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## Essays on dynamic macroeconomics

Romp, Willem Eduard

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## Chapter 1

# Introduction

The trade-off between welfare of future and current generations is one of the key issues in macroeconomic research (Royal Swedish Academy of Sciences, 2006). Economists and policy makers have long realised that many decisions have a dynamic and intergenerational nature and that merely focusing on either the immediate effects or – at the other extreme – the long-run effects of different policy options does not reveal potentially important transitory effects. To understand the implications of supposedly welfare enhancing decisions made today, we must know what the effects are on economic performance, *and* who reaps the rewards.

Dynamic macroeconomics is by now a well-developed field. Just a few of the questions that have been studied are how to optimise economic growth (e.g. Phelps, 1961), what the determinants of economic growth are (e.g. Barro, 1991 and Sala-i-Martin, 1997) and how different generations interact (e.g. Diamond, 1965).

This dissertation covers two of the many different aspects of dynamic macroeconomics. Part I focuses on the role of demographics and demographic changes as one of the determinants of intergenerational transfers. Part II looks at the impact of public capital on economic growth. Both parts are self-contained and can for this reason be read separately.

## 1.1 Realistic demographics in overlapping generations models

Death is the only certainty in life. Unfortunately, for planning purposes, most of us do not know when the Grim Reaper will make his one and final call. The microeconomic implications of this *lifetime uncertainty* were first studied in the context of a

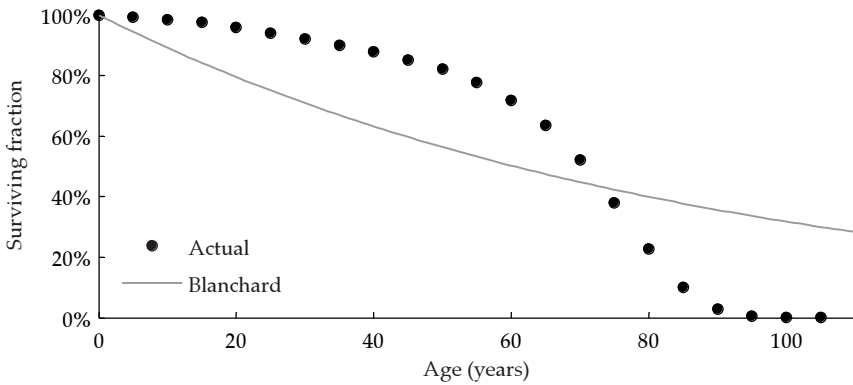
dynamic consumption-saving model by Yaari (1965). He showed that, faced with a positive mortality rate, individual agents will discount future felicity more heavily due to the uncertainty of survival. Furthermore, with lifetime uncertainty the consumer faces not only the usual solvency condition ('living within one's means') but also a constraint prohibiting negative net wealth at any time – the agent is simply not allowed by capital markets to die indebted. To solve this problem, Yaari assumes that an individual can purchase (annuity) or sell (life insurance) actuarial notes at an actuarially fair interest rate. A 'rational' individual will use such notes to fully insure itself against the adverse effect of lifetime uncertainty.

Yaari's insights were embedded in a general equilibrium growth model by Blanchard (1985). Because of its flexibility, the Blanchard-Yaari model and the closely connected Buiter (1988) and P. Weil (1989) model have achieved workhorse status in macroeconomic analysis during the last two decades. One typical area of application of these models is intergenerational welfare analysis of various policies (e.g. Bovenberg, 1993, 1994, and Bettendorf and Heijdra, 2001a). Other areas where the Blanchard-Yaari models have been used are demographic change and economic growth (e.g. de la Croix and Licandro, 1999; Kalemni-Ozcan et al., 2000), and social security and ageing (e.g. Bettendorf and Heijdra, 2006). Most intermediate and advanced macroeconomic textbooks nowadays contain a description of the Blanchard-Yaari overlapping generations models (e.g. Blanchard and Fischer, 1989 and Heijdra and van der Ploeg, 2002).

Although the Blanchard-Yaari framework is quite flexible, it has at least one major drawback. In order to allow for exact aggregation of individual decision rules, Blanchard simplified the Yaari model by assuming a constant death probability, i.e. the probability of dying does not depend on the age of the individual. A direct implication of this assumption is that individuals enjoy a perpetual youth. No matter what their age is, the expected remaining lifetime remains the same. This makes exact aggregation of individual choices possible since the propensity to consume out of total wealth is the same for everybody. This propensity to consume is age-independent because everybody faces the same mortality rate and expected remaining lifetime and uses the same mortality-risk adjusted discount factor.

