &= (1 - \alpha_y) A_{yt,L_{yt,t}}^{-\alpha_y} \\
    w_{ut,t} &= (1 - \alpha_u) A_{ut,L_{ut,t}}^{-\alpha_u} \\
    w_{lt,t} &= (1 - \alpha_t) A_{lt,L_{lt,t}}^{-\alpha_t} 
\end{align*}
\]  

(3.106)  

(3.107)  

(3.108)  

Government:

\[
\begin{align*}
[2 - L_{yt,t} - L_{ut,t} - L_{lt,t}]b &= \\
\tau_t(L_{yt,t}w_{yt,t} + L_{ut,t}w_{ut,t} + L_{lt,t}w_{lt,t} + [2 - L_{yt,t} - L_{ut,t} - L_{lt,t}]b) \\
p_{lt,t}L_{lt,t-1} + p_{lt,t}L_{lt,t-1} + p_{lt,t}[L_{yt,t-2} - L_{lt,t-1}] + p_{ut,t}[1 - L_{yt,t-2} - L_{ut,t-1}] = \\
\theta_t(L_{yt,t}w_{yt,t} + L_{lt,t}w_{lt,t} + L_{ut,t}w_{ut,t} + [2 - L_{yt,t} - L_{ut,t} - L_{lt,t}]b) 
\end{align*}
\]  

(3.109)  

(3.110)
CHAPTER 3. INTERGENERATIONAL EFFECTS OF UNEMPLOYMENT ON PENSIONS

First order conditions union:

\[
0 = E_t \left[ L_{t+1}(c_{t+1}) - u(c_{t+1}) + L_{t+1}u'(c_{t+1})c'_{t+1} + \beta[L_{t+1}(u(p_{l,t+2}) - u(p_{u,t+2})) + L_{t+1}u'(p_{l,t+2})p'_{l,t+2}] \right] \tag{3.111}
\]

\[
0 = E_t \left[ L_{u,t+1}(c_{u,t+1}) - u(c_{u,t+1}) + L_{u,t+1}u'(c_{u,t+1})c'_{u,t+1} + \beta[L_{u,t+1}(u(p_{u,t+2}) - u(p_{u,t+2})) + L_{u,t+1}u'(p_{u,t+2})p'_{u,t+2}] \right] \tag{3.112}
\]

\[
0 = E_t \left[ L_{y,t}(u(c_{y,t}) - u(c_{y,t})) + L_{y,t}u'(c_{y,t})c'_{y,t} + \beta^2[L_{y,t}(u(p_{u,t+2}) - u(p_{u,t+2})) + L_{t+1}u'(p_{u,t+2})p'_{y,t+2,Y} + [L_{y,t} - L_{t+1}u'(p_{u,t+2})p'_{y,t+2}] \right] \tag{3.113}
\]

in which the following utility functions and derivatives are used (for \( i = \{b, y, l, u\} \) and \( j = \{ll, lu, ul, uu\} \)):

\[
u(c_{i,t}) = \frac{c_{i,t}^{1-\eta} - 1}{1-\eta} \tag{3.114}
\]

\[
u(p_{j,t}) = \frac{p_{j,t}^{1-\eta} - 1}{1-\eta} \tag{3.115}
\]

\[u(c_{i,t})' = c_{i,t}^{-\eta} \tag{3.116}\]

\[u(p_{j,t})' = p_{j,t}^{-\eta} \tag{3.117}\]

Consumption working generations and derivatives (for \( i = \{y, l, u\} \)):

\[c_{b,t} = (1 - \theta_t - \tau)\beta \tag{3.118}\]

\[c_{i,t} = (1 - \theta_t - \tau_i)w_{i,t} \tag{3.119}\]

\[c'_{i,t} = (1 - \theta_t - \tau_i) \tag{3.120}\]

Consumption retired and derivatives:

\[p_{uu,t} = \gamma_5 \tag{3.121}\]

\[p_{ll,t} = \gamma_1 w_{y,t-2} + \gamma_2 w_{l,t-1} \tag{3.122}\]

\[p_{ul,t} = \gamma_3 w_{u,t-1} \tag{3.123}\]

\[p_{lu,t} = \gamma_4 w_{y,t-2} \tag{3.124}\]

\[p'_{ll,t,y} = \gamma_1 \tag{3.125}\]

\[p'_{ll,t,l} = \gamma_2 \tag{3.126}\]

\[p'_{ul,t} = \gamma_3 \tag{3.127}\]

\[p'_{lu,t} = \gamma_4 \tag{3.128}\]

Derivatives of labour demand (for \( i = \{y, l, u\} \)):

\[L'_{i,t} = -\frac{1}{\alpha_w} \frac{L_{i,t}}{w_{i,t}} \tag{3.129}\]
3.D Simulation with different risk aversion parameters

Figure 3.9: Effects of technology shock on labour demand and wages (log-utility)

Note: deviation from steady state. For $L_y$, $L_l$ and $L_u$ percentage point difference, for $w_y$, $w_l$ and $w_u$ percent difference.
Figure 3.10: Effects of technology shock on utility (log-utility)

Note: deviation from steady state. All in percent difference. $U$: utility at birth, $V_l$: utility young working, $V_u$: utility young unemployed, all in certainty equivalents of consumption.
Figure 3.11: Effects of technology shock on labour demand and wages ($\eta = 2.5$)

Note: deviation from steady state. For $L_y$, $L_l$ and $L_u$ percentage point difference, for $w_y$, $w_l$ and $w_u$ percent difference.
Figure 3.12: Effects of technology shock on utility ($\eta = 2.5$)

Note: deviation from steady state. All in percent difference. $U$: utility at birth, $V_1$: utility young working, $V_u$: utility young unemployed, all in certainty equivalents of consumption.
4 Shifts in euro area Beveridge curves and their determinants

4.1 Introduction

The Beveridge curve is widely used as a succinct summary of the overall state of the labour market and to distinguish structural shifts from cyclical developments. It traces a (predominantly) negative relationship between unemployment rates and vacancy rates over the course of a business cycle, with low unemployment and high vacancies in expansionary phases and vice versa in contractions. In the initial stages of the global economic and financial crisis, vacancy rates fell sharply, while unemployment rates rose across almost all euro area economies. Since 2009 vacancy rates have recovered somewhat in many countries, but unemployment rates have remained high or kept rising, suggesting outward shifts in Beveridge curves. Such shifts in the Beveridge curve are of particular interest in times of crisis, since they are suggestive of structural changes in the labour market.

This chapter analyses euro area Beveridge curves over the past 25 years, at both the aggregate euro area level and at country level, focusing in particular on Beveridge curve developments since the onset of the global financial crisis. Our aim is to identify deviations from the pre-crisis Beveridge curves and to isolate salient structural factors influencing these movements. Distinguishing between high unemployment rates that are due to cyclical factors (i.e. lack of labour demand) or to labour market mismatch, has important policy implications.

In the literature, cross-country analysis of euro area Beveridge curves has been limited by the absence of a long and harmonised vacancy series for the euro area and its constituent economies. To address this challenge, we consider two vacancy series: firstly, Eurostat’s relatively recent series on euro area job vacancy rates; secondly, the longer European Commission series of employers’ perceptions of labour shortages in manufacturing, as used by ECB (2002) and European Commission (2011b).

We first present a graphical depiction of recent Beveridge curve developments using both vacancy series, and illustrate shifts of the curve in a number of euro area countries since the onset of the crisis. This overview also motivates our use of the series of employers’ perceptions of labour shortages in manufacturing as a reasonable proxy for vacancies. Both series produce a similar picture of recent labour market developments, and the series correlate well. Additionally, the two concepts are closely related; a larger shortage of labour is likely to be reflected in a high number of unfilled vacancies.

Next, we proceed to the econometric analysis in which we apply an autoregressive distributed lag (ARDL) model to test for statistical significance of observed shifts and changes in the slope of the Beveridge curve for both the euro area aggregate and the individual
countries since the onset of the global financial and economic crisis. We find a significant shift and change in the slope of the euro area Beveridge curve since the onset of the crisis, but considerable heterogeneity at country level. At the extremes, country level differences include a significant deviation from the pre-crisis Beveridge curve for Spain and France, but an inward shift for Germany. We find weak evidence for an outward shift of the Beveridge curve for Cyprus, Greece and the Netherlands.

We then extend our analysis to a second stage, in order to examine factors underlying the observed developments. A range of country-specific factors — including labour force characteristics, sectoral employment composition and financial conditions — are tested using the local projections method of Jordà (2005). We find evidence for skill mismatch and tentative evidence for sectoral and geographical mismatch. A high share of low skilled workers, a high homeownership rate, high pre-crisis financial slack and a high share of workers (previously) employed in the construction sector tends to shift the Beveridge curve outward in case of a negative shock. A high share of female workers in the labour force on the other hand tends to mitigate these effects.

The Beveridge curve has raised a lot of interest in the literature lately, but with some exceptions (e.g. ECB (2002), European Commission (2011b), Hobijn and Sahin (2012) and Bouvet (2012)), most studies are country specific, in part due to the lack of long and comparable cross-country vacancy series.1 Our choice of using the European Commission series of employers’ perceptions of labour shortages in manufacturing data allows us to do cross-country analysis. Like our analysis, ECB (2002) covers most euro area countries, but that study relates to developments in the 1990s whereas we focus on the Great Recession. Hobijn and Sahin (2012) provide a cross-country analysis for a number of OECD countries, including some euro area countries, however their analysis does not cover all euro area countries.

Our analysis builds on a number of earlier studies. Borsch-Supan (1991) tests for structural shifts in unemployment as a consequence of recessions in a panel of German federal states from 1963 to 1988. Shift periods are identified by visual inspection of regional Beveridge curves, so as to specify shift dummies, which are then tested for statistical significance. Wall and Zoega (2002) use a similar, though two-stage, approach; first identifying shifts in the Beveridge curve, before trying to explain the shifts by means of institutional variables. Examining Beveridge curves and its shifts for Australia, Groenewold (2003) suggests coefficients of a similar magnitude to Wall and Zoega (2002) and confirms the importance of worker characteristics as a major determinant of increased structural unemployment. Our ARDL specification is a dynamic variation of the basic OLS model originally applied to the United States by Valletta (2005), who estimates a reduced form equation using a similar method to Borsch-Supan (1991). Valletta (2005) does not fully isolate the structural shifts in Beveridge curve movements, since Beveridge curves are able to move back and forth from year to year, because of the use of yearly dummies. Our method restricts the movements to specific — and rather more protracted — periods.2 To reproduce the dynamics of the Beveridge curve accurately we augment these models into an autoregressive distributed lag model. In the second step of our analysis, we investigate what has driven the shifts of the euro area Beveridge curves using the local projections method of Jordà (2005) where we apply specifications developed in Teulings and Zubanov (2010).

The chapter proceeds as follows. Section 2 briefly describes the data and presents a graphical depiction of developments of the euro area Beveridge curve(s) over the past two decades. In section 3 we examine the statistical significance of observed shifts using an

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1 There is an increasing number of recent studies that estimate matching functions and Beveridge curves for the U.S., including Barnichon et al. (2010) Barnichon and Figura (2011), Daly et al. (2011), Daly et al. (2012), Elsby et al. (2010), Sahin et al. (2014).

2 As a robustness check we replace our shift dummy with yearly dummies to allow Beveridge curves to move back.
ARDL-model. Section 4 extends the analysis to a second stage, using the local projections method, to examine factors underlying the observed shifts. Section 5 concludes.

4.2 Overview of Beveridge curve developments

4.2.1 The data

The basis for our analysis are quarterly data on unemployment and vacancy developments. To ensure cross-country comparability, we use Eurostat’s harmonised unemployment rate for the euro area countries and the aggregate. Since official data on job vacancy developments are still somewhat embryonic, two vacancy series are considered: firstly, Eurostat’s job vacancy rates for the euro area as a whole;² secondly, the longer European Commission series of employers’ perceptions of labour shortages in manufacturing. These data are taken from the European Commission’s regular Surveys of Business Confidence — specifically the aggregated responses from the question relating to employers’ perceptions of labour shortages as limits to business.³ Advantages of these data over Eurostat’s job vacancy rates stem from the longer availability of the series (for most countries, from at least 1990) and their seasonally-adjusted form. These data have a very similar cyclical pattern as Eurostat’s job vacancy rates, correlating well with contemporaneous vacancy movements in the Eurostat series (see Table 4.2 in the appendix for a correlation matrix).

In our analysis of the drivers of the Beveridge curve shifts we use data on sectoral, age, skill and gender (un-)employment figures. In an attempt to isolate the impact of financial factors on labour market outcomes, we assess also the impact of non-performing loans (using data from the IMF) and the inverted financial shortage index of the European Commission series of employers’ perceptions of financial shortages in manufacturing as a limit to business (European Commissions’ Surveys of Business Confidence) as a measure of financial slack.

