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2 Introduction

This paper investigates the empirical and theoretical relationship between saving and demographic structure. Canonical theoretical results, such as the life-cycle/permanent income hypothesis (LC/PIH), suggest that, in the absence of inter-generational consumption-sharing mechanisms other than individual saving, there should be a strong relationship between age and saving behaviour. Very young individuals should borrow against future income; those in middle age should save, while the old should liquidate their savings, all to support a steady level of permanent consumption over their whole lives. This, in turn, implies that there should be a robust relationship between demographic structure and aggregate savings rates, and between demographic change and the returns on financial assets, particularly if the capital stock of the economy – and hence the quantity of financial assets – is fixed.

Micro-economic survey data partly support the predictions of the LC/PIH, at least for individual savings rates: in most countries, these peak in late middle age (between 40 and 60 years of age). However, besides the dissaving caused by annuities and defined benefit pensions, the evidence that old people dissave to support their consumption is limited. Also, few people appear to borrow to sustain their consumption when they are very young. At a macro-economic level, there is evidence that aggregate national savings rates are affected by demographic structure, with countries that have a high proportion of working-age people having higher savings rates. However, demographic structure does not, by itself, explain a significant fraction of the differences in savings behaviour between different countries. In some studies, demographic structure explains as little as 11% of the variation in savings rates across countries (Weil 1994). Finally, there appears to be little empirical support for theoretical predictions of the LC/PIH for returns on financial assets: researchers have struggled to find a significant relationship between changes in demographic structure and the rate of return on financial assets.

Besides statistical issues, part of the explanation may lie in the fact that individual saving is only one mechanism by which individuals are able to smooth consumption over their lives. Kotlikoff and Summers (1981) first raised the issue of transfer wealth in the context of the LC/PIH. Using the framework developed by the National Transfer Accounts (NTA) project, we calculate tentative comprehensive wealth accounts by generation, using a framework called Generational Wealth Accounting (GWA), for four European countries. These quantify the relative importance of three channels in supporting future consumption: private saving, public transfer systems, such as publicly-provided old-age pensions, medical and educational expenditure, and private transfers, such as bequests and *inter vivos* transfers. Our results provide some explanation for the weak empirical relationship between savings rates and demographic structure: individual savings are *not* the most important channel by which individuals smooth consumption over their lives, at least in the countries we examine. Public transfers are, arguably, the most important, while private transfers are also significant. These transfer systems are much more highly dependent on demographic structure than private saving or the returns earned on financial assets.

In section 2 we review the LC/PIH from a theoretical perspective, focusing on both micro- and macro-economic implications of the hypothesis presented in its simplest form, as well as the implications of the LC/PIH for the relationship between the returns on financial assets and changes in demographic structure. In section 3 we examine empirical evidence in favour of, and against, the LC/PIH at both a macro- and a micro-economic level, including evidence on the relationship between financial asset returns and demographic structure. While there does appear to be a strong relationship between age and savings behaviour, demographic structure at the macro-economic level only explains a small portion of the variation in savings rates across countries. Further, the empirical relationship between demographic structure and asset returns is weak. The NTA framework, which we present in section 4, shows that financial markets, public and private transfer systems all play an important role in smoothing consumption across the life cycle. In section 5, we explain how McCarthy *et al* (2015) use the NTA framework to generate forward-looking measures of the relative and absolute importance of the different consumption-smoothing mechanisms to different generations, called Generational Wealth Accounting (GWA). Tentative sample generational wealth accounts are presented for four European countries: Austria, Slovenia, Spain and the UK. Our results illustrate the importance of both public and private transfers in smoothing consumption, supporting our contention that incorporating public and private transfers into the LC/PIH is vital. Our results allow the relative importance of asset markets, public transfers and private transfers in supporting future consumption to be quantified for the first time, giving a comprehensive picture of all consumption-smoothing mechanisms. The final section presents concluding comments.

3 The life-cycle or permanent income hypothesis: theoretical implications[1]

Much economic analysis of the relationship between age and savings starts with the Life Cycle or Permanent Income Hypothesis (LC/PIH), developed independently by Modigliani and Brumberg (1954) and Friedman (1956). It posits people choosing a consumption profile over their lives that maximises their expected discounted utility of their future consumption, making the crucial assumption that individuals can only smooth consumption by freely saving and dissaving through the capital markets. One consequence is that consumption should change independently of earnings. The slope of the consumption path will depend only on the relative values of the return on savings and the individual's subjective discount rate. A higher rate of return on savings will raise the rate of consumption growth, and a higher subjective discount rate will lower it, all else equal. The level of the consumption path at any point will then depend only on current wealth plus the expected discounted present value of future earnings, as well as on its future slope. With labour income following a hump-shaped profile – empirically, labour income typically starts at zero, increases rapidly with age until around age 40, then levels off, ultimately falling back to zero after retirement – a second consequence of the LC/PIH is that there should be strong age-related effects on saving. Very young individuals will borrow to sustain their consumption, those in middle age will save in anticipation of reaching retirement, while those already retired will dissave. Younger individuals should then accumulate financial debt, which they will pay off in early middle age. From some point, financial wealth should rise rapidly until retirement. Once individuals have retired, financial wealth should fall as individuals dissave to support consumption. A stylised picture of the labour

[1] The theoretical and empirical literature review in this and the subsequent section rely heavily on prior work by one of the authors and Anthony Neuberger (McCarthy and Neuberger, 2003). Readers of this paper are referred to that monograph for a more comprehensive discussion.