Figure 1.1 shows the fit of the predicted surviving fraction of a of Blanchard's perpetual youth model. The stars denote the observed – and for the ages above 85 the predicted – surviving fraction of the cohort born in the Netherlands in 1920. The line shows the best possible fit of Blanchard's surviving fraction. The figure clearly shows the poor fit of Blanchard's perpetual youth model. Of the cohort under con-

Figure 1.1. Actual versus estimated survival fractions for Blanchard's perpetual youth model



Notes: Data for the cohort born in the Netherlands, 1920 (male and female). Observed survival rates for ages 0–85, projected survival rates otherwise. *Source:* Human Mortality Database (2006) and own calculations.

sideration, 70% actually reached the age of 60; according to the perpetual youth model, only 50% should have survived that long. After 77 years, the perpetual youth model grossly overestimates the surviving fraction. According to the demographic projections, only 0.03% of the 1920-cohort will reach the age of 100, whereas the perpetual youth model predicts 30%! Blanchard's modelling dilemma is clear: exact aggregation is 'bought' at the expense of a rather unrealistic description of the demographic process. Of course, in a closed-economy context the aggregation step is indispensable because equilibrium factor prices (wages and interest rates) are determined in the aggregate factor markets. However, in the context of a small open economy, factor prices are typically determined in world markets so that the aggregation step is not necessary.

The main objective in Part I of this dissertation is to extend the standard overlapping generations (OLG) model of a small open economy with a realistic demographic process, to compare the results of the extended OLG-model with the results of the standard perpetual youth model, and finally to use our extended OLG model to analyse the effects of ageing shocks on economic growth and retirement. In Chapter 2 we show that, provided we restrict attention to the case of a small open economy, it is quite feasible to construct and analytically analyse a Blanchard-Yaari type overlapping-generations model with a realistic description of the mortality process. One main effect of a realistic mortality process is that it results in a

humped shaped savings profile, as in Modigliani's classic life cycle model.

As in Blanchard's OLG model, it is possible to analytically determine the steady state comparative effects of our extended model. Our comparative static analysis shows that the long-run effects are qualitatively equal to the effects in the standard Blanchard-Yaari models. However, there are major differences in the transition paths. We show that a realistic mortality process gives rise to drastically different impulse-response functions associated with various macroeconomic shocks. The transition period of our more realistic model is much shorter than in the standard Blanchard-Yaari models. These old models sometimes predict transition periods of one, maybe two centuries, in our models this time is reduced to 40 to 60 years. This is because in our models individuals age as time goes by. During the transition periods, the fluctuations are larger than in the standard models, sometimes even twice as large.

Chapters 3 and 4 use the framework developed in Chapter 2 to study two questions. In Chapter 3 we introduce a schooling decision. Following *inter alia* Bils and Klenow (2000), and Kalemni-Ozcan et al. (2000) agents engage in educational activities at the start of life and thus create human capital to be used later on in life for production purposes. Individuals have no preference for either school or work, so utility maximisation ensures that the schooling period is chosen in such a way that it maximises the present value of after tax income. The schooling externality is based on the 'standing on the shoulders of'-type as proposed by Azariadis and Drazen (1990). The effect of schooling on an individual's knowledge and earnings potential depends on the knowledge of the teacher. An individual's education decision affects future generations because the students of today are tomorrow's teachers. Depending on the strength of the intergenerational externality in the accumulation of knowledge, the model gives rise to exogenous growth or, in a knife-edge case, endogenous growth.

We then use this model to analyse the effects of demographics shocks, i.e. a longevity shock and a baby bust, on the main economic indicators like economic growth during transition and in the long run. Even though the model is more complex than the basic model in Chapter 2, we are still able to analytically characterise the long-run effects. One of the more surprising results is that there is a highly non-linear, even non-monotonic relation between longevity and economic growth; lower mortality may lead to lower per capita growth, even in the long run. Depending on the type of shock, a change in the mortality process or in the birth rate, economic growth changes gradually or with jumps. In both cases the transition

process is non-monotonic and the transition periods extend over decades or even centuries. This may explain the results of Kelley and Schmidt (1995). Based on a panel consisting of 89 countries and covering 30 years they found that the link between population growth, birth rates and the mortality process changes over time and the transition profile depends heavily on the type of demographic shock.