4.2.2 Beveridge curve developments in the euro area

Figure 4.1a shows developments in the aggregate euro area Beveridge curve since 2004Q1 on the basis of Eurostat job vacancy data. The pre-crisis observations trace the typical business cycle pattern of falling unemployment as vacancies increased, thus tightening the labour market. As the recession took hold, the vacancy rate fell sharply and unemployment increased strongly, represented by a south-eastern movement in the Beveridge coordinates. This pattern continued even after the resumption of economic growth (from 2009Q3). However, following the partial recovery in the aggregate euro area vacancy rate, the unemployment rate has not declined.

Figure 4.1b makes use of the time series on labour shortages to trace the euro area Beveridge curve since 1990. This suggests that, following an outward shift in the Beveridge curve in the late 1990s, over the course of much of the first decade of economic and monetary union (EMU), euro area unemployment appears to have become considerably more responsive to vacancy developments, resulting in an inward shift in the euro area Beveridge curve during the middle years of the 2000s (blue lines in Figure 4.1b). This longer series, ²Although job vacancy data are available from Eurostat since 2006Q1, these data are not fully harmonised across countries (e.g. cross-country sectoral and coverage differences).
³See European Commission (2011a). Three labour shortages series are available, covering manufacturing, construction and services. We use labour shortages for manufacturing, since (a) this is the longest of the series and (b) has been used extensively in the literature (see, for instance, ECB (2002), European Commission (2011b)). Composite indexes of manufacturing, services and construction labour shortages render largely similar results.
however, suggests a clear deviation from the previous unemployment-vacancy relationship since the onset of the crisis (2008Q1), alluding to growing structural problems in some euro area labour markets. However, a salient feature of euro area labour markets in the recent period has been the growing degree of cross-country heterogeneity.

To understand better the possible sources of the apparent shift in euro area Beveridge curves, Figure 4.2 shows developments for the four largest euro area economies since 1999, again using labour shortages as a proxy for vacancy developments. For Germany, the Great Recession had a relatively short-lived impact on the labour market. The relatively short-lived fall in the vacancy rate following the onset of the Great recession (in 2008Q2) led to a negligible increase in unemployment in Germany — as has been widely studied in the literature. Since the start of the recovery, the German unemployment rate has continued to decline as vacancies have increased modestly, resulting in suggestions of an inward shift in the Beveridge curve over the crisis period. Meanwhile in France, the crisis looks to have had a strong and considerable adverse reaction. Thus, despite some rebound in labour demand since the depths of recession were reached in 2009, the unemployment rate in France remains considerably above its pre-crisis level, effectively undoing much of the progress made over the course of EMU. The pattern is similar in Italy, though low levels of labour shortages and the long and sluggish reaction speeds evident in the Italian Beveridge curves render clear conclusions difficult to draw.

Developments in Spain, on the other hand, are clearly less ambiguous. While vacancy rates and reports of labour shortages remain close to their series lows, the exceptionally strong rise in the unemployment rate (an increase of over 10 percentage points since 1999 — though similar to rates seen in the early 1990s), together with the strong sectoral dimension of job losses following the bursting of the housing bubble are all highly suggestive

---

5 For a more detailed elaboration of the various country-level developments, see the country sections of Bonthuis et al. (2013).

6 A prominently cited explanation has been the private sector’s strong reliance on publicly-funded short-time working schemes (e.g. Cahuc and Carcillo (2011)). Other explanations have been cited as well; Burda and Hunt (2011) claim that in the 2005–2007 expansion, firms hired significantly less than expected given the extent warranted by GDP and wages, moderate wage growth in recent years as well as the Hartz reforms are frequently quoted as having played an important role.

7 See Scarpetta (1996), Bonthuis et al. (2013) and OECD (2014).
of a deep and significant increase in structural mismatch in the Spanish labour market.

Figure 4.3 summarises the full effect of Beveridge-type elasticities — dividing changes in the unemployment rate by changes in labour shortages — for all euro area countries for the pre-crisis period and since the onset of the financial crisis.\(^8\) Two countries — Germany and Italy — have seen periods in which labour market tightness drop slightly in combination with a decline in unemployment. For Germany this happened since the start of the Great Recession, while Italy experienced a similar move prior to the crisis (see checkered observations for Germany and Italy in Figure 4.3).

This chart shows that, on average euro area unemployment rose slightly more than labour shortages fell. More importantly, it shows that the reaction of unemployment to changing labour shortages during the crisis was much larger than during the pre-crisis period. The chart also summarises the considerable heterogeneity in unemployment responses to subdued labour shortages since the 2008 recession. For all countries labour shortages and vacancies remain below their pre-crisis levels, though to markedly differing degrees. Unemployment reactions have varied significantly, with disproportionately large elasticities in Spain, Greece, Italy, Portugal and France in stark contrast to the lower elasticities of Malta, Belgium, Slovenia, Finland and Austria despite broadly similar pro-

\(^8\)Figure 4.1 in the Appendix shows Beveridge curve profiles for the remaining euro area countries
2002 - start crisis ( ), start crisis - 2013 ( ).

Note: elasticity (y-axis) defined as the absolute value of the total change in unemployment divided by the total change in labour shortages: \( |\Delta UR/\Delta LS| \). Both in percentage points. Germany (crisis - 2013) and Italy (2002 - crisis) have both declining labour shortages and declining unemployment. Sources: Eurostat, European Commission, own calculations.

Portional declines in labour shortages. Moreover, most of the countries on the right have experienced large increases of elasticities compared to the pre-crisis situation, revealing clear candidates of suspected outward movements of the Beveridge curve.

### 4.3 Econometric analysis of euro area Beveridge curve movements

To test for statistical significance of the observed shifts and slope changes, we apply an autoregressive distributed lag (ARDL) model to a basic Beveridge curve specification:

\[
U_t = \beta_0 + \sum_{i=1}^{P} \beta_{i,1} U_{t-i} + \sum_{j=0}^{q} \beta_{j,2} LS_{t-j} + \sum_{j=0}^{q} \beta_{j,3} LS_{t-j} D_{t-j}^{cri} + \beta_4 D_t^{cri} + \beta_5 D_t^{emu} + \epsilon_t \tag{4.1}
\]

where \( U_t \) is the official Eurostat harmonised unemployment rate and \( LS_t \) is the labour shortages variable serving as proxy for vacancy developments.\(^\text{10}\) To test the impact of the crisis on euro area Beveridge curves, we incorporate a dummy variable, \( D^{cri} \) (taking a value of one from the first of at least two consecutive quarters of negative quarter-on-quarter GDP growth after 2007 to the end of the series, this way identifying the period from the start of the crisis until the end of the sample, all crisis periods are therefore country-specific). We also interact the crisis dummy with labour shortages \( (LS_t D_t^{cri}) \) to identify changes in the slope of the Beveridge curve. Finally, \( D^{emu} \), (taking a value of 1 at each country’s entry into EMU) is used. Therefore, in our model we effectively allow for three different Beveridge curve positions; our baseline 1990s, the EMU period and the crisis period.


\(^{10}\)For an analysis of the use of vacancy data instead of labour shortages see Bonthuis et al. (2013)
The model is estimated on quarterly data covering the period 1990Q1 to 2014Q1. So as to improve the comparability of the Beveridge curve parameter estimates across countries (by taking specific account of the typical reported degree of variability in labour demand over the respective business cycles), the labour shortages data were mean-adjusted. Moreover, country-specific differences in lag structure of unemployment adjustment were taken into account (by allowing \( p \) and \( q \) to differ across countries, according to country-specific values suggested by AIC and BIC information criteria). This specification produces stationary results and downward-sloping (\( \sum_j \beta_{j,2} < 0 \)) Beveridge curves for most countries.

Table 4.1 summarises the main results for the four biggest euro area economies as well as the euro area aggregate. Beginning with the results at the euro area aggregate level (column 1), as anticipated, the sum of coefficients on the lagged unemployment rate is large and highly significant, suggesting considerable persistence in euro area unemployment. The coefficient on the first lag of unemployment, which is larger than 1, suggests that there is an initial “overshooting” of unemployment after the initial shock (all else being equal). As expected, the labour shortages variable, \( LS_t \), displays the necessary negative coefficient, confirming the well-behaved inverse relationship between unemployment and vacancies, which underlies the Beveridge curve.

Turning to the dummy variables, EMU looks to have had a significant and favourable impact on euro area labour markets, coinciding with an inward shift in the euro area Beveridge curve. To some extent, this inward shift could be a result of structural labour market reforms which accompanied EMU membership in several euro area countries. As regards the impact of the crisis, \( D_{cri} \) is both positive and highly significant, suggestive of a strong outward shift in the euro area Beveridge curve since the onset of the recession and the interaction term \( (LS_t \times D_{cri}) \) is both positive and significant reflecting an overall decline in the responsiveness of unemployment to vacancy developments.

Turning to the results of the four largest euro area countries, the model performs well for Germany, Spain and France, with the expected signs on all variables. The coefficient on the crisis dummy for Germany is strongly significant but negative, suggesting a coincident apparent inward shift of the German Beveridge curve since the crisis and suggestive of an ongoing improvement in labour market matching in recent years. This inward shift, however, is more likely to reflect the implementation of the structural labour market reforms (Hartz reforms) undertaken from the mid-2000s in Germany, than the impact of the crisis. Also, the widespread use of short time working schemes (\( Kurzarbeit \)) and working time accounts have played a role in containing adverse labour market effects of the crisis.

For France and Spain, meanwhile, the model suggests strong and significant outward shifts in the Beveridge curve. For France, this result appears to confirm that the recent outward movement seen in the graphical representations of the French Beveridge curve (in Figure 4.2). However, it should be noted that this outward shift merely offsets the inward shift exhibited over the course of the EMU. Results for Spain, meanwhile, suggest that the crisis has led to a substantial shift in that country’s unemployment-vacancy relationship. The positively-signed shift dummy \( D_{cri} \) is strongly suggestive of a significant increase in the degree of mismatch since the onset of the crisis for Spain.

\[ \text{Data for France and Finland from 1992, for Malta from 2004 and for Slovakia from 2000. The labour shortages series for Ireland stops in 2008. Earlier observations appear exceptionally volatile and outside the range of all subsequent observations in these series.} \]

\[ \text{Only for Malta a Beveridge curve with stationary standard errors cannot be found. Additionally its Beveridge curve is not downward sloping. Ireland, Italy, Luxembourg and Slovakia have stability issues since the sum of the lagged dependent variables is not significantly different from unity. For Cyprus, Greece, Ireland and Luxembourg it is not immediately clear that their Beveridge curve is downward sloping (see the long run coefficients in Table 4.4 of the appendix). However, Greece has a significantly downward sloping Beveridge curve if we test for the joint significance of labour shortages and the interaction of labour shortages and the crisis dummy.} \]
Table 4.1: Beveridge curve estimation

<table>
<thead>
<tr>
<th>Dependent ( U_t )</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( U_{t-1} )</td>
<td>1.650***</td>
<td>2.027***</td>
<td>1.617***</td>
<td>1.269***</td>
<td>1.031***</td>
</tr>
<tr>
<td></td>
<td>(0.098)</td>
<td>(0.102)</td>
<td>(0.075)</td>
<td>(0.098)</td>
<td>(0.103)</td>
</tr>
<tr>
<td>( U_{t-2} )</td>
<td>-0.713***</td>
<td>-1.443***</td>
<td>-0.681***</td>
<td>-0.393***</td>
<td>-0.042</td>
</tr>
<tr>
<td></td>
<td>(0.198)</td>
<td>(0.185)</td>
<td>(0.067)</td>
<td>(0.090)</td>
<td>(0.105)</td>
</tr>
<tr>
<td>( U_{t-3} )</td>
<td>0.240</td>
<td>0.388***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.214)</td>
<td>(0.098)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( U_{t-4} )</td>
<td>-0.488**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.195)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( U_{t-5} )</td>
<td>0.262***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.095)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( LS_t )</td>
<td>-0.017**</td>
<td>-0.030**</td>
<td>-0.049</td>
<td>-0.018***</td>
<td>-0.031**</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.014)</td>
<td>(0.046)</td>
<td>(0.007)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>( LS_{t-1} )</td>
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<td>-0.004</td>
<td>-0.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.020)</td>
<td>(0.051)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( LS_{t-2} )</td>
<td></td>
<td>0.019</td>
<td>0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.020)</td>
<td>(0.051)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( LS_{t-3} )</td>
<td></td>
<td>-0.001</td>
<td>-0.024</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.014)</td>
<td>(0.048)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_t^{cri}LS_t )</td>
<td>0.035***</td>
<td>0.016</td>
<td>0.042</td>
<td>0.021</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
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<td>(0.014)</td>
<td>(0.078)</td>
<td>(0.015)</td>
<td>(0.079)</td>
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<tr>
<td>( D_t^{cri}LS_{t-1} )</td>
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<td>-0.026</td>
<td>0.102</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(0.019)</td>
<td>(0.087)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_t^{cri}LS_{t-2} )</td>
<td></td>
<td>0.054***</td>
<td>0.142</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.019)</td>
<td>(0.088)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_t^{cri}LS_{t-3} )</td>
<td></td>
<td>-0.033**</td>
<td>-0.148*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.014)</td>
<td>(0.081)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_t^{emu} )</td>
<td>-0.068**</td>
<td>0.021</td>
<td>-0.289***</td>
<td>-0.190***</td>
<td>-0.173***</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.030)</td>
<td>(0.107)</td>
<td>(0.062)</td>
<td>(0.065)</td>
</tr>
<tr>
<td>( D_t^{cri} )</td>
<td>0.141***</td>
<td>-0.095**</td>
<td>0.725***</td>
<td>0.172***</td>
<td>0.256</td>
</tr>
<tr>
<td></td>
<td>(0.036)</td>
<td>(0.039)</td>
<td>(0.164)</td>
<td>(0.049)</td>
<td>(0.205)</td>
</tr>
<tr>
<td>( Cons. )</td>
<td>0.489***</td>
<td>0.229**</td>
<td>1.063***</td>
<td>1.286***</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>(0.105)</td>
<td>(0.091)</td>
<td>(0.261)</td>
<td>(0.260)</td>
<td>(0.171)</td>
</tr>
</tbody>
</table>

| Observations (Obs.) | 100 | 93 | 100 | 92 | 100 |
| Adj. - \( R^2 \)    | 0.994 | 0.997 | 0.997 | 0.969 | 0.981 |
| RMSE                 | 0.099 | 0.097 | 0.273 | 0.175 | 0.240 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Sample period: 1990Q1-2014Q1
The model does not perform well for Italy. All parameters are estimated with the correct signs, but there is an almost unit root on the lagged dependent variables. This reflects the typically sluggish adjustment of the Italian labour market noted earlier. Overall the lack of a well-behaved Beveridge curve relationship for Italy means that the suggestion of an outward shift of the Italian Beveridge curve since the onset of recession should be viewed with caution.