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income, life cycle consumption and implied financial wealth predicted by the LC/PIH is shown in Figure 1.

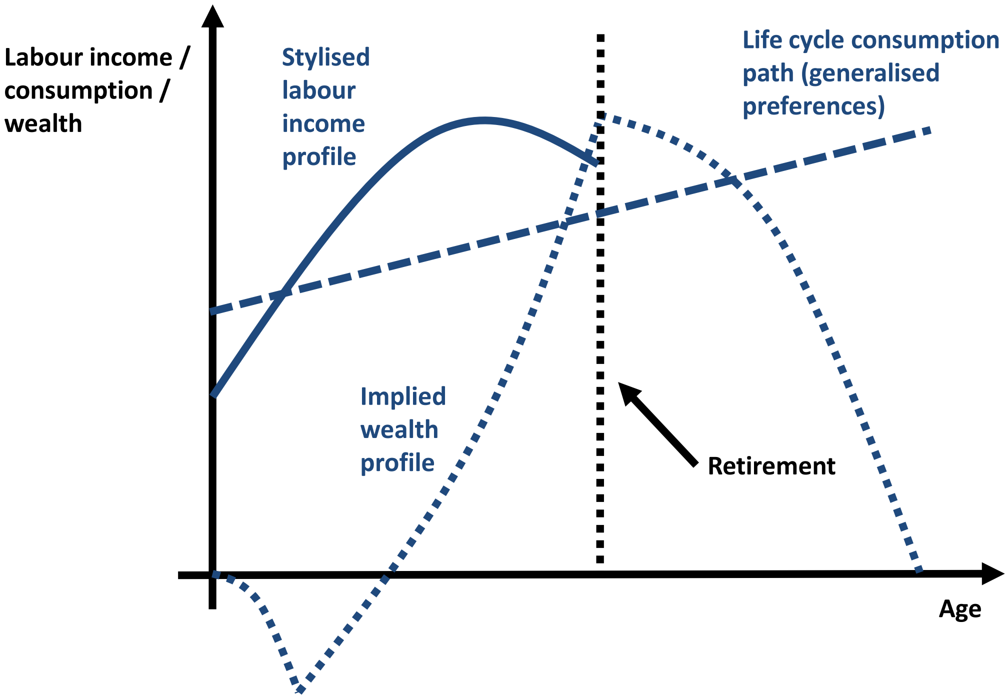

Figure 1: A stylised picture of the life-cycle/permanent income hypothesis

Such a simple insight has some significant implications. On a micro-economic scale, the LC/PIH implicitly divides wealth into two parts: human capital wealth (the expected discounted present value of future wages) and financial wealth (accumulated savings or borrowings). If individuals start out with no financial wealth, as many young people do, and consume in line with the pure LC/PIH, the stylised implication of the model for the composition of total wealth over the life cycle between human capital wealth and financial wealth is shown in Figure 2.

By assumption, at the start of life all wealth is in the form of human capital. In the first few years, wages are less than consumption, with the difference

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financed by borrowings, so financial wealth becomes negative. Over time, wages rise, and at some point, exceed consumption. From this point onwards, past debt is paid down and financial assets are accumulated. Over time, the proportion of total wealth made up of human capital falls, and the proportion made up of financial wealth rises. On retirement, human capital wealth is fully depleted, and from that point on, wealth is made up only of financial wealth.

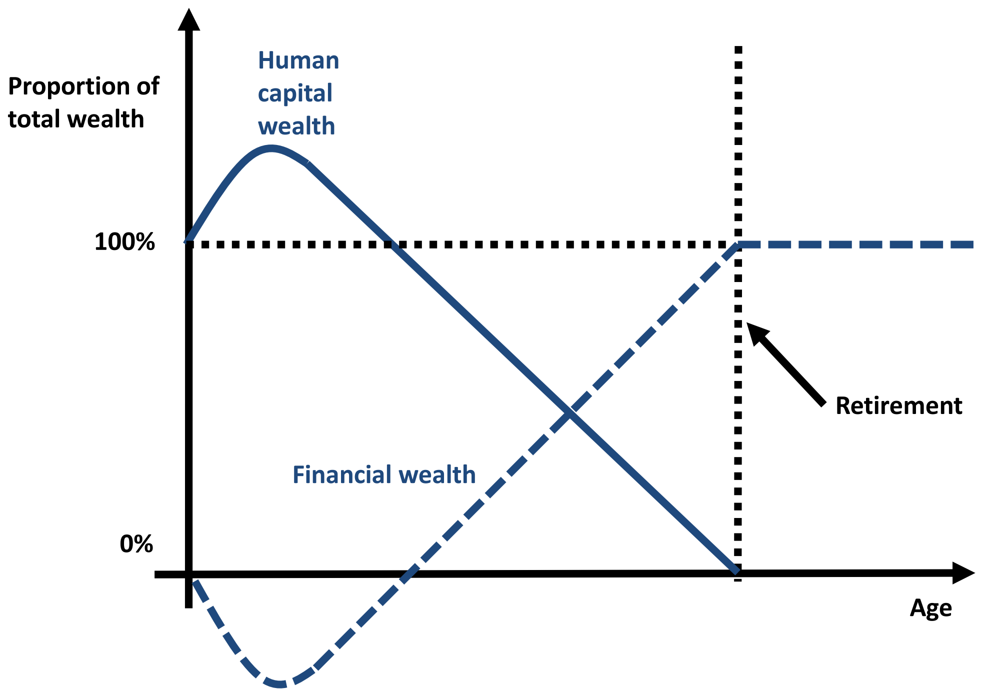

Figure 2: Composition of wealth over the life cycle implied by the life-cycle/permanent income hypothesis