In Chapter 4 we extend the basic framework of Chapter 2 with a retirement decision similar to the one proposed by Sheshinski (1978), and a pension system. We use this model at a microeconomic level to study the effects of ageing shocks and public pension system reforms on the retirement decision of an individual who faces lifetime uncertainty. We extend the literature in two directions. First, we show how to transform the individual optimisation problem into a problem with a convenient and intuitive graphical representation. As always, a two dimensional visualisation of the originally infinite dimensional optimisation problem greatly simplifies the comparative static analysis. Using this graphical apparatus we can easily explain why most people in the Western world retire at the youngest age that (early) retirement benefits become available and why the optimal retirement age seems to be insensitive to fiscal stimuli (Gruber and Wise, 1999; Duval, 2003). Second, we show the analytical comparative static effects that describe how rational individuals will react to demographic shocks and fiscal stimuli of the pension system.

We use our retirement model at the macroeconomic level to determine the required system reforms to keep the pension systems sustainable in the long run. In the current ageing societies of the Western world, the sustainability of the social security and retirement systems is questionable (Gruber and Wise, 1999, 2004, 2005; OECD, 1998, 2005). The problem is twofold. On the one hand, people live longer but do not tend to work longer. This increases the number of people that receive old age benefits. On the other hand, due to lower birth rates, the number of productive people decreases. The pressure on the retirement system calls for reforms, usually painful ones (see Lindbeck and Persson, 2003 for a literature overview).

Confronting our model with demographic shocks of the type and magnitude that have hit the Western world in the post-war period, we find some remarkable results. First, a baby bust immediately puts pressure on the pension system, whereas the effects of a mortality shock only show up after 60 years. Second, the negative welfare effects are much smaller if the policy reform includes raising the retirement age instead of only raising tax revenues.

Two main conclusions can be drawn from Part I. First, we cannot ignore the

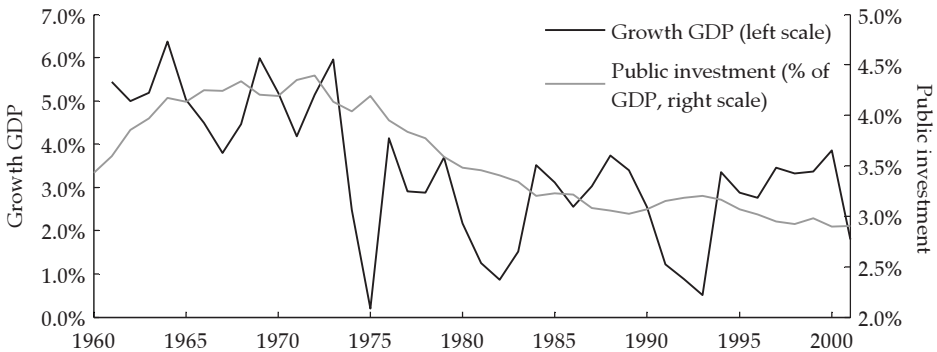
transitional dynamics in OLG models. The transition periods are usually very long and the transition paths are non-monotonic. Focusing solely on the comparative statics implies that one neglects the interests of the people that live during the transition period. Second, it is quite feasible to extend the standard Blanchard-Yaari type OLG models for the small open economy with a realistic description of the mortality process and the demographic realism matters. The extended models predict very different impulse-response functions, on both the individual and the aggregate level and, maybe even more important, different welfare effects.

## 1.2 Public capital and economic growth: an empirical analysis

In Part II of this dissertation we ignore intergenerational issues and focus entirely on public capital, one of the determinants of economic growth. Public capital, and especially infrastructure, is central to the activities of households and firms. According to the World Bank (1994), public capital represents the ‘wheels’ – if not the engine – of economic activity. Input-output tables for example show that telecommunications, electricity, and water are used in the production process of nearly every sector, while transport is an input for every commodity.