Analysis of the largest euro area economies suggests strong evidence of a definitive Beveridge curve shift in two and possibly three of the four biggest euro area labour markets. However, this is not the general picture for the euro area. Table 4.3 in the appendix shows that only three of the 13 remaining countries — Cyprus, Greece and the Netherlands — have any suggestion of an outward shift in their respective Beveridge curves (though the Beveridge curve for Cyprus is not particularly well-behaved). None of the countries exhibit significant changes in the slope of the Beveridge curve at a 5% level. However, there is some weak evidence for a slope change in Belgium and Finland. To make the coefficients of the Beveridge curves comparable we have added the long-run coefficients in Table 4.4.

It is of course possible that the euro area Beveridge curve has shifted back recently. Adding a crisis dummy can be very restrictive and "force" the model to pick up a shift in the Beveridge curve. To test for this possibility we replace the crisis dummy with yearly dummies starting in 2008 (much like Valletta (2005), see Table 4.5). We see no evidence that the Beveridge curve has shifted back for the euro area aggregate, Cyprus and Spain. For France the picture is less clear, the Beveridge curve seems to move around a lot but is not permanently shifted out. However, in this specification the slope seems to have changed significantly, suggesting that there is evidence of a clear deviation from the pre-crisis Beveridge curve. For Greece adding the yearly dummies results in a the Beveridge curve that is not well behaved. This makes sense since it was mainly the crisis period which saw a clearly downward sloping Beveridge curve. For the Netherlands some evidence exists that the Beveridge curve has shifted back.

In summary, evidence of a significant deviation from the pre-crisis Beveridge curve is found for the euro area, Spain and France. Results for Cyprus, Greece and the Netherlands are suggestive of a deviation. However, the latter results are less robust.

### 4.4 What drives shifts in euro area Beveridge curves?

For policy purposes, it is not sufficient to know whether shifts in the Beveridge curves are evident, but rather to understand what is driving those shifts. In this section we investigate the role of labour force characteristics, sectoral composition as well as financial factors in driving outward shifts in euro area Beveridge curve(s) using the local projections method of Jordà (2005) augmented with specifications developed in Teulings and Zubanov (2010). Institutional variables were tested in our analysis but robust results were not found.14

13 However, for Cyprus it is difficult to clearly identify a downward sloping Beveridge curve.

14 Often institutional variables do not work well in econometric analyses — due, in large part, to data limitations, such as: short and infrequent series; the inherent need for heavy synthesis of complex cross-country indicators in very different institutional settings; lack of cross-country variation and lack of temporal variation. Given these and associated problems, it was difficult to include institutional features directly in our econometric analysis. For an extended discussion of institutional variables in a Beveridge curve analysis see Bonthuis et al. (2013).
ment developed given pre-crisis Beveridge curve data and therefore gives an indication of deviations of unemployment from the pre-crisis Beveridge curve. The advantage of this method over for instance a fully-fledged VAR model is that it is robust to misspecifications. Additionally, it allows for a more flexible specification which we will explore in the second part of this section when we investigate the drivers behind the Beveridge curve shift.

Compared to the previous section, using impulse response functions inherently allows the Beveridge curve to move back to its original position. Whether the Beveridge curve has shifted out permanently can simply be assessed by looking whether the impulse response function moves back to 0 (or at least becomes insignificant).

We start with a Beveridge curve specification similar to section 4.3 in panel form using the local projections method proposed by Jordà (2005):

\[ U_{c,t+k} = \beta_{c,0} + \sum_{i=1}^{p} \beta_{ik,1} U_{c,t-i} + \sum_{j=0}^{q} \beta_{jk,2} LS_{c,t-j} + \sum_{l=0}^{r} \beta_{lk,3} D_{c,t-l} + \epsilon_{c,t} \]  \hspace{1cm} (4.2)

in which \( D_{c,t} \) takes the value of 1 at the time of the shock (the first quarter of the crisis) but is 0 otherwise, \( \beta_{c,0} \) is the country fixed effect (we ignore the EMU dummy for the moment). For each period \( k \) following the crisis we can estimate this equation forward, obtaining the impulse response function described by the parameter \( \beta_{lk,3} \). However, as Teulings and Zubanov (2010) note, the forecast \( k \) periods ahead will not only be influenced by crises that occurred before or at period \( t \) but also by any crisis occurring between \( t \) and the forecast horizon \( k \). A similar argument applies to the labour shortage variable. This is of particular importance in our analysis since rising unemployment as such does not necessarily constitute an outward shift of the Beveridge curve. If vacancies drop as well, this represents simply a movement along a given Beveridge curve towards the extremes. We follow Teulings and Zubanov (2010) by retaining all manifestations of the crisis variable up to period \( k \). Additionally, we will include labour shortages up to period \( k \):

\[ U_{c,t+k} = \beta'_{c,0} + \sum_{i=1}^{p} \beta'_{ik,1} U_{c,t-i} + \sum_{j=0}^{k+q} \beta'_{jk,2} LS_{c,t+k-j} + \sum_{l=0}^{k+r} \beta'_{lk,3} D_{c,t+k-l} + \epsilon_{c,t} \]  \hspace{1cm} (4.3)

Because we account for the change in the labour shortages, the projection should not be interpreted as an impulse response function, rather it should be considered as a conditional impulse response.\(^{15}\)

In this setup we can unfortunately not test directly for a change of the slope of the Beveridge curve. However, we can give an indication of the deviation of labour shortages from the pre-crisis Beveridge curve. In addition to the above specification we will estimate a similar conditional impulse response function for labour shortages:

\[ LS_{c,t+k} = \beta'^*_{c,0} + \sum_{i=1}^{p} \beta'^*_{ik,1} LS_{c,t-i} + \sum_{j=0}^{k+q} \beta'^*_{jk,2} U_{c,t+k-j} + \sum_{l=0}^{k+r} \beta'^*_{lk,3} D_{c,t+k-l} + \epsilon_{c,t} \]  \hspace{1cm} (4.4)

This way we can test whether labour shortages deviate significantly from the pre-crisis Beveridge curve giving an indication of the possibility of a slope change.

To determine which sample of countries and time period to use in our panel we test for a common slope across countries (see results in Table 4.6 in the appendix). For the entire sample starting in 1990 we find that the null-hypothesis of poolability is rejected for all euro area countries, all countries with a significantly downward sloping Beveridge Curve in the long run (i.e. \( P(\sum \beta_{j,2}/(1 - \sum \beta_{l,1}) \geq 0) < 0.05 \)) and all original euro area countries with a downward sloping Beveridge Curve. Restricting the sample period to the

\(^{15}\)We estimate the errors using cluster robust errors as is done in Teulings and Zubanov (2010).
EMU period improves the results for countries with a downward sloping Beveridge Curve, particularly if we restrict this sample to the original euro area countries. We therefore restrict ourselves to the EMU period (which allows us to exclude the EMU dummy) and estimate the projections using only the sample of original euro area countries yielding downward-sloping Beveridge Curves — i.e., Austria, Belgium, Germany, Spain, Finland, France, Greece, the Netherlands and Portugal. Several of these countries — Greece, Ireland, Portugal and Spain — were subsequently subject to intense financial stress, resulting in eventual reliance on international aid programmes, and are henceforth referred to collectively as the “stressed” economies. As another robustness check we use the local projection method of Jordà (2005) directly; excluding contemporaneous observations of the crisis and labour shortages from the projections and find qualitatively similar results.

Figure 4.4a shows the results of the local projections method for the baseline crisis dummy with a 95% confidence interval using equation 4.3. We observe a persistent and significant rise in the unemployment rate — corrected for the vacancy rate — which is consistent with the (permanent) shift of the euro area aggregate Beveridge curve in section 4.3. This effect becomes significant in 2011. There is tentative evidence of a considerable long run effect of the crisis on unemployment. Labour shortages do not seem to deviate significantly from the pre-crisis Beveridge curve in the long-run (see Figure 4.4b). In the short-run labour shortages seem to drop faster than unemployment rises but they also recover faster, confirming the typical counter-clockwise movement of the Beveridge curve. All impulse response functions in the sections to follow measure the effects of a shock on unemployment corrected for labour shortages.

Splitting the countries between two distinct groups of stressed economies (containing Spain, Portugal and Greece) and the rest (Austria, Belgium, Germany, Finland, France and the Netherlands) suggests a strong dichotomy. While the whole sample does not seem to shift outward the stressed countries exhibit a large and significant outward shift (see Figure 4.5).

Turning to the drivers behind the Beveridge curve shifts we follow for a large part

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16 We find however that our results are robust to including Estonia and Slovenia.
17 Remember that we correct for unemployment developments in Equation 4.4.
Figure 4.5: Adjustment of unemployment following shock in stressed and non-stressed countries

(a) Crisis dummy

(b) Stressed countries

Local projection (--), 95% confidence interval (- - -)

Note: local projection of the crisis dummy for all countries and for the stressed countries separately (Spain, Portugal and Greece)

Bernal-Verdugo et al. (2013). Rewriting equation 4.3 as:

\[
U_{c,t+k} = \beta''_{c,0} + \sum_{i=1}^{p} \beta''_{ik,1} U_{c,t-i} + \sum_{j=0}^{k+q} \beta''_{jk,2} LS_{c,t+k-j} + \sum_{l=0}^{k+r} \beta''_{lk,3} D_{c,t+k-l} + \sum_{l=0}^{k+r} \beta''_{lk,4} D_{c,t} N_{c,t} + \epsilon_{c,t+k}
\]

(4.5)

in which \( N_{c,t} \) is a matrix with variables influencing the position of the Beveridge curve expressed as deviation from the euro area aggregate of which we take the pre-crisis four quarter average.\(^{18}\) To test for the effect of these variables during the crisis we interact them with the crisis dummy.\(^{19}\) This way we can compare the impact of the crisis (reflected in the simple crisis dummy) on the position of the Beveridge curve with features most likely to influence the position of the Beveridge curve (reflected in the interaction term). We are essentially decomposing the aggregate effect of the shock impact on the position of the Beveridge curve into the different effects of the labour market features on the position of the Beveridge curve. Since the interaction term deviates from zero only at crisis impact we can exclude the possibility of reverse causality; only the pre-crisis values of our drivers influence the position of the Beveridge curve. We will now turn to analysing, one by one, the effect of the variables mentioned in the beginning of this section on the position of the Beveridge curve.

\(^{18}\)This means for factor \( n \) we take: \((\sum_{i=0}^{3} n_{c,t-i} - \sum_{i=0}^{3} n_{c,t-i})/4\). This way we assure that we are not picking up a one off spike in the data. For yearly data we pick the value of the year in which the crisis starts.

\(^{19}\)Most of these variables are relatively stable throughout our sample which is why we do not include them as separate variables in our main analysis since the cross country differences are already picked up by the country fixed effects, however, we do include them separately as a robustness check and find qualitatively the same results.
Figure 4.6: Adjustment of unemployment following shock, labour force characteristics decomposition

(a) Crisis dummy

(b) Low skilled

(c) Young

(d) Female

Local projection (—), 95% confidence interval (---)

Note: Low skilled: share of the labour force with less than upper secondary education; Young: share of the labour force aged 15-24; Female: female share of the labour force.