Most people would acknowledge serious shortcomings in the pure LC/PIH. It ignores risk, and therefore cannot model or explain precautionary savings. It assumes unfettered access to the capital markets, especially difficult in the case of the young, who in practice are likely to be significantly credit constrained, limiting their ability to borrow to finance consumption. Important in our context, the LC/PIH ignores all inter-

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generational transfers mediated outside financial markets – most especially those facilitated by the public sector, such as pay-as-you-go social security and health-care systems, but also those facilitated by the private sector, such as *inter vivos* transfers or bequests. This was first pointed out in the context of public transfers by Kotlikoff and Summers (1981), and in the context of private transfers (largely bequests) by Bernheim *et al* (1986). Given these caveats, the importance of public and private transfer systems in any given economy should strongly influence the extent to which savings behaviour is age-related, the extent to which aggregate saving in the economy reflects the demographic composition of the population, and the extent to which asset returns are influenced by changes in demographic structure. The strength of these relationships should reflect the relative importance of saving and public and private transfer systems in smoothing consumption in each economy.

3.1 Theoretical implications of the LC/PIH for the relationship between age and savings

The LC/PIH implies that there must be a strong relationship between age and savings behaviour. At a micro-level, savings should be concentrated among the middle-aged, with dissaving, subject to credit constraints, at younger and older ages. At a macro-level, economies with significant numbers of people of working age should have higher savings rates, while economies with large numbers of young or old people should have lower savings rates.

Most general-equilibrium models of demographic change find that, although savings rates follow the broad predictions of the LC/PIH – rising and falling with the dependency ratio as we have discussed – the demographic transition is generally associated with some form of capital deepening, that is, with a broad and sustained increase in the capital-labour ratio. This is the consequence of higher savings rates among the middle-aged, which comprise an increasing proportion of the population in the middle stages of the demographic transition, leading to increased investment in the economy. Capital deepening benefits future generations, who become more productive, and therefore earn higher wages, as a consequence of the higher capital-labour ratio. This effect, in conjunction with lower future fertility and consequently greater *per capita* human capital investment in children, is also known as the second demographic dividend, after Lee and Mason (2006). The timing and extent of the second demographic dividend is significantly affected by both the public sector, and the private-sector response to population ageing.

For instance, Auerbach and Kotlikoff (1992) illustrate how sensitive their general equilibrium results, including capital deepening, are to the response of the public sector to changes in demographic structure. For instance, in their base case, savings rates fall from 11.7% in 1990 to 6.3% of income in the long run, largely as a consequence of population ageing. However, reducing the generosity of public-sector transfers by raising the social security retirement age postpones the fall in private savings rates by up to 20 years, and raises the ultimate savings rate to 6.6% of income each year. They also show that the size and timing of these effects are sensitive to how open the economy is. In a small open economy, where interest and wage rates are set outside the economy, savings rates peak 20 years later than they would in a large closed economy, where these factors are set internally.[2]

Floden (2003) presents a further illustration of how sensitive results are to the public sector. He shows that if public sector debts are maintained at current levels, population ageing will reduce welfare substantially relative to the case where public sector debt is reduced in anticipation of population ageing. Further, in a small open economy setting, he finds that private sector capital movements between countries may exacerbate rather than alleviate the effects of the demographic transition in some countries.

[2] Miles (1999) presents a model based on Auerbach and Kotlikoff, but calibrated to the European economy. While his projections, consistently with Auerbach and Kotlikoff, show large changes in savings rates and significant capital deepening, the return on capital in his model stays between 4.7% and 5.3%.

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3.2 Theoretical implications of the LC/PIH for the rate of return on financial assets

The LC/PIH also has significant implications for how changes in demographic structure affect both the price of capital and expected returns on savings. It implies that the non-human capital wealth of a nation – represented, by assumption, by the aggregate stock of financial assets – gets passed around from generation to generation. The young, who are saving, purchase assets from the old, who are dissaving. Both are trying to smooth their consumption over their lives in the face of labour income profiles that are not smooth. These transfers are illustrated in Figure 3.