As Gramlich (1994) notes, it is surprising how long economists have ignored the impact of infrastructure on aggregate productivity. Macroeconomists have long felt that the stock of public capital is an important factor input in the production of total output, but no one had empirically linked the movements of infrastructure and productivity until Aschauer (1989). In his seminal contribution Aschauer estimated the output elasticity of public capital and concluded that a 10 percent increase of the public capital stock resulted in a 4 percent increase in total output, an output elasticity of 40%! His paper hit a magic button and ever since a substantive research effort focused on estimating the contribution of public capital to the productivity of private factors and to economic growth. A reason why Aschauer’s work received this much attention is that it provided an explanation for the productivity slowdown of the 1970s and 1980s in the US, as well in other OECD countries. As Figure 1.2 shows, average output growth in 22 OECD countries (left scale) dropped dramatically in the 1970s. The drop in output growth more or less coincides with a reduction of public investment (right scale). The policy message was simple: increase public capital spending to stimulate productivity. A message loved by policy makers (Gramlich, 1994).

Figure 1.2. Average economic growth and public investment in 22 OECD countries



Source: Kamps (2006) and own calculations.

However, several economists questioned Aschauer's estimates on the grounds that they were implausibly high (see, for instance, Gramlich, 1994). Furthermore, the early studies were fraught with methodological and econometric difficulties. Issues ranking high on the list of potential problems include reverse causation from productivity to public capital and a spurious correlation due to non-stationarity of the data. In their survey of the earlier literature, Sturm et al. (1998) show that the literature contained a relatively wide range of estimates, with a marginal product of public capital that is much higher than that of private capital (e.g., Aschauer, 1989), roughly equal to that of private capital (e.g., Munnell, 1990a), well below that of private capital (e.g., Eberts, 1986) and, in some cases, even negative (e.g., Hulten and Schwab, 1991). The wide range of estimates makes the results of these older studies almost useless from a policy perspective.

The contribution of the second part of this dissertation is twofold. Chapter 5 provides an up-to-date overview of the modern empirical literature on public capital and economic growth. Chapter 6 provides new estimates of the growth-enhancing effects of public capital and tests whether one of the main tools in the literature on growth enhancing effects of public capital, the production function approach, can actually provide robust estimates.

In our survey in Chapter 5 we focus on two questions. First, can a robust empirical relationship be found that an increase in public capital spurs economic growth? And second, to what extent do conclusions on the effect of increases of public capital change once it is taken into account that infrastructure construction diverts re-



sources from other uses. We observe that most studies have tackled the methodological issues that hampered the early literature and that there seems to be more consensus in the more recent literature about the effects of public capital on economic performance. Most recent studies generally suggest that public capital may, under specific circumstances, raise real income per capita.

Another conclusion of our survey is that estimates of the impact of infrastructure investment on economic growth differ substantially, depending on the countries and time period covered, the level of aggregation and the econometric methods employed. In Chapter 6 we attempt to arrive at a set of robust estimates of the output elasticity of public capital using internationally comparable aggregate and industry data for a considerable number of developed countries and a substantial number of years.

As mentioned by Munnell (1992), many studies use growth rates to identify the effect of infrastructure on productivity, thereby destroying the long-run relationship. Infrastructure investment however mostly consists of projects with long durations and effectiveness. In Chapter 6 we use the Pooled Mean Group (PMG) estimator proposed by Pesaran et al. (1999) that avoids this problem by identifying the long-run relationship between variables in an error-correction framework. In cross-country and cross-industry estimates, efficiency gains are possible by restricting the parameter of interest to be equal across countries and/or industries. However, the PMG estimator only restricts the long-run parameter to be the same across countries or industries, while allowing for heterogeneity in the adjustment to this long run.

Chapter 6 contains estimates of the impact of infrastructure on economic growth based both on aggregate and industry data. But while data and econometric methodology are state-of-the-art and counter much, if not all, criticism raised in this literature, stable output elasticity estimates are elusive. Indeed, the estimated parameters of the output elasticities at the industry level vary wildly between equally plausible econometric specifications, ranging from -2 to 2. The aggregate estimates tend to be more stable, but even here, output elasticities range between 0.04 and 1.13. While it is hard to discount cross-country variation, the cross-specification variation we find suggests extreme sensitivity to conceptually innocuous specification choices. Overall, this suggests that production function estimates of the impact of infrastructure are not well-suited to be used for infrastructure policy recommendations.