4.4.1 Labour force characteristics

Strong increases in unemployment have been heavily concentrated among the low skilled and young people in many euro area countries. Furthermore, the strong increase in female participation in many countries over the last decades seem to have mitigated the adverse effects of the crisis somewhat. In figure 4.6 we plot the projections for the baseline crisis dummy and different worker characteristics. The results in Figure 4.6 confirm that labour force composition had significant impact on the outward shift of a country’s Beveridge curve over the crisis period.

Higher pre-crisis proportions of low-skilled in the labour force — defined as the number of low skilled (employed and unemployed) divided by the total labour force — seem to produce a significant and persistent outward shift of a country’s Beveridge curve.\(^{20}\) One possible explanation is that sectors with a large amount of low skilled workers were especially hard hit during the crisis (for instance construction and to a lesser extent manufacturing). Restructuring of these sectors and difficulties in reallocating labour to other sectors can lead to permanent losses in employment.

The record level of youth unemployment in many euro area countries raises the question of the influence of the age distribution of the labour force on the Beveridge curve.

\(^{20}\) Low skilled is defined as having attained up to lower secondary education. Countries with a high share of low skilled are Spain, Portugal and Greece.
CHAPTER 4. SHIFTS IN EURO AREA BEVERIDGE CURVES AND THEIR DETERMINANTS

However, in the local projections method, the pre-crisis proportion of young in the labour force does not show a significant effect.\(^2\) Thus, it seems that although young people in many countries may have been particularly hard hit by the Great Recession, this is not to say that a younger average labour force is likely to increase (or reduce) the likelihood of structural mismatch, simply that it reflects the higher volatility of youth unemployment (which tends to rise strongly in recessions but also falls more rapidly than unemployment rates among older workers).\(^2\)

High shares of women participating in the labour force on the other hand seem to shift the Beveridge curve inward (countries with a high share of female workers include Portugal, France and Finland). One potential explanation is that the crisis has mainly hit male dominated sectors, whereas public sector employment - where women are typically more strongly represented - has suffered smaller losses. Furthermore, economies with higher female participation are more likely to keep a shock to consumption to a minimum. For households in which income is mainly provided by one of the members of the household a spell of unemployment is likely to significantly reduce consumption, whereas in a dual-earner household the effects will be dampened.

However, including these three labour force composition indicators does not render the long term effect of the crisis dummy insignificant. The “unexplained” part of the rise in unemployment is still present.\(^2\)

### 4.4.2 Sectoral mismatch

To shed light on the extent to which sectoral developments were a key driver of the observed outward shifts (whereby displaced workers from one sector were not able to reallocate to employment in alternative sectors), we extend our analysis using shares of employment by sector.\(^2\) Using the NACE2 sectoral breakdown, we distinguish three broad sectors, construction, financial and business services, and non-market services.

We tested whether including other sectors would change the results, but did not find significant changes. The pre-crisis proportion of workers employed in industry (excluding construction) for instance does not seem to have a significant effect on the position of the Beveridge curve (not shown). As Burda and Hunt (2011) point out, it could be that industry (at least in Germany) in the pre-crisis period employed significantly less workers than the growth in value added would typically warrant. This would mean that the slack in the industrial labour market was low, leaving less reason to reduce employment. Moreover, it is likely that the employment elasticities may be significantly lower in industry than in other sectors, given the typically higher capital intensity of the manufacturing sector. Some corroboration for this view is provided in Anderton et al. (2014), who find that differences in employment elasticities across sectors help explain a large part of the unemployment reaction across the crisis.

The construction sector stands out as particularly important. Heavy job losses in the construction sector have been a common feature of many euro area labour markets since the start of the crisis. Across the euro area as a whole, construction employment declined by roughly 7% year-on-year — over twice the rate of contraction as in the economy as a whole — at the depths of the crisis. In some countries, losses were higher still, for instance in Spain where construction constituted almost 14% of employment in the

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\(^2\)This result holds even if we control for sectoral composition effects.

\(^2\)This effect can be stronger or weaker depending on the movements into and out of education.

\(^2\)One explanation for this could be the fact that the other variables are expressed as deviations from the euro area aggregate. We have shown that the euro area as a whole exhibits an outward shift, since the effects of the other variables are fixed to be zero for the euro area, the overall shift of the Beveridge curve needs to be picked up by the simple crisis dummy.

\(^2\)The strong sectoral dimension of the recent crisis has been well documented. See, for instance, ECB (2012).
4.4. WHAT DRIVES SHIFTS IN EURO AREA BEVERIDGE CURVES?

Figure 4.7: Adjustment of unemployment following shock, sector decomposition

(a) Crisis dummy

(b) Construction

(c) Financial and business services

(d) Non-market services

Local projection (—), 95% confidence interval (---)

Note: Construction sector: employment in sector F; Financial and business services: employment in sectors K to N; Non-market services: employment in sectors O to U. NACE2 classification. All as share of total employment.

Pre-crisis period. Moreover, employment contractions have tended to be rather longer-lived in construction — as job losses began rather earlier than in other sectors. In some countries the losses have been particularly persistent, resulting in construction employment levels well below their pre-crisis peaks in several euro area economies. Part of the downsizing observed is likely to be permanent, reflecting some correction to previously over-expanded construction sectors in some euro area economies. Displaced construction workers are unlikely to be readily absorbed into other activities with ease. This, coupled with the generally low-skill nature of construction work, are clear prerequisites for the long-lasting significantly positive outward shift of the Beveridge curve (see Figure 4.7). This effect seems to fade out after roughly three years.

As the ensuing crisis began with the global credit crunch, the financial sector has been at the core of the crisis and, in many respects, a key driver of the observed adjustments across many euro area economies. At the depths of the crisis, both the financial services sector and business services sector suffered strong employment contractions. However, in general, the losses in these sectors were both shallower and shorter-lived than in construction. Moreover, given the typically higher average skill levels of those (formerly) engaged in these sectors, they were probably rather easier to re-deploy than their lower-skilled construction counterparts. These reasons are likely to explain why empirically the share of employment in finance and business services do not seem to have a significant impact
**Figure 4.8:** Adjustment of unemployment following shock, financial conditions decomposition

(a) Crisis dummy  
(b) Home ownership  
(c) Financial slack  
(d) Gross non-performing loans

Local projection (—), 95% confidence interval (–––)

Note: Home ownership: ownership rate as percent of the population; Financial slack: inverse of financial shortages; Gross non-performing loans: non-performing loans as percent of total gross loans.

on the position of the Beveridge curve.

Finally, downsizing in the typically large public sectors of many euro area economies might be reasonably expected to lead to a potential outward shift of euro area Beveridge curves. However, for the period of this investigation, no such result is found. This is not to say that, in time, such a result will prove significant but rather that, for many of the countries under investigation, significant downsizing of the public sectors did not occur till well into the second phase of the crisis, following the emergence of sovereign debt concerns in some euro area economies. As a result, the impact of public sector downsizing was not evident at the start of the crisis and is likely to have generated too few subsequent observations to yield robust empirical results.

As with the labour force characteristics, including these three sectoral composition indicators does not render the long term effect of the crisis dummy insignificant.

### 4.4.3 Financial conditions

In an attempt to assess the impact of financial variables on labour market outcomes, finally we regress observed Beveridge curves developments on rates of home ownership and a variety of financial variables as a first attempt to isolate the impact of the credit crunch itself on labour market outcomes.
Figure 4.8 shows that a high pre-crisis rate of home ownership appears to have a significant and positive effect on the position of the Beveridge curve. One explanation — in common to the findings of several US studies — is that, following a sharp revaluation of asset prices (including domestic real estate) following the credit crunch and the bursting of construction bubbles in several euro area economies, homeowners in negative equity (or those whose homes were subsequently revalued to market rates lower than they had paid) were left unable (or unwilling) to move to less severely hit areas.  

To attempt to evaluate the effect of pre-crisis financial conditions, we use the European Commission series of employers’ perceptions of financial shortages in manufacturing as a limit to business, inverted so as to provide an approximate metric of the ease with which credit can be procured (or alternatively, of financial slack). The local projections method using this indicator shows a positive and significant effect on the Beveridge curve, suggesting that over-heated financial markets before the crisis have tended to amplify the unemployment consequences of the downturn. One potential explanation is that firms that have received finance “too easily” may have “overhired” during the boom, and have thus been forced to rationalise more quickly during the downturn. However, the effect is not persistent.

As with the previous two tests, including financial conditions in the local projections method does not fully explain the long term increase in unemployment. The unexplained effect of the crisis dummy is significant throughout our estimated period.

4.5 Conclusion

The labour market consequences of the recent crisis have been heterogeneous across countries and sectors in the euro area. Overall, there are risks that the rise in euro area unemployment over the crisis may become persistent both at the aggregate euro area level and for some of the member economies. Whether the high unemployment rates are due to cyclical factors and a lack of labour demand, or to structural factors such as labour market mismatches, has important policy implications. In this chapter we find evidence for the latter.

We find a significant shift in the aggregate euro area Beveridge curve since the onset of the crisis, suggestive of a marked increase in labour market mismatch over the subsequent period. At the country level, however, there is considerable heterogeneity. At the extremes, country level differences include significant outward shifts in the Beveridge curves for France and Spain, an inward shift for Germany, while the majority of euro area countries reveal no significant changes in the responsiveness of unemployment to vacancy developments over the course of the crisis. Our results find also some evidence of outward shifts in Cyprus, Greece and the Netherlands though for these countries the results are less unequivocal (given the lack of robust Beveridge curve specifications for these labour markets).

The results from a local projections analysis, designed to isolate the salient structural features influencing Beveridge curve movements, suggest that labour force characteristics — in particular, smaller proportions of lower-skilled workers and a higher proportions of

25It is well documented that homeowners are unwilling to sell their house below the price at which they bought it even if it is considered the market price — see for instance Genesove and Mayer (1997, 2001); Ferreira et al (2010) and Goetz (2013).


27Other variables considered included gross and net non-performing loans as proportion of total outstanding loans as well as arrears of mortgage payments. Neither seem to be an important indicator for the position of the Beveridge curve. It is likely that non-performing loans indicate a generally worsening of economic conditions resulting in a move along the Beveridge curve rather than a structural shift reflecting worsening labour market mismatch.
women in the total labour force — significantly decrease the probability of an outward shift. Sectoral factors — particularly, the heavy employment losses in the construction sector — are important determinants of observed Beveridge curve shifts with long lasting effects. At a more structural level, this paper finds high incidences of home ownership rates also increase the likelihood of outward shifts in Beveridge curves following the onset of a negative shock.

Appendix

4.A Figures

Figure 4.1: Beveridge curves for euro area countries over EMU part a

Note: X-axis: unemployment rate, y-axis: Labour shortages. Notes: Blue line is pre-crisis, red line is crisis. Sources: Eurostat, European Commission.
Beveridge curves for euro area countries over EMU part b


Note: X-axis: unemployment rate, y-axis: Labour shortages. Notes: Blue line is pre-crisis, red line is crisis. Sources: Eurostat, European Commission.
4.B Tables

Table 4.2: Correlation vacancies and labour shortages

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Eurostat reports breaks in the vacancy series for some countries. For those countries we test both the entire sample as well as before and after the break. bb = before break, ab=after break. Breaks occur in Belgium in 2012, Germany in 2010, Spain in 2010, France in 2011, Malta in 2010 and Portugal in 2010.
### Table 4.3: Beveridge curve estimation part a

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### CHAPTER 4. SHIFTS IN EURO AREA BEVERIDGE CURVES AND THEIR DETERMINANTS

#### Beveridge curve estimation part b

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## Beveridge curve estimation part c

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Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Sample period: 1999Q1-2014Q1
Table 4.4: Beveridge curve estimation long run coefficients

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<th>Dependent var.: $U_t$</th>
<th>(1) $\bar{E}_A$</th>
<th>(2) $\bar{A}_T$</th>
<th>(3) $\bar{B}_E$</th>
<th>(4) $\bar{C}_Y$</th>
<th>(5) $\bar{D}_E$</th>
<th>(6) $\bar{E}_E$</th>
<th>(7) $\bar{E}_S$</th>
<th>(8) $\bar{F}_I$</th>
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P-values in parentheses. Long run coefficient calculated as: $\bar{\beta}_{j,x} = \frac{\sum j \beta_{j,x}}{\sum i \beta_{i,1}}$
Table 4.5: Beveridge curve estimation with yearly dummies long run coefficients part a

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<th>(4)</th>
<th>(5)</th>
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<td>0.997</td>
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### Chapter 4: Shifts in Euro Area Beveridge Curves and Their Determinants

#### Beveridge curve estimation with yearly dummies long run coefficients part B

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<td>$Y_{2011}$</td>
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<td>0.000</td>
<td>0.000</td>
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- $P$-values in parentheses. Long run coefficient calculated as: $\frac{\sum_j \beta_{j,x}}{1-\sum_i \beta_{i,1}}$

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#### Table 4.6: Poolability test

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<tr>
<th>Start sample</th>
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<th>Significant Beveridge curve</th>
<th>Significant BC excluding SI &amp; EE</th>
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<tr>
<td>1990</td>
<td>F(160,792) = 2.55</td>
<td>F(100,526) = 2.47</td>
<td>F(80,474) = 2.47</td>
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<tr>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1999</td>
<td>F(160,435) = 1.73</td>
<td>F(100,277) = 1.28</td>
<td>F(80,232) = 1.28</td>
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<td></td>
<td>0.00</td>
<td>0.06</td>
<td>0.29</td>
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</tbody>
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Note: Test for common slope of Beveridge curve and common parameters on lagged dependent variable.
5 Downward wage rigidities in the euro area

5.1 Introduction

In this chapter we estimate wage equations to test for changes in the responsiveness of wages to unemployment using panel estimates which pool the data across the euro area countries. The objective of this chapter is to improve our understanding of the effect of rising unemployment on the evolution of wages during the recent crisis period and the possible causes behind changes in responsiveness. We estimate equations where wage growth is explained by inflation, productivity growth and unemployment and test various hypotheses by extending this basic specification. For example, short and long-term unemployment may have a different impact on wage adjustment. This might also be important during the crisis, since the proportion of those defined as long-term unemployed has increased markedly. A rise in structural unemployment, perhaps due to various factors such as an increase in labour market mismatch, may also reduce the impact on wages of a given change in unemployment. Additionally, employment protection and unionisation might improve the bargaining position of existing workers, thereby enabling them to resist (or reduce) downward pressure on wages. Accordingly, this chapter investigates whether the sensitivity of wages to movements in unemployment is different during downturns (i.e., downward wage rigidity), whether it has changed during the crisis and which institutional features might be driving these results.