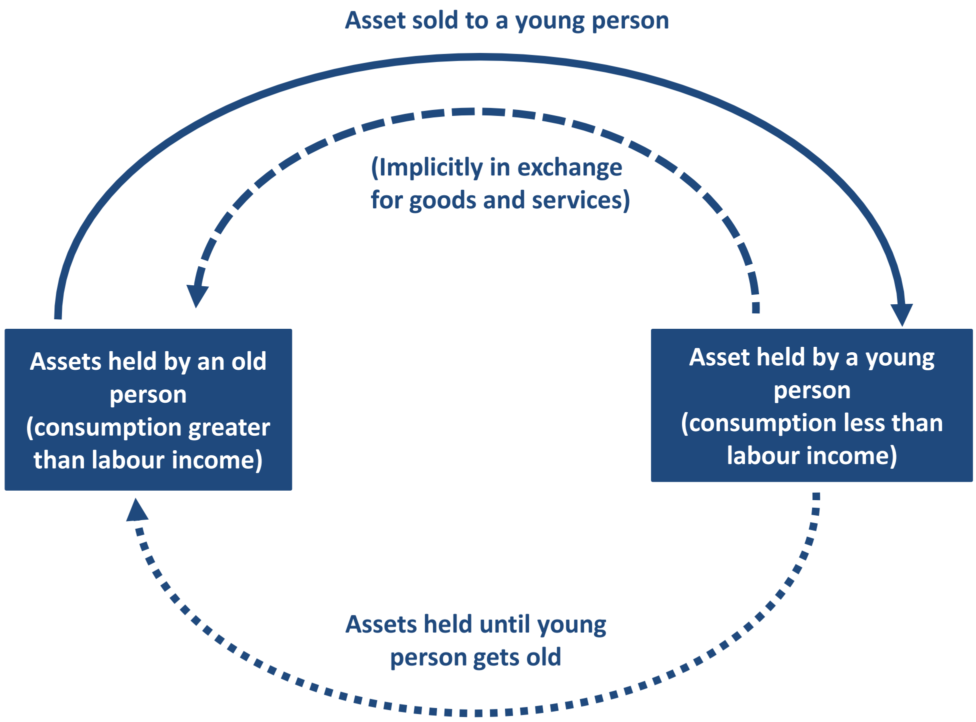

Figure 3: Transfers of financial assets implied by the pure life-cycle/permanent income hypothesis

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In the LC/PIH, the supply of financial assets is determined by the aggregate dissaving of the old, while the demand for financial assets is determined by the aggregate saving of the young. The greater the number of young relative to the old, and the richer the young are relative to the old, the greater the demand for financial assets relative to supply. Of course, the total stock of financial assets may change as capital is created by investment and destroyed by consumption, depreciation and technological change. However, it follows that the price of financial assets, and the expected return on them, will be affected by changes in demographic structure. One way of assessing the relationship between demographic structure and savings is therefore to examine the empirical relationship between changes in demographic structure and the rate of return on financial assets.

This insight was first derived by Samuelson (1956). He assumed a closed overlapping-generations economy, with no aggregate or idiosyncratic risk, and a fixed stock of capital, so no way of shifting aggregate consumption from one period to another other than through trading in capital markets. In this economy, almost by assumption, whether aggregate consumption is shifted between generations through capital markets, or by private or public transfers, is immaterial: the implicit rate of return on public or private transfer systems must equal the rate of return on financial assets, and both must equal the population growth rate. There is thus a perfect relationship between demographic structure and the return on savings.

Later theoretical studies loosened the strict assumptions of Samuelson's model. We focus on the models of Auerbach and Kotlikoff (1992), Yoo (1994), Miles (1999) and Brooks (2002). They all have an overlapping generations framework and allow the price of labour and capital to be determined endogenously. Agents make consumption and savings decisions that maximize expected lifetime utility, and different generations interact through trading in the same capital markets. Crucially, because these models allow for substitution between labour and capital, the aggregate

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supply of capital, and thus financial assets, can adjust to changing supply and demand caused by demographic shocks.

In general, demographic structure changes slowly. Most models assume that the birth rate, which is determined exogenously, is the only source of demographic shocks. Further, these surprises can be observed one or even two generations before they have any *direct* effect on capital or the demand for financial assets, because it takes a while for young people to be educated, enter the labour force, and start to save. Of course, changes in birth rates may have a more immediate *indirect* effect on consumption and savings, as parents adjust their own decisions in response to their own realised or anticipated fertility. With so much warning, however, rational, forward-looking agents, and prices, will have plenty of time to adjust. An inherent consequence of this is that even where the aggregate effect on prices could be large, the effect on the expected returns on financial assets over long periods will be small. Also, the timing of responses to demographic surprises will depend heavily on the particular assumptions made in each model.

As an example, Yoo (1994) models a simple economy in which there is an unanticipated, but temporary, baby boom: the population growth rate rises to 2% p.a. from 1% p.a. for 15 years, and then unexpectedly returns to its original level. The effect, consistent with the LC/PIH, is that the national savings rate rises as the baby boom generation reaches maturity, peaking just before they start to retire. Once they are in retirement, the savings rate falls, again just as the LC/PIH would predict. The expected rate of return on financial assets varies by no more than 0.20% p.a. from steady-state values, first rising and then falling as the demographic transition proceeds. In a different model, but using the same population assumptions, Yoo (1997) shows that in a pure endowment economy, asset *prices* increase by about 35% over 50 years – so the real interest rate increases by around 0.70% p.a. – but that in a production economy it increases by only around 0.30% p.a., illustrating the effect of changes in the capital stock in damping out the effects of demographic changes. In both papers, the author assumes that agents cannot forecast these changes in expected returns. If agents have perfect foresight, prices change quicker, taking thirty rather than fifty years to peak. Similar results are found by Brooks (2002), who calibrates his model to the US economy. Here, the real return on capital varies by as much as 0.45% p.a. from steady state, again first rising as the baby-boom reaches retirement and then falling once they stop working.

The importance of the changing capital stock can be seen by comparing Yoo's papers and Auerbach and Kotlikoff (1990) with Geanakoplos, Magill and Quinzii (2002). The latter paper assumes that the capital stock is fixed, different from Yoo (1994, 1997) and that there is no public sector, different from Auerbach and Kotlikoff (1990). They find that demographic changes have much larger effects than the other papers on the return on capital. In their base case the expected real interest rate varies between 1.5% and 5.6% per annum over a 20 year period according to the changing demographic composition, which is calibrated on the demographic cycles in the US in the last century. Changes in demographic structure change the level of output, but in this model there is no way besides trading financial assets that aggregate consumption can be shifted between generations and from one period to another. A flexible social security system that collected taxes from the working population and paid pensions to the elderly, as modelled in Auerbach and Kotlikoff (1990) could make demand for financial assets more stable, and therefore reduce the volatility in returns. Private transfers, whether *inter vivos*, or in the form of bequests, could serve the same function. Finally, labour supply in Geanakoplos, Magill and Quinzii (2002) is also fixed. Changes in wage rates caused by changes in the underlying capital-labour ratio would cause offsetting effects in labour supply, ameliorating the effects of demographic change.

None of the models discussed up to this point take account of shocks to dividends and labour income. For this reason, they cannot distinguish between the returns on financial securities such as debt – which is riskless – and equities – which are not. Financial theory suggests that returns on

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equity vary both in response to changes in returns on riskless debt, and to changes in the underlying risk premium. To avoid misidentification in empirical work, it is important to understand whether there might be theoretical grounds for suspecting an economically significant relationship between demographic structure and the risk premium on equities.

In addition to the deterministic model discussed above, Geanakoplos, Magill and Quinzii (2002) have a stochastic version in which there are shocks to dividends and labour income. These do not influence the effect of demographic changes on interest rates very much, and in their formulation there seems to be little if any relationship between the size of the equity risk premium and demographic structure.

Well-known results in portfolio theory (see, for example, Merton, 1969) connect the equity risk premium to the average level of risk aversion of its owners. If risk aversion differs systematically by age, there may well be an induced relationship between demographic structure and the equity risk premium, in addition to the effect on risk-free interest rates. For instance, Bakshi and Chen (1994) have a model where, on average, people get more risk averse as they get older. They have a representative agent whose level of relative risk aversion falls linearly with the population's average age. In this model, the risk-free interest rate is assumed to be constant, so demographic changes only influence the returns on financial assets by changing the risk premium. Unfortunately, risk aversion is not directly observable, and must be imputed from asset prices, leading to an unavoidable circularity in their argument when used for our purposes.

There does not seem to be a consensus in the academic literature on whether risk aversion should fall as people age. On the one hand, many theoretical papers recommend switching assets from equities to bonds with age (Campbell, Cocco, Gomes and Maenhout, 2001; Constantinides, Donaldson and Mehra, 2002), although much of this effect is due to a combination of horizon effects and assumed mean reversion in equity prices, and the unwinding of human capital as a component of total wealth,

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as illustrated in Figure 2, rather than the consequence of changes in risk aversion. Empirically, some studies on cross-sectional data seem to support the contention that portfolio composition changes with age (Heaton and Lucas, 2000). On the other hand, household portfolios reported in Guiso *et al* (2002) show little sign of the share of risky assets declining as the household head ages, conditional on the household head holding any equities at all. As in all empirical work, however, cohort effects may be highly significant and are difficult to tease out.

Ang and Maddaloni (2005), on the other hand, suggest that older populations might have a *lower* effective risk aversion than younger ones. As shown in Figure 2, a significant fraction of the total wealth of younger people is held in the form of human capital, that is, the expected discounted present value of their future labour income. This income is uncertain and subject to random shocks. As a consequence, people of working age might be more reluctant than older people to hold equities, especially if equities and labour income shocks are correlated (as they might well be if structural changes in the economy simultaneously affect both the returns to labour and the returns to capital). Retired people will not be affected by this consideration.

In aggregate, the theoretical results discussed in this section suggest that while there may be a demographic effect on riskless interest rates caused by the life-cycle savings decisions of individuals, it is likely to be small, and vary slowly over time. The greater the role of the public sector, and the more flexible the capital stock, the smaller this effect is likely to be. Demographic changes might also affect equity returns, although this would need to be the consequence of underlying changes in risk aversion, possibly driven by demographic change, although supporting evidence of such an effect is far from conclusive. None of the models of equity returns examined here consider the effect of demographically-caused changes in public or private transfers on the returns on equities in particular.

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4 Empirical evidence on savings and demographic structure

We now turn to empirical evidence on the theoretical results discussed above. First we look at studies that have sought to connect aggregate savings across different countries to the demographic structure of the population, and then we examine studies that relate savings and financial asset holdings at household level to the age of the household head. We then try to reconcile the findings from these two areas of research.