Our empirical results suggest evidence of lower responsiveness of wages at high levels of unemployment in the euro area. This result applies to all downturns, even though wage responsiveness has somewhat recovered as the crisis became more protracted. Additionally, we find that differences in bargaining position — in particularly differences between unionised vs non-unionised labour and permanent vs temporary jobs — explain a large part of the downward wage rigidity. Perhaps surprisingly a larger share of long term unemployment tends to decrease wages. However, this effect is reversed at high levels of unemployment. Other findings show that a higher share of temporary workers lowers overall wage growth but this effect is also partially reversed during downturns. Including the share of temporary workers also partly addresses the question as to whether composition bias (such as skill composition effects in employment) disguises the degree of downward wage flexibility (see for instance Keane et al. (1988) and Solon et al. (1994)). Finally, including indicators on employment protection, unions and share of temporary workers touches on the issues raised by Kudlyak (2014) who argues that the user cost of labour is a better indicator than the wage, since workers are typically hired for more than one period. Kudlyak (2014) finds that user costs are more pro-cyclical than wages. Our results — though limited by the use of aggregate wages — seem supportive of this finding considering that the measures of employment (in)flexibility partially explain the downward wage rigidity.

Our chapter builds on an extensive existing literature on the cyclicalities of wages and the relationship between wages and unemployment specifically. Katz and Blanchard (1999) note that empirics usually show a negative relation between the change in wages and unemployment, while theory suggests a negative relation between the level of wages and unemployment.\(^1\) However, the empirically observed characteristics are in line with the New Keynesian Wage Phillips Curve (NKWPC) (Galí (2011)). For our baseline wage equation we therefore follow to a large extent the reduced form equation described by Galí (2011) with wage growth as dependent variable and unemployment as the main independent variable. Inflation is included as independent variable if nominal wage growth is used as the dependent variable. In contrast to the NKWPC, we model the dynamics as well as productivity explicitly introducing lagged wage growth and productivity growth as separate variables. Furthermore, we add squared unemployment to allow for nonlinearities in our wage-unemployment relation.\(^2\)

As Holden and Wulfberg (2009) and Babecký et al. (2010) argue, theories that are commonly used to explain wages above labour market clearing levels can also be applied to wage rigidity.\(^3\) In a standard wage bargaining framework workers and firms bargain over the division of the available economic rent. The division depends on the relative strength of the bargaining positions of the parties involved. There is evidence that the bargaining position is not equally strong across groups of potential workers. The insider-outsider theory outlined by Lindbeck and Snower (1988) states that insiders have a more privileged position compared to outsiders.\(^4\) This privileged position includes (but is not limited to) higher wages.

One example of different bargaining positions is unionised versus non-unionised workers. Some of the most commonly mentioned models are the monopoly union model, the right to manage model and the efficient bargaining model (Leontief (1946), Dunlop (1950), McDonald and Solow (1981) and Nickell (1982)). Even though the models differ in many respects, one commonality is that wages are typically higher and employment lower than under the competitive solution. In this framework, wages also decline less in the case of a negative shock to the economy with employment taking part (or even all) of the hit. Both the unions’ bargaining power and the fact that unions typically represent only part of the labour force are important drivers behind these results.

Even though the exact modeling of these theories cannot be directly adopted to test for wage rigidity on an aggregate level, some can be assessed through the use of proxies. Union data can be used to test for the effects described in the above-mentioned union theory. Other sources of differences in bargaining position can be proxied by long-term unemployment, employment protection legislation and the share of temporary workers.\(^5\)

Our empirical results relate to a number of studies. Several papers in the literature confirm the existence of downward wage rigidity in multi country studies. Dessy (2004), Dickens et al. (2007), Arpaia and Pichelmann (2007), Knopfik and Beissinger (2009) and Heinz and Rusinova (2011) find significant nominal (and real) wage rigidity in Europe or the euro area. However, most studies also find a large degree of heterogeneity between countries. The setup of our model most closely resembles Nunziata (2005) and European

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\(^1\)See Blanchard and Diamond (1994) for a discussion on the Phillips curve (Phillips (1958)) vs. wage curve (Blanchflower and Oswald (1990)).

\(^2\)Galí (2011) observes that the wage equation in its most basic form does not fit the data well if the crisis is included. The main cause mentioned is downward wage rigidity. Excluding the crisis improves the fit and raises the negative effect of unemployment on wages.

\(^3\)Some of these theories can only be tested on a firm or industry level. In this analysis we are evidently limited to institutional features for which data are available on the aggregate level.

\(^4\)It should however be noted that the effect of outsiders on bargaining can extend beyond the influence through an outside option (see Anderton and Barrell (1995)).

\(^5\)Other variables that have been tested but were not found to be significant are: union density, the share of young workers, the share of low skilled workers and the share of high skilled workers.
Commission (2011b) in which wages are determined by prices, unemployment and productivity. The former also includes macroeconomic shocks and institutional features.

On an industry level Hanes (2000), Holden and Wulfberg (2008) and Kimura and Ueda (2001) generally find rigid wages but the latter also finds that wages respond downward during the recessions in the late 90s, indicating that the degree of wage rigidity might change over time.

A large number of papers investigate the existence of downward wage rigidity using micro data (personnel files, survey data, administrative data or firm data). Using surveys of employers both Bewley (1999) and Agell and Lundborg (2003) find rigid wages for the US and Sweden respectively. Many other studies find evidence for downward wage rigidity ranging from relatively rigid wages to very rigid wages (McLaughlin (1994), Kahn (1997), Altonji et al. (1999), Christofides and Tuen Leung (2003), Lebow et al. (2003), Nickell and Quintini (2003), Kuroda et al. (2003), Knoppik and Beissinger (2003), Fehr and Goette (2005), Elsby (2006) and Du Caju et al. (2007)). However, the degree of wage rigidity declines during downturns for the latter.

Other studies find that wages are (largely) pro-cyclical and that downward wage rigidity is more limited than previously suggested (Solon et al. (1994), Carneiro et al. (2012), Doris et al. (2015) and Smith (2000)). Again others find mixed evidence or inconclusive results (Brandolini (1995), Elsby et al. (2013) and Abraham and Haltiwanger (1995)).

Our chapter is closely related to the nonlinear Phillips curve found in the literature (see for instance Laxton et al. (1999), De belle and Vickery (1998), Eklässon (2001), Dolado et al. (2005) and Daly and Hobijn (2014)). In these papers inflation reacts less at very high levels of unemployment, whereas inflationary pressure is high at low levels of unemployment. The main difference between our chapter and papers on the nonlinear Phillips curve is that we study wage inflation rather than inflation. However, the modeling of the nonlinearity is very similar.

In terms of the effects of institutions on wage setting the literature generally reports union density (or coverage), employment protection, wage bargaining coordination and centralization, active labour market policies and the tax wedge to have a significant impact on wage flexibility (Clar et al. (2007), Dessy (2004), Dickens et al. (2007) and Babeký et al. (2010)). Babeký et al. (2010), for instance find both real and nominal wage rigidity, which is positively related to collective bargaining coverage, employment protection (also in combination with the use of permanent contracts), share of high skilled workers, employee tenure and firm size.

The remainder of this chapter is structured as follows. In section 5.2 we describe our model, in section 5.3 we present the results for our baseline model, in section 5.4 we test for the effects of institutional features and in section 5.5 we conclude.

### 5.2 The model

In this chapter we use quarterly data for 12 euro area countries between 1999 (introduction euro) and 2013. Our baseline model is a relatively straightforward dynamic fixed
effects panel model. All variables are stationary as we use log differenced variables (except for unemployment). We define the following wage specification based on quarterly data:

\[
\Delta W_{i,t} = \alpha_i + \sum_{j=1}^{4} \gamma_j \Delta W_{i,t-j} + \beta_1 \Delta \text{Prod}_{i,t} + (\beta_2 \Delta CPI_{i,t}) + \\
\beta_3 U_{i,t} + \beta_4 U_{i,t}^2 + (\beta_5 U_{i,t} \text{Trend}_t) + e_{i,t}
\]  

(5.1)

in which \(\Delta W_{i,t}\) is the change in real (nominal) compensation per person-hour at time \(t\) in country \(i\), \(U_{i,t}\) is the unemployment rate, \(\Delta \text{Prod}_{i,t}\) is change in real output per person-hour, \(\Delta CPI_{i,t}\) is annual inflation, \(\alpha_i\) are fixed effects and \(e_{i,t}\) is an error term. We experiment with two main variants of the above equation (i.e., nominal wages and real wages as the dependent variable). Inflation is included as an explanatory variable if we use nominal compensation as the dependent variable. When real compensation is the dependent variable, then inflation is not included in the regression and we effectively restrict \(\beta_2\) to unity in the nominal wage equation. The nominal compensation specification, on the other hand, allows \(\beta_2\) to be freely estimated. Our differenced variables are year-on-year log differences using quarterly data. To test for possible differences in the effect of unemployment on wages in normal times and recessions, we include squared unemployment (\(U_{i,t}^2\)). The squared term is designed to test for the nonlinear relation between wages and unemployment thus allowing for a different impact of economic downturns on wage determination. It focuses on the possible change in the wage elasticity with respect to the unemployment rate, thereby capturing any downward wage rigidities. It should be noted that this does not imply that wages are never adjusted downward. It simply means that wages are less responsive to unemployment at high levels of unemployment. As an extension of our baseline model, to test for a possible change in responsiveness of wages to unemployment over the course of the crisis, we include unemployment interacted with a time trend starting in 2008Q1 (\(U_{i,t} \text{Trend}_t\)).

Rising unemployment should put wage growth under pressure. Therefore, the sign on unemployment in our model should be negative. Rising productivity on the other hand should have a positive impact on wages, therefore, we expect the sign to be positive. The same holds for inflation, rising prices are likely to result in rising nominal wages if indexation is taken into account. A coefficient of unity on inflation would mean that wages are fully indexed. Finally, the sign on the squared unemployment term (\(U_{i,t}^2\)) will be positive if wages are less responsive at high levels of unemployment.

One reason for the latter phenomenon could be that during downturns a rising share of long-term unemployment puts less downward pressure on wages, as they become less able to effectively compete for jobs (due to a loss of human capital). Therefore, we also experiment with a measure of long term unemployment in our specification and explicitly estimate its impact. A positive sign for \(U_{i,t}^2\) could also be due to the generally observed

\[\Delta W_{i,t} = \ln(W_{i,t}) - \ln(W_{i,t-4}).\]

10 While our baseline model is largely consistent with the reduced form NKWPC framework as described by Galí (2011), the nonlinearity on the effect of unemployment and the explicit modelling of the wage inertia are clear deviations.

11 In some countries, like Spain and Slovenia, wage indexation is automatic or widely used.
downward wage rigidity for many euro area countries due to labour market institutions. Another reason could be a rising mismatch between vacancies and the unemployed: if a large proportion of the unemployed is not suitable for existing vacancies, less downward pressure is applied to wages for those positions.\textsuperscript{14} Or it could be because the public employment services of countries with rapidly rising unemployment are overloaded with job seekers, decreasing their ability to effectively place people into work. By contrast, non-significant parameters for the squared term, in combination with significant and correctly signed other coefficients, imply that the effect of unemployment on wages is the same for upturns and downturns.