4.1 Macro-economic evidence on the relationship between savings and demographic structure

Weil (1994) tests whether demographic data from fourteen OECD countries between 1960 and 1985 explains differences in aggregate savings rates. His dependent variable is the log of the private savings rate (net national saving less net public saving expressed as a proportion of GDP). He regresses this on the age structure of the population, using the population share of the young (ages 0-20), people of working age (ages 20-65) and the elderly (ages 65 and over). *Per capita* income and its growth are used as controls. A second specification includes country fixed effects to account for country-specific omitted variables, meaning that the results in this regression are driven by changes in savings rates in each country over time associated with demographic change, rather than by differences in levels between countries. To account for the slow change in demographic structure, he uses quinquennial rather than annual observations.[3] He reports the regression coefficients, with standard errors in parentheses, reported in Table 1.

[3] It is not known how he accounts for collinearity between his population structure variables (as they all must sum to 1). The conventional approach would be to omit the youngest age category.

Young	Working	Elderly	R^2
-0.27 (0.11)	0.39 (0.09)	-0.50 (0.20)	0.11
0.05 (0.09)	0.20 (0.06)	-0.33 (0.29)	0.79

Note: Young, working and elderly are respectively the proportion of those aged 0-20, 20-65 and 65+ in the population. The second regression includes fixed country effects.

Table 1: Regression coefficients of log of private savings on demographic and control variables across 14 OECD countries over the period 1960-1985. From Weil (1994)

His results suggest that a shift of 1% of the population from working age (20-64) to elderly (65+) reduces the private savings rate by between 0.5 and 0.9 percentage points of GDP. Using the personal savings rate (net household saving out of net household personal disposable income, hence excluding corporate savings) as the dependent variable leads to larger coefficients. These results are largely in line with other work on developed countries, such as Modigliani and Sterling (1983), Graham (1987) and Masson *et al* (1995). Note, however, that differences in demographic structure account for only 11% of differences in savings rates across countries. Country-specific factors, (the fixed effects) on the other hand, account for a further 68% of the differences, even if these are assumed to be constant over time, which they likely are not. This implies that demographic structure may not be the most important determinant of savings rates.

Work that examines both developing and developed countries broadly confirms these results. For instance, Loayza, Schmidt-Hebbel and Serven (2000) regress the private savings rate, in differences, on the youth and old-age dependency ratios. They allow for country-specific controls for growth, real interest rates and other variables that may influence saving behaviour. Their results, with standard errors in parentheses, are reported in Table 2.

Sample	Youth dependency ratio	Old-age dependency ratio
69 advanced and developing countries	-0.30	-0.66
	(0.07)	(0.21)
20 OECD countries	-0.07	-0.22
	(0.10)	(0.15)

Note: Youth and old-age dependency ratio are respectively the ratio of those aged 0-15, and 65+ to those aged 16-64.

Table 2: A regression of savings rates on demographic and control variables across 69 countries in the period 1965-94. From Loayza, Schmidt-Hebbel and Serven (2000).

The first specification includes data on 69 developed and developing countries, while the second includes only 20 members of the OECD. When all countries are included, the dependency ratios are highly statistically significant, with the old-age dependency ratio being economically more important (the magnitude is twice as large). However, the relationship is not statistically significant when only OECD countries are examined. These regressions indicate that a 1% shift of the population from working age to elderly would lower the private savings rate by about 1.5% in all countries, but only by 0.5% in the OECD. These results are broadly similar to the findings of Weil (1994).

Neither of these studies examine the relationship between demographic change and national savings rates, that is, savings rates including the effect of public sector borrowing (or saving). The role of the public sector in offsetting, or augmenting any demographic effects on saving is therefore

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unknown.[4] There are other difficulties in interpreting these results that mean that using them to predict changes in future savings rates is difficult. Firstly, standard errors may be understated as demographic structure is highly correlated across time in each country, and correlated between different countries. Changes in savings rates may then be the consequence of similar economic factors affecting different countries at the same point in time, rather than demographic effects. Second, the results incorporate changes in country-specific economic factors that affect the demand for savings as well as the supply. These economic factors may change significantly over time, and are likely the reason that Auerbach and Kotlikoff (1992) state that no model succeeded in predicting changes in the rate of US national saving in the 1980's.

4.2 Micro-economic evidence on the relationship between age and savings

While the broad features of the LC/PIH are confirmed in micro data, there are some important caveats. Firstly, probably due to credit constraints, few young people borrow significantly to support their consumption as the pure LC/PIH would predict. It is perhaps trite to point out that very young people – those who have not attained the age of majority – rely almost exclusively on transfers from their parents (and in some countries, the state) to support their consumption. But even young adults do not rely on borrowing. Instead, as reported by Carroll (1992), most young adults save up until they have accumulated a small 'buffer stock' of savings that they subsequently use to smooth out short-term fluctuations in income. Second, while individuals appear to smooth consumption relatively well over short time periods (Hall, 1987), over longer periods (say 5 years or more) consumption appears to broadly track income, at least until late middle age

[4] Inconsistencies between the cash-flow accounting basis used by most governments and the modified accrual basis used in the private sector would probably render such results meaningless in any case. Important examples are discussed by Auerbach and Kotlikoff (1992) in the context of US social security cash flows and liabilities.

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and in the United States (Carroll, 1997). After around age 40, however, micro data do confirm the accumulation of financial assets until retirement. Some studies find evidence of unanticipated falls in consumption at or just after retirement, which many researchers interpret as evidence of a lack of preparedness for retirement on the part of a significant proportion of the elderly, for example, Bernheim *et al* (2001). These caveats aside, however, most studies do report significant age-related effects on saving, with the broad pattern confirming the LC/PIH. For example, Borsch-Supan and Brugiavini (2001) estimate household savings rates by age for six different countries (UK, Netherlands, Italy, Germany, USA and Japan). While the pattern varies somewhat from country to country, savings rates appear to be highest around age 50. After this point, they do not fall significantly, and do not appear to be negative in any country.

Part of the explanation for the last anomaly may be mismeasurement. Generally, neither savings rates nor asset holdings take sufficient account of defined benefit (DB) pension or annuity wealth or income. These forms of wealth are automatically drawn upon after retirement. Their exclusion from measures of wealth leads to an understatement of the rate at which wealth falls with age. The same factor affects the measurement of the savings rate. Pension income from annuity policies or DB plans is treated as earned income for the purpose of computing savings rates. Yet the true economic position, as argued by Miles (1999), is that in funded pension plans or insurance policies, pensions are paid by a combination of asset sales and investment income on assets. Many elderly people, at least in the UK and the US, may be using income from pensions or annuities to sustain their consumption and thereby leaving their directly-owned financial assets untouched. A similar issue may be at play with public transfer systems. The cash-flow-based accounting systems, commonly in use, cause reported public sector saving measures to be wildly inaccurate once accrued pension liabilities, and their release as pension incomes, are properly accounted for.

Evidence on asset holdings is broadly consistent with the age-related picture of savings reported above. Poterba (2001) constructs age-specific

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mean asset holdings using the US Survey of Consumer Finances. Broad measures of financial wealth increase with age, peaking after age 50, but do not appear to fall after this point. This finding is robust if cohort effects are allowed for. Levels of wealth and the composition of household wealth vary widely from country to country. However, this pattern of financial wealth development with age is broadly confirmed in many countries, for instance in Guiso *et al* (2002).

4.3 Evidence on the relationship between demographic structure and asset returns

Given the findings of the previous section, we should be surprised if empirical studies find a significant relationship between demographic structure and asset returns. Prominent studies are by Poterba (2001), Cannon (2003) and Ang and Maddaloni (2005). Poterba (2001) focuses on the US between 1926 and 1999, and examines the relationship between US annual real returns on Treasury bills (short-term interest rates), long term Government bonds and US equities on different variables representing demographic structure (the median age in the population, the mean age of those older than 20, the proportion of the US population aged between 40 and 64, the ratio of those aged between 40 and 64 to those older than 65, and the ratio of those aged between 40 and 64 to those older than 20). For US equities none of the demographic variables are found to be statistically significant. For fixed-income securities, demographic structure is significant, but results are not robust over different sub-periods. Their results indicate that a 1% increase in the proportion of the US population aged between 40 and 64 – the peak savings period according to the LC/PIH – lowers long-term interest rates (bond returns) by 1.7% p.a. and short-term interest rates (bill returns) by a little less. Although the direction of these effects is consistent with the theoretical studies we presented earlier, their magnitude is far too large. The proportion of population aged 40 to 64 increased by 5% between 1975 and 2000, indicating that, were these results to be taken at face value, demographic change alone should have resulted in an 8 percentage point fall in long-term interest rates over this period.

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Poterba (2001) argues that the relationship between demographic structure and the level of financial asset prices should be stronger than the relationship between demographic structure and observed returns on financial assets. He therefore regresses equity price levels (measured by the P/D (price/dividend) ratio) on variables representing demographic structure, in differences (to account for time trends in both variables). He finds weak evidence that a 1% increase in the fraction of people aged between 40 and 64 increases the P/D ratio by 6. Again, this appears too high to reconcile with the theoretical models.

Cannon (2003) extends Poterba's (2001) analysis to a panel of 16 advanced economies between 1900 and 1999. He regresses non-overlapping 10-year real returns on equities, bonds and bills on variables representing demographic structure (population growth rates, the proportion of the population aged between 20 and 39, between 40 and 64 and older than 65), controlling for the rate of inflation as well as the volatility of prices. He includes both country fixed effects – so effectively looking at differences in returns between countries – and time fixed effects to account for events that influenced returns across all countries, such as the First and Second World Wars and the oil price shocks of the 1970's. He finds no statistically significant results for equities or short-term interest rates (bills). For long-term interest rates (bonds), he finds that a 1% increase in the proportion of the population aged between 40 and 64 leads to a 0.3% decline in bond returns per year. However, his results are not robust to different country samples: for instance, excluding just South Africa renders the relationship insignificant.

Ang and Maddaloni (2005) focus particularly on the size of the equity risk premium, that is, the difference between expected equity returns and the risk-free interest rate. They examine the relationship between *n*-year excess returns on equities over risk-free interest rates and yearly changes in demographic variables, controlling for growth in consumption and the slope of the yield curve (the difference between long-term and short-term interest rates, the term spread). To account for overlapping periods, they use the method of Hodrick (1982). Their regression structure pools data across different countries, allowing the equity risk premium to vary between countries but imposing the same coefficients on the demographic variables.