In the section on institutions we extend our basic specification of Equation 5.1 and include institutional variables ($Z_{i,t}$):

\[
\Delta W_{i,t} = \alpha_i + \sum_{j=1}^{4} \gamma_j \Delta W_{i,t-j} + \beta_1 \Delta \text{Prod}_{i,t} + (\beta_2 \Delta CPI_{i,t}) + \\
\beta_3 U_{i,t} + \beta_4 U_{i,t}^2 + \beta_5 U_{i,t} t_{08-13} + \zeta_1 Z_{i,t} + \zeta_2 Z_{i,t} U_{i,t} + \epsilon_{i,t} \tag{5.2}
\]

In which $Z_{i,t}$ represents institutional variables such as union coverage, employment protection, share of temporary workers and long-term unemployment (all in year-on-year differences). We interact the institutional variables with unemployment to test for possible differences in reaction of wages to institutions at high levels of unemployment. Since some of the institutional variables are relatively slow moving we test for robustness of results by using the Fixed Effects Vector Decomposition estimation described in Plümper and Troeger (2007) (see Appendix for results).\textsuperscript{15}

To check for the viability of pooling all countries in our analysis we run a Hausman test to compare between our fixed effects results and the mean group estimator (see Table 5.5 in the Appendix).\textsuperscript{16} We find that our real wage results are robust in most cases according to the Hausman test. The results for nominal wages are unfortunately less supportive of the fixed effects model and should therefore be treated with caution.

### 5.3 Econometric results

Starting with our basic equation (Equation 5.1) we see a clear negative and statistically significant relation between wage growth and unemployment in Table 5.1 (columns 1 and 3 for the real wage equation and 2 and 4 for the nominal wage equation). The unemployment rate is found to have the expected negative sign and is statistically significant, suggesting downward pressure from the unemployed on wages. The squared unemployment term ($U^2$) is positive and significant, indicating a lower downward responsiveness of wages at high unemployment levels. The derivative of the wage equation with respect to unemployment becomes 0 at 28\% and 23\% for the baseline real and nominal wage equation respectively (columns 1 and 2). The reduced downward pressure could be capturing the impacts of higher long-term and/or structural unemployment on wage pressures, or it could indicate general downward wage rigidity, possibly due to institutional settings.

In columns 1 to 4 of Table 5.1, the parameter on productivity ranges from 0.26 to 0.31, indicating that only part of productivity gains are incorporated into wages. However, it should be noted that these are short-run parameters. Taking the lagged dependent variables into account the total effect of an increase in productivity on wages is higher (but

\textsuperscript{14}See for instance Hobijn and Şahin (2013) and Bonthuis et al. (2015) for the possible existence of mismatch in the euro area.

\textsuperscript{15}However, as Greene (2011) points out, since the institutional variables are in fact changing, all parameters can be estimated consistently and efficiently with fixed effects.

\textsuperscript{16}For more on mean group wage equation estimations see Anderton and Bonthuis (2015)
### Table 5.1: Results baseline

<table>
<thead>
<tr>
<th>VARIABLES</th>
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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
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<td>( \Delta w_{real/nom.(-1)} )</td>
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<td>0.565***</td>
<td>0.593***</td>
<td>0.555***</td>
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<tr>
<td>( U )</td>
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<td>-0.340***</td>
<td>-0.418***</td>
</tr>
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<td>(0.0717)</td>
<td>(0.0709)</td>
<td>(0.0631)</td>
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<tr>
<td>( U^2 )</td>
<td>0.00612**</td>
<td>0.00819***</td>
<td>0.00793***</td>
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<td></td>
<td>(0.00204)</td>
<td>(0.00222)</td>
<td>(0.00224)</td>
<td>(0.00307)</td>
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<td>( U \ast Trend )</td>
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<td></td>
<td>-0.00258**</td>
<td>-0.00259</td>
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<td></td>
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<td>2.582***</td>
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<td>(0.369)</td>
<td>(0.567)</td>
<td>(0.373)</td>
<td>(0.426)</td>
</tr>
</tbody>
</table>

| Observations               | 646   | 646   | 646   | 646   |
| Number of countries        | 12    | 12    | 12    | 12    |
| \( R^2 \)                  | 0.639 | 0.747 | 0.643 | 0.749 |
| \( Adj - R^2 \)            | 0.635 | 0.744 | 0.638 | 0.746 |
| \( RMSE \)                 | 1.622 | 1.460 | 1.614 | 1.454 |

Notes: *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel.
still less than one-to-one) once the dynamics have played out. However, the fact that not all productivity gains are incorporated in wages seems to be consistent with the well-documented decline in the labour share in the euro area over past decades. The sign of the parameter on CPI is positive as expected, but again not all of the change in prices is transmitted to wages (only around 17-18% of the change in the CPI is passed through directly to wages).

In column 3 and 4 it is tested whether the degree of downward wage rigidity has changed over the duration of the crisis. Various arguments suggest that the results could go either way. On the one hand, stylised facts suggest that wage moderation increased during the crisis. This is possibly related to labour market reforms implemented during the crisis, which may help to increase the impact of unemployment on wages. By contrast, the rapid rise in long-term unemployment as the crisis continued may lead to less downward pressure on wages from unemployment. To see if downward wage rigidity has changed over the course of the crisis, we add an additional term which simply multiplies unemployment by a simple time trend starting in 2008 ($U \cdot Trend$). The sign and significance of $U \cdot Trend$ will indicate whether the degree of downward wage rigidity rises or decreases as the duration of the crisis becomes more prolonged.

The result for real wages indicates that the degree of downward wage rigidity has declined as the crisis became more prolonged. Column 3 of Table 5.1 shows that the term $U \cdot Trend$ is negatively signed and statistically significant. The trend in the nominal wage equation (column 4) is insignificant in our current setup but significant at a 10% level using the Arellano-Bover estimator (see Table 5.6 in the Appendix). The (weak) evidence for a decline in wage rigidity as the crisis became more prolonged could be explained by several factors: (a) the magnitude of the rise in unemployment, also over an extended period during the crisis, may lead to threshold effects which deliver stronger downward pressure on wages relative to previous downturns; (b) the wave of labour market reforms since the onset of the crisis, particularly those aimed at reforming wage setting, may already have a significant downward impact on wages (eg, Spain); (c) the continuation of fiscal consolidation and persistent downward pressure on public sector wages which may also entail spill over effects to private sector wages; (d) it may also be the case that downward rigidities tend to mostly slow down the responsiveness of wages to unemployment, implying that rigidities become weaker as downturns become more prolonged and extended.

Our results are robust to changes in the estimation technique. In Table 5.6 in the Appendix we use an instrumental variable estimator (Arellano-Bover linear dynamic panel estimator), which returns results similar to Table 5.1.

5.4 Institutional features

Wage rigidity might depend on the relative strengths of bargaining positions of different groups. Those that are covered by unions or enjoy stricter employment protection tend to have a stronger bargaining position. On the other hand, temporary workers can function as a limit to permanent-employee power but can also quickly become outsiders once the economy is in decline. Similarly, the long-term unemployed are likely to put less downward pressure on wages, because of their relatively lower probability of re-employment. In this section we therefore test for the effects of union coverage, employment protection (EPL), temporary work and long term unemployment on wage setting.\footnote{Since union coverage data (from the ICTWSS database) and employment protection data (from the OEC) are only available on a yearly basis we interpolate them using a cubic spline. All institutional variables in this section enter in differences.}

Since some of the institutional variables included in this section are slow moving we

\footnote{See, for example, Anderton and Hiebert (2010).}
replicate the exercise using the Fixed Effects Vector Decomposition method by Plümper and Troeger (2007). Most of the results are confirmed using this method (see Tables 5.9 and 5.10 in the Appendix).

To proxy for the effects of union power we experiment with union coverage (Union) in our wage equation (see Table 5.2 columns 1 and 2). Union coverage reflects the share of wage earners covered by unions during wage negotiations. Many European countries tend to have union coverage of 80% or higher with the notable exceptions of Estonia, Ireland and Slovakia. In Germany the union coverage significantly decreased over time from 85% in 1990 to 60% in 2010.

The results show that wages react less to unemployment if union coverage is increasing (the Union+U variable is positively signed and statistically significant). This confirms the notion that unionised labour has wage bargaining power which can put upward pressure on wages. The results for the nominal wage equation should be treated with caution as the two robustness checks in the Appendix (IV and FEVD) indicate that the results are likely to change if a different estimation technique is used.

The wave of labour market reforms during the crisis may have reduced the bargaining power of unions by, for example, removing some employment protection or increasing the role of firm-level bargaining. Hence, these changes in bargaining power could explain the reduction in downward wage rigidity during the crisis evident in Table 5.1. We explore this further below by assessing changes in hiring and firing costs and empirically testing their impacts on wage setting.

Sources of differences in bargaining power between different types of workers may occur through the existence of hiring and firing costs. Because of hiring and firing costs companies either have to pay higher wages because of an improved bargaining position of workers (Emerson (1988)) or firms want to pay higher wages to avoid recurring search, recruitment and training cost (Stiglitz (1974)).

To assess the firing cost component we use the OECD’s employment protection legislation index (EPL), where countries with stricter rules on individual and collective dismissals have a higher EPL index. The EPL index ranges from 0 to 6, with 2.7 as the average of the countries in our sample, most of the countries lie in the range of 1.8 (Ireland, flexible) and 4.1 (Portugal, rigid). We use the indicator on regular contracts since we will cover temporary contracts separately later on and since rules concerning regular contracts are more binding for firms.

Countries with increasingly strict employment protection legislation seem to experience higher wage growth during downturns (Table 5.2 columns 3-4, ∆EPL*U). One possible explanation could again be improved bargaining strength for permanent employees when firing costs are high. Lower wage growth can be resisted if layoffs are less likely due to more employment protection. On the other hand countries that have eased their employment protection would experience lower wage growth. The reforms in a number of euro area countries during the crisis resulted in reductions in employment protection and a decline in the EPL index. The reforms implemented in Spain for instance since 2010 have resulted in a drop of the EPL index of 0.4, which combined with unemployment levels of around 25% would lead to a drop of 0.8% for real wages and 0.5% of nominal wages. Employment protection legislation seems to have no impact on wage setting in normal times (∆EPL is insignificant). Intuitively this makes sense since the restrictions on dismissals are less binding in normal times.

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19 We use union coverage instead of union density because union density measures only the share of the wage earners with a union membership. While union coverage reflects the share of wage earners covered by unions during wage negotiations. Since we are interested in the effect on wage setting for all workers, union coverage better suits our needs.

20 In the case of a temporary contract, an employer can in the worst case simply wait out the term of the relatively short contract without much cost.
### 5.4. Institutional Features

<table>
<thead>
<tr>
<th>VARIABLES</th>
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<th>(3)</th>
<th>(4)</th>
</tr>
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<tbody>
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<td>$\Delta w_{\text{real/nom.}}(-1)$</td>
<td>0.529***</td>
<td>0.497***</td>
<td>0.545***</td>
<td>0.513***</td>
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Notes: *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel. Union coverage ($Union$) and employment protection legislation ($EPL$) not available for full sample.
### Table 5.3: Results institutional variables

<table>
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<th>VARIABLES</th>
<th>(1) Temp. Δw_{real/nom.(-1)}</th>
<th>(2) Temp. Δw_{nominal}</th>
<th>(3) LTU Δw_{real}</th>
<th>(4) LTU Δw_{nominal}</th>
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<td>Δw_{real/nom.(-1)}</td>
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<td>0.545***</td>
<td>0.581***</td>
<td>0.547***</td>
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<td>0.154*</td>
<td>0.108*</td>
<td>0.158**</td>
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<td>-0.291***</td>
<td>-0.385***</td>
</tr>
<tr>
<td></td>
<td>(0.113)</td>
<td>(0.0762)</td>
<td>(0.0789)</td>
<td>(0.0629)</td>
</tr>
<tr>
<td>U^2</td>
<td>0.00941**</td>
<td>0.0123***</td>
<td>0.00539*</td>
<td>0.00995***</td>
</tr>
<tr>
<td></td>
<td>(0.00338)</td>
<td>(0.00316)</td>
<td>(0.00284)</td>
<td>(0.00306)</td>
</tr>
<tr>
<td>U * Trend</td>
<td>-0.00295***</td>
<td>-0.00306</td>
<td>-0.00229*</td>
<td>-0.00275</td>
</tr>
<tr>
<td></td>
<td>(0.00102)</td>
<td>(0.00206)</td>
<td>(0.00108)</td>
<td>(0.00208)</td>
</tr>
<tr>
<td>ΔTemp</td>
<td>-0.247**</td>
<td>-0.165*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.102)</td>
<td>(0.0911)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔTemp * U</td>
<td>0.0154***</td>
<td>0.00878</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00471)</td>
<td>(0.00507)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔLTU</td>
<td></td>
<td></td>
<td>-7.311**</td>
<td>-6.275***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2.813)</td>
<td>(1.713)</td>
</tr>
<tr>
<td>ΔLTU * U</td>
<td></td>
<td></td>
<td>0.283***</td>
<td>0.182*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0737)</td>
<td>(0.0920)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.276***</td>
<td>3.878***</td>
<td>2.273***</td>
<td>3.268***</td>
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<tr>
<td></td>
<td>(0.600)</td>
<td>(0.503)</td>
<td>(0.454)</td>
<td>(0.492)</td>
</tr>
</tbody>
</table>

**Notes:** *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel. Share of temporary contracts (Temp) and share of long-term unemployed (LTU) not available for full sample.
In addition to the effects described above, the crisis has had a severe impact on other parts of the labour market. Both the share of temporary workers has decreased at the start of the crisis and the share of long-term unemployment has increased as the crisis dragged on. Both effects are likely to have influenced wage growth. Spain is the absolute front-runner in terms of use of temporary contracts with a share of over 30% of employment before 2008. In 2013 most countries typically have around 10% temporary contracts with the upper bound set by Spain, the Netherlands and Portugal at 20% and the lower bound at less than 5% set by Estonia. Temporary workers typically have low hiring cost (less intense search and less training required) and low firing cost (contracts simply run out or are not extended). Additionally temporary workers are likely to receive lower wages compared to permanent workers. We would therefore expect an increase in the share of temporary workers to generally have a negative effect on wage growth. This is indeed what we find when we add such a variable to our wage equation (see negative and statistically significant parameter for $\Delta Temp$ — temporary workers as share of total employment — in Table 5.3 columns 1 and 2). Significant downward wage rigidities are evident even when upward wage bias from employment skill composition effects are taken into account, given that squared unemployment is still significant and that temporary workers are largely low-skill, low-pay workers. The interaction term ($\Delta Temp * U$) is positive and significant for the real wage equation pointing to a potential reversal of the above mentioned effect once unemployment is high. This can be due to the relatively low bargaining power of (former) temporary workers when they look for a new job compared to other workers.

Finally, to test for the potential effect of long-term unemployment on wage setting we add the share of long-term unemployed, $LTU$, (ie, those unemployed for more than 6 months as share of total unemployment) to the existing wage equation. This reveals, perhaps surprisingly, that the share of long-term unemployed lowers wages (see columns 3 and 4, Table 5.3). However, also this effect is reversed at high levels of unemployment. A possible explanation behind the latter effect is loss of skills from unemployment which makes it harder for the long-term unemployed to effectively compete with both the short-term unemployed and the employed. The negative effect of the share of long-term unemployed on wages might be due to two things. First, during normal times the share of long-term unemployed out of total unemployment might be relatively high in more flexible labour markets. If labour markets are flexible the pool of short-term unemployed will be relatively limited as people tend to move from job to job with relatively short spells of unemployment. Only workers with for instance redundant skills or workers of advanced age might be stuck in unemployment longer. Second, timing might be a crucial element in this result. Typically, during the early stages of a crisis the share of long-term unemployed falls as more short-term unemployed flow into the unemployment pool. During the early stages of a crisis companies might also be reluctant to start cutting wages. As the crisis drags on wages moderation could potentially kick-in coinciding with a rise in long-term unemployment.

Interestingly, the inclusion of the institutional variables has limited effect on the significance of the squared unemployment term and the trend term. This means that our institutional variables only explain part of downward wage rigidities and that there are potentially other indicators not captured by our institutional variables which explain wage rigidity. For instance the reluctance of employers to cut wages because of adverse effects on worker motivation (which is very difficult to measure, especially on a macro level) can be an important factor. Furthermore, the reforms undertaken in some countries in terms of (union) wage bargaining and hiring and firing practices could potentially explain some of the wage moderation taken place over the course of crisis. But the limited effect on the trend term indicates that again it is not sufficient to explain all of the wage modera-
tion. Other factors, such as public sector wage cuts, could be important in explaining this phenomenon.

5.5 Conclusion

In summary, panel estimates across the euro area countries suggest a lower responsiveness of wages to rising unemployment during economic downturns. This may indicate that rising long-term unemployment reduces the elasticity of wages with respect to unemployment during downturns, or that the euro area is generally characterised by downward wage rigidities due to institutional features. However, the downward wage rigidities tend to become weaker as the crisis became more protracted. The decline in wage rigidity as the crisis became more protracted may have been due to the wave of labour market reforms in a number of euro area countries during the crisis or it may be the case that rigidities slow down the response of wages to unemployment during downturns and become weaker as downturns become more protracted and extended.

Overall, we find that differences in bargaining power can potentially explain a large part of the observed downward wage rigidity. Extensive union coverage, high long-term unemployment, a high share of temporary workers and high employment protection, all in combination with high unemployment, seem to drive up wages and hamper downward adjustment during downturns. A rising share of temporary labour and surprisingly a higher share of long-term unemployed seem to dampen wage growth. The former is likely due to the generally lower wages for temporary contracts. Conversely, the large labour shedding of temporary workers, who tend to be low-skilled and low-paid, will put upward pressure on aggregate wages during the crisis. Downward wage rigidities are still evident after allowing for the effect of institutions on wages.
Appendix

5.A Data sources

Table 5.4: Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Frequency</th>
<th>Adjustment</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation per hour</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA</td>
<td>1999 Q1-2013 Q4</td>
</tr>
<tr>
<td>Unemployment</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA</td>
<td>1999 Q1-2013 Q4</td>
</tr>
<tr>
<td>Productivity</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA</td>
<td>1999 Q1-2013 Q4</td>
</tr>
<tr>
<td>Consumer price index</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA</td>
<td>1999 Q1-2013 Q4</td>
</tr>
<tr>
<td>Union coverage</td>
<td>ICTWSS</td>
<td>Y</td>
<td>INT</td>
<td>1999 - 2011</td>
</tr>
<tr>
<td>EPL</td>
<td>OECD</td>
<td>Y</td>
<td>INT</td>
<td>1999 - 2013</td>
</tr>
<tr>
<td>Temporary employment</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA, INT</td>
<td>1999 Q1-2013 Q4</td>
</tr>
<tr>
<td>Unemployment &gt; 6 months</td>
<td>Eurostat</td>
<td>Quarterly</td>
<td>SA, INT</td>
<td>1999 Q1-2013 Q4</td>
</tr>
</tbody>
</table>

Notes: SA=seasonally adjusted; INT=interpolated, cubic spline. EPL is employment protection for regular contracts. Data on temporary employment and unemployment for more than 6 months are interpolated because of missing values early in the sample.

5.B Robustness checks

Table 5.5: Hausman test

<table>
<thead>
<tr>
<th></th>
<th>(1) Baseline</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real</td>
<td>Nominal</td>
<td>Trend</td>
<td>Real</td>
<td>Nominal</td>
<td>Union</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>5.680</td>
<td>52.300</td>
<td>4.560</td>
<td>179.850</td>
<td>20.460</td>
<td>10.220</td>
</tr>
<tr>
<td>Prob &gt; $\chi^2$</td>
<td>0.224</td>
<td>0.000</td>
<td>0.472</td>
<td>0.000</td>
<td>0.005</td>
<td>0.250</td>
</tr>
<tr>
<td>(7) EPL</td>
<td>Real</td>
<td>Nominal</td>
<td>Temp</td>
<td>Real</td>
<td>Nominal</td>
<td>LTU</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>1.600</td>
<td>55.840</td>
<td>4.740</td>
<td>1063.340</td>
<td>17.010</td>
<td>153.310</td>
</tr>
<tr>
<td>Prob &gt; $\chi^2$</td>
<td>0.979</td>
<td>0.000</td>
<td>0.692</td>
<td>0.000</td>
<td>0.017</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: Data range: 1999 Q1-2013 Q4.

In our Hausman test (Table 5.5) we compare the mean-group estimator (consistent under H0 and Ha) with the fixed effects estimator (efficient under H0 and inconsistent under Ha). The results suggest that our real wage specification is consistent and efficient in most cases. For the nominal wage specification the results are unfortunately less supportive of the fixed effects model.
### 5.C Alternative estimation techniques

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Baseline $\Delta w_{\text{real}}$</th>
<th>(2) Baseline $\Delta w_{\text{nominal}}$</th>
<th>(3) Trend $\Delta w_{\text{real}}$</th>
<th>(4) Trend $\Delta w_{\text{nominal}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta w_{\text{real/nom.(-1)}}$</td>
<td>0.627***</td>
<td>0.576***</td>
<td>0.619***</td>
<td>0.572***</td>
</tr>
<tr>
<td></td>
<td>(0.0257)</td>
<td>(0.0256)</td>
<td>(0.0258)</td>
<td>(0.0257)</td>
</tr>
<tr>
<td>$\Delta w_{\text{real/nom.(-2)}}$</td>
<td>0.104***</td>
<td>0.161***</td>
<td>0.106***</td>
<td>0.162***</td>
</tr>
<tr>
<td></td>
<td>(0.0331)</td>
<td>(0.0322)</td>
<td>(0.0330)</td>
<td>(0.0322)</td>
</tr>
<tr>
<td>$\Delta w_{\text{real/nom.(-3)}}$</td>
<td>0.0129*</td>
<td>0.0642*</td>
<td>0.0121</td>
<td>0.0608</td>
</tr>
<tr>
<td></td>
<td>(0.0379)</td>
<td>(0.0377)</td>
<td>(0.0379)</td>
<td>(0.0377)</td>
</tr>
<tr>
<td>$\Delta w_{\text{real/nom.(-4)}}$</td>
<td>-0.208***</td>
<td>-0.139***</td>
<td>-0.220***</td>
<td>-0.152***</td>
</tr>
<tr>
<td></td>
<td>(0.0316)</td>
<td>(0.0315)</td>
<td>(0.0318)</td>
<td>(0.0322)</td>
</tr>
<tr>
<td>$\Delta \text{Pro}d$</td>
<td>0.285***</td>
<td>0.337***</td>
<td>0.267***</td>
<td>0.321***</td>
</tr>
<tr>
<td></td>
<td>(0.0269)</td>
<td>(0.0237)</td>
<td>(0.0276)</td>
<td>(0.0250)</td>
</tr>
<tr>
<td>$\Delta CPI$</td>
<td>0.207***</td>
<td></td>
<td></td>
<td>0.197***</td>
</tr>
<tr>
<td></td>
<td>(0.0337)</td>
<td></td>
<td></td>
<td>(0.0340)</td>
</tr>
<tr>
<td>$U$</td>
<td>-0.295***</td>
<td>-0.289***</td>
<td>-0.293***</td>
<td>-0.308***</td>
</tr>
<tr>
<td></td>
<td>(0.0682)</td>
<td>(0.0655)</td>
<td>(0.0681)</td>
<td>(0.0662)</td>
</tr>
<tr>
<td>$U^2$</td>
<td>0.00485*</td>
<td>0.00556**</td>
<td>0.00647**</td>
<td>0.00734***</td>
</tr>
<tr>
<td></td>
<td>(0.00249)</td>
<td>(0.00236)</td>
<td>(0.00255)</td>
<td>(0.00253)</td>
</tr>
<tr>
<td>$U \times \text{Trend}$</td>
<td>-0.00237***</td>
<td></td>
<td>-0.00162*</td>
<td></td>
</tr>
<tr>
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<td>(0.000847)</td>
<td></td>
<td>(0.000844)</td>
<td></td>
</tr>
<tr>
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<td>2.214***</td>
<td>2.161***</td>
<td>2.231***</td>
<td>2.379***</td>
</tr>
<tr>
<td></td>
<td>(0.399)</td>
<td>(0.430)</td>
<td>(0.399)</td>
<td>(0.445)</td>
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</tbody>
</table>

**Notes:** *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel. Arellano-Bover estimator.
### Table 5.7: Results IV

<table>
<thead>
<tr>
<th>VARIABLES</th>
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<th>(2) Union</th>
<th>(3) EPL</th>
<th>(4) EPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-1) )</td>
<td>0.585***</td>
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<td>0.519***</td>
</tr>
<tr>
<td></td>
<td>(0.0300)</td>
<td>(0.0301)</td>
<td>(0.0281)</td>
<td>(0.0282)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-2) )</td>
<td>0.0646*</td>
<td>0.135***</td>
<td>0.0887***</td>
<td>0.153***</td>
</tr>
<tr>
<td></td>
<td>(0.0377)</td>
<td>(0.0375)</td>
<td>(0.0341)</td>
<td>(0.0340)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-3) )</td>
<td>0.0289</td>
<td>0.107**</td>
<td>-0.0196</td>
<td>0.0321</td>
</tr>
<tr>
<td></td>
<td>(0.0423)</td>
<td>(0.0430)</td>
<td>(0.0389)</td>
<td>(0.0394)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-4) )</td>
<td>-0.230***</td>
<td>-0.208***</td>
<td>-0.241***</td>
<td>-0.164***</td>
</tr>
<tr>
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<td>(0.0363)</td>
<td>(0.0382)</td>
<td>(0.0339)</td>
<td>(0.0350)</td>
</tr>
<tr>
<td>( \Delta \text{Prod} )</td>
<td>0.302***</td>
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<td>0.222***</td>
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<td>(0.0315)</td>
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<td>(0.0271)</td>
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<tr>
<td>( \Delta \text{CPI} )</td>
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<td>0.223***</td>
<td></td>
<td>0.239***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0492)</td>
<td></td>
<td>(0.0369)</td>
</tr>
<tr>
<td>( U )</td>
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<td>-0.380***</td>
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<td>-0.348***</td>
</tr>
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<td>(0.110)</td>
<td>(0.109)</td>
<td>(0.0687)</td>
<td>(0.0683)</td>
</tr>
<tr>
<td>( U^2 )</td>
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<td>0.00864***</td>
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</tr>
<tr>
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<td>(0.00476)</td>
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<td>( U \ast \text{Trend} )</td>
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<tr>
<td>( \Delta \text{Union} \ast U )</td>
<td>0.00351***</td>
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<tr>
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<td>(0.000959)</td>
<td>(0.000929)</td>
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<td>( \Delta \text{EPL} )</td>
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<td>-0.112</td>
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<td></td>
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</tr>
<tr>
<td>( \Delta \text{EPL} \ast U )</td>
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<td>0.0732***</td>
<td>0.0266*</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(0.0156)</td>
<td>(0.0153)</td>
<td></td>
</tr>
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<td>( \text{Constant} )</td>
<td>2.349***</td>
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<td>2.889***</td>
</tr>
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<td>(0.467)</td>
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<td>590</td>
</tr>
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<td>Number of countries</td>
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<td>12</td>
<td>12</td>
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</tr>
</tbody>
</table>