Their results are reported in Table 3. For the US over the period 1900-2001 they are not significant at the 5% level, for either demographic variable. However, the sign of their coefficients are consistent with Bakshi and Chen (1994), indicating that excess returns rise with the average age of the population and the proportion over the age of 65. This is consistent with an increase in effective risk aversion as individuals age.

Demographic Variable	US	UK	Japan	G5	G15
Age	15.3	2.6	-13.1	-5.0	4.5
Proportion older than 65	4.9	4.7**	-2.6*	-2.1*	-4.1**
Controls	Y	Y	Y	Y	Y
Period	1900-2001	1900-2001	1920-2001	1920-2001	1970-2001
Countries				US, UK Japan, France, Germany	

Note: Age is log average age of population over 20, proportion older than 65 is the log of the proportion of the population older than 65. Controls are consumption growth and the slope of the yield curve in each country. * and ** mean significant at 5% and 1% respectively.

Table 3: A regression of annual excess stock returns on lagged changes in demographic and control variables. From Ang and Maddaloni (2005).

In no sample is the log of the average age of adults significant. In some of the samples the log of the proportion of the population older than 65 is significant, but signs differ between specifications. In the cross-country regressions, there appears to be a statistically-significant negative

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relationship between the log of the proportion of the population older than 65 and the equity risk premium. This is not consistent with either increasing risk-aversion by age, or with the idea that older people should sell off their financial assets to those younger than them to finance their consumption.

4.4 Summarising the empirical evidence

Viewed as a whole, the empirical literature appears to reveal a puzzle. Macro-economic data on savings rates suggest that savings rates decline as the proportion of elderly people in an economy rises. However, both aggregate portfolio data and micro-economic data on saving behaviour find little evidence of substantial decumulation of financial assets among older people. The counterpart of this puzzle is also visible in financial asset returns: empirical studies fail to find a robust relationship between demographic structure and returns on financial assets. There are various possible explanations for these observations.

One explanation is bequests. If people who actually receive bequests – or those who expect to receive them – save less as a consequence, then a higher proportion of older people in a population will reduce the overall savings rate even if older generations themselves do not actually dissave. Weil (1994) reports micro-economic evidence in favour of this thesis. More generally, *inter vivos* private transfers may have a similar effect.

Another possible explanation might be transfers mediated through the public sector. If tax rates on pay-as-you-go social security and other transfer systems rise with the proportion of older people in a population, then younger workers may respond to the change by reducing their savings rather than their consumption. In effect, workers are passing the burden of supporting their future consumption onto future generations through transfer systems, rather than by saving in private markets. As in the case of bequests, even if older people do not have low savings rates, the higher the proportion of older people, the lower the aggregate savings rate of the whole population will be. Feldstein (1974) provides empirical evidence in favour of this proposition.

But bequests and public-sector transfers are only two possible mechanisms, other than the direct compositional effect, by which demographic structure can influence saving behaviour. One may be changes in factor prices caused by the changes in population composition – most especially changes in wage rates caused by changes in the capital-labour ratio and the relative size of the labour force. Political economy effects may also be important. For instance, an increased weight of the old in the electorate may affect the expectations that younger people may have about benefits for the elderly and the need to save privately. These mechanisms will manifest themselves as a connection between demographic structure and savings rates even if there was no systematic relationship between age and saving behaviour at the micro level. We should not therefore be surprised that the micro and the macro evidence is not entirely consistent.

Specifically as regards the relationship between financial asset returns and demographic structure, some of the difficulties may be statistical. Firstly, demographic structure changes very slowly, meaning that the effective number of independent data points in even a century of data is not large. Although cross-country data may increase the effective sample size, demographic changes have occurred near-simultaneously in many countries, limiting the benefits. Secondly, theoretical models indicate that the magnitude of any demographic effect on returns is likely to be only a small component of the overall variability in returns. Models we have cited suggest demographic effects of at most around of 1% p.a.. Variation in real stock returns, on the other hand, even when measured over a decade or longer, is often an order of magnitude greater. Finally, but less importantly, theoretical studies give little indication about which demographic variables are likely to be important, or about the possible lead or lag between demographic changes and their effect on asset returns.

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Better econometric techniques may well resolve some of these difficulties, especially if variation in intermediate variables, such as saving levels and household portfolio composition, are included in explanatory regressions. But our expectations should be limited. Firstly, capital flows between countries in different stages of the demographic transition may limit the observed relationship between demographic structure and financial asset returns in any one country. Of course, there is some evidence that world capital markets are not perfectly integrated. Feldstein and Horioka (1980), for instance, show how national consumption matches national income, and the "home bias puzzle" suggests that households are reluctant to invest beyond their borders. But Rey (2015) illustrates how the monetary policy response to the Global Financial Crisis spread from advanced to developing countries. Demographic effects could spread in a similar fashion. Secondly, as we have suggested earlier in this paper, other factors limit the influence that demography has on financial markets and savings rates. The capital stock is not fixed, but varies with the demographic transition in a way that tends to