Notes: *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel. Union coverage (Union) and employment protection legislation (EPL) not available for full sample. Arellano-Bover estimator.
### Table 5.8: Results IV

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Temp.</th>
<th>(2) Temp.</th>
<th>(3) LTU</th>
<th>(4) LTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-1) )</td>
<td>0.594***</td>
<td>0.566***</td>
<td>0.606***</td>
<td>0.560***</td>
</tr>
<tr>
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<td>(0.0257)</td>
<td>(0.0258)</td>
<td>(0.0251)</td>
<td>(0.0253)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-2) )</td>
<td>0.0965***</td>
<td>0.155***</td>
<td>0.109***</td>
<td>0.156***</td>
</tr>
<tr>
<td></td>
<td>(0.0325)</td>
<td>(0.0323)</td>
<td>(0.0320)</td>
<td>(0.0316)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-3) )</td>
<td>0.0174</td>
<td>0.0589</td>
<td>0.0201</td>
<td>0.0550</td>
</tr>
<tr>
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<td>(0.0372)</td>
<td>(0.0377)</td>
<td>(0.0367)</td>
<td>(0.0369)</td>
</tr>
<tr>
<td>( \Delta w_{\text{real/nom.}}(-4) )</td>
<td>-0.231***</td>
<td>-0.157***</td>
<td>-0.222***</td>
<td>-0.145***</td>
</tr>
<tr>
<td></td>
<td>(0.0314)</td>
<td>(0.0325)</td>
<td>(0.0311)</td>
<td>(0.0323)</td>
</tr>
<tr>
<td>( \Delta Proc )</td>
<td>0.296***</td>
<td>0.331***</td>
<td>0.327***</td>
<td>0.359***</td>
</tr>
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<td>(0.0276)</td>
<td>(0.0252)</td>
<td>(0.0284)</td>
<td>(0.0257)</td>
</tr>
<tr>
<td>( \Delta CPI )</td>
<td>0.219***</td>
<td>0.183***</td>
<td></td>
<td></td>
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Notes: *** 1%; ** 5%; * 10% significance. Robust standard errors in parentheses. Maximum data range: 1999 Q1-2013 Q4. Unbalanced panel. Share of temporary contracts (Temp) and share of long-term unemployed (LTU) not available for full sample. Arellano-Bover estimator.
Table 5.9: Results FEVD

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<th>(4) EPL $\Delta w_{nominal}$</th>
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Bibliography


Summary

In this dissertation we study labour markets, pension systems, and the interaction between the two.

In the second chapter we study the effects of fiscal changes in an overlapping generations model. The model features imperfect annuities, real world demographics and a realistic productivity profile. We find that, even though tax revenue is redistributed in a lump sum fashion, both a consumption tax hike and a labour tax hike lower lifetime utility for almost all generations. A labour tax increase that returns the same amount in discounted tax revenue as a consumption tax increase reduces welfare more. This confirms the notion that labour taxes are more distorting than consumption taxes. Announcing the aforementioned tax hikes reduces variation between generations. However, even though differences between generations can be significant, social welfare does not differ significantly between announcing and not announcing the tax change. Finally we find that a tax swap — replacing part of the labour tax with a higher consumption tax — makes all newborn generations better off. However, during transition it opens up a welfare gap between the retired, who are worse off, and the working, who are better off. This negative effect can be offset by an appropriate redistribution (towards the old) of tax income by the government. Therefore, a tax swap in combination with a skewed redistribution scheme can be Pareto improving.

In the third chapter we study the intergenerational effects of unemployment caused by wage rigidity on the accumulation of pension entitlements. A negative shock combined with wage rigidity can lead to large groups of (mainly) young being excluded from employment over the course of a crisis. Certain cohorts are therefore stuck with relatively low income and low pension entitlement accumulation for a large part of their lives. Other cohorts on the other hand are largely shielded from the shock, enjoying steady wages in combination with a sustained build up of pension rights.

We build an overlapping generations model with three generations (two working and one retired) in which unions, representing each cohort sequentially, set the wages for a certain cohort before this cohort enters the labour market. Firms pick the employment level once the state of the economy is known. The interaction between the pension system and the labour market is limited in the case of a technology shock. The pension system has a significant effect on steady state outcomes of labour market variables; but because wages are pre-determined pension systems matter less for the transitional dynamics. The shock is largely reflected in labour market outcomes which do not differ significantly across pension systems.

The fourth chapter analyses euro area Beveridge curves over the past 25 years, at both the aggregate euro area level and at country level, focusing in particular on Beveridge curve developments since the onset of the global financial crisis. The aim is to identify deviations from the pre-crisis Beveridge curves and to isolate salient structural factors influencing these movements.

We apply an autoregressive distributed lag (ARDL) model to test for statistical significance of observed shifts and changes in the slope of the Beveridge curve(s). We find a significant outward shift of the aggregate euro area Beveridge curve and of the Beveridge curves for Spain and France since the onset of the crisis, but an inward shift for Germany. We then extend our analysis in order to examine factors underlying the observed developments. A range of country-specific factors — including labour force characteristics, sec-
Summary

toral employment composition and financial conditions — are tested using the local projections method. We find evidence for skill mismatch and tentative evidence for sectoral and geographical mismatch.

In the fifth and final chapter we estimate wage equations to test for changes in the responsiveness of wages to unemployment using euro area panel estimates. The objective of this chapter is to improve our understanding of the effect of rising unemployment on the evolution of wages, and also to identify the possible causes behind changes in responsiveness during the recent crisis period. We estimate equations where wage growth is explained by inflation, productivity growth and unemployment and test various hypotheses by extending this basic specification.

Our empirical results suggest evidence of lower responsiveness of wages at high levels of unemployment in the euro area (wage rigidity). This result applies to all downturns, even though wage responsiveness has somewhat recovered as the recent crisis became more protracted. Additionally, we find that differences in bargaining position — in particularly differences between unionised vs. non-unionised labour and permanent vs temporary jobs — explain a large part of the downward wage rigidity. Perhaps surprisingly a larger share of long term unemployment tends to decrease wages. However, this effect is reversed at high levels of unemployment. Other findings show that a higher share of temporary workers lowers overall wage growth but this effect is also partially reversed during downturns.
Samenvatting

In dit proefschrift bestuderen we arbeidsmarkten, pensioensystemen en de interactie tussen arbeidsmarkten en pensioensystemen.

In het tweede hoofdstuk bestuderen we de effecten van belastingveranderingen in een overlapping generations model. Ons model bevat onvolledige annuïteiten, een realistische demografie en een realistisch productiviteitsprofiel. We simuleren twee soorten belastingverhogingen: een BTW verhoging en een loonbelasting verhoging. Onze resultaten laten zien dat beide belastingverhogingen het totale nut van bijna alle cohorten verlagen, ondanks het op forfaitaire wijze hervertellen van belastinginkomsten. Een verhoging van de loonbelasting verlaagt de welvaart meer dan een BTW verhoging met dezelfde opeenbrengst. Dit bevestigt het idee dat loonbelasting verstorend is dan BTW. Een van tevoren aangekondigde belastingverhoging vermindert de variatie in nut tussen cohorten. Maar deze verschillen tussen het wel of niet aankondigen van een belastingverhoging zijn niet terug te vinden in een significant verschil in welvaart. Tot slot laten de resultaten zien dat alle nieuwgeboren cohorten baat hebben bij een belastingverschuiving (het verlagen van de loonbelasting en het verhogen van de BTW om belastinginkomsten constant te houden). Maar tijdens het aanpassen van de belastingen heeft de belastingverschuiving een negatief effect op gepensioneerden. Dit negatieve effect kan echter opgeheven worden doormiddel van een herverdeling die de oudere generatie bevoordeelt. Een belastingverschuiving met de juiste herverdeling kan dus een Pareto verbetering zijn.

In het derde hoofdstuk bestuderen we de intergenerationele effecten van werkloosheid (veroorzaakt door loonrigiditeit) op de opbouw van pensioenrechten. In een crisis kunnen vaak grote groepen (vooral) jonger moeilijk werk vinden. Bepaalde cohorten kunnen daarom blijven steken in laagbetaalde banen met lage pensioen opbouw. Aan de andere kant zijn er cohorten die wel al werk hebben en die minder last hebben van de crisis doordat lonen rigide zijn en pensioenopbouw voortgezet wordt.

We zetten een overlapping generations model op met drie generaties (twee werkend en een gepensioneerd) waarin vakbonden voor elk cohort apart de lonen bepalen voordat dit cohort de arbeidsmarkt opgaat. Bedrijven bepalen uiteindelijk de arbeidsvraag op het moment dat de staat (technologie) van de economie bekend is geworden. De interactie tussen het pensioensysteem en de arbeidsmarkt is beperkt in het geval van een technologie schok. Het pensioensysteem heeft een significant effect op de evenwichtswaarden van de arbeidsmarkt variabelen maar omdat lonen vooraf bepaald worden heeft het pensioensysteem niet veel invloed op de aanpassingspaden. De technologie schok is voor het grootste deel terug te zien in de uitkomsten voor de arbeidsmarkt; deze uitkomsten verschillen niet veel tussen de verschillende pensioensystemen.

Het vierde hoofdstuk bestudeert de Beveridge curve van de eurozone van de afgelopen 25 jaar. We bestuderen de Beveridge curve zowel voor de totale eurozone als voor elk land afzonderlijk. We zijn vooral geïnteresseerd in de ontwikkeling van de Beveridge curve sinds het uitbreken van de financiële crisis. Het doel is om verschillen tussen de Beveridge curve van voor de crisis en de Beveridge curve van na de crisis te onderzoeken en om de belangrijkste structurele factoren die aan deze verschillen ten grondslag liggen te identificeren.

We zetten een autoregressive distributed lag (ARDL) model op om significante afwijkingen van de pre-crisis Beveridge te identificeren. We vinden een significante verslechtering van de positie van de Beveridge curve voor de totale eurozone en voor de Beveridge curve
Samenvatting

van Spanje en Frankrijk. Aan de andere kant is de positie van de Duitse Beveridge curve verbeterd. Om de structurele verschillen die hieraan ten grondslag liggen te identificeren gebruiken we een local projections methode waarin we testen voor het effect van karakteristieken van de beroepsbevolking, werkgelegenheidsverdeling per sector en financiële condities op de positie van de Beveridge curve. We vinden bewijs voor een discrepantie tussen gevraagde en aangeboden kwalificaties en bewijs voor discrepantie tussen sectoren en locatie van arbeidsvraag en arbeidsaanbod.

In het vijfde en laatste hoofdstuk schatten we loonvergelijkingen waarin we testen voor veranderingen in responsiviteit van lonen ten opzichte van werkloosheid in een panel van eurozone landen. Het doel van het hoofdstuk is om inzicht te krijgen in hoe stijgende werkloosheid lonen beïnvloedt en om mogelijke factoren te identificeren die een verandering in responsiviteit kunnen veroorzaken. We schatten loonvergelijkingen waarin loongroei bepaald wordt door inflatie, productiviteitsgroei en werkloosheid en we testen verschillende hypotheses door deze simpele specificatie uit te breiden.

Onze empirische resultaten suggereren dat lonen minder op werkloosheid reageren als werkloosheid hoog is (loonrigiditeit). Deze resultaten gelden voor alle recessies, al lijkt het erop dat lonen iets meer reageerden tijdens de laatste crisis naarmate de crisis voortduurde. Verschillen in onderhandelingspositie blijken een groot deel van de loonrigiditeit verklaren. Vooral verschillen tussen vakbondswerk en niet vakbondswerk en tijdelijk en vast werk zijn belangrijke factoren. Het lijkt erop dat een groter gedeelde langdurig werklozen (als deel van totale werkloosheid) lonen verlaagt, al wordt dit voor een deel teniet gedaan als werkloosheid hoog is. Tot slot vinden we dat een groter gedeelde tijdelijke arbeid (als deel van totale werkgelegenheid) lonen drukt maar ook dit wordt voor een deel teniet gedaan als werkloosheid hoog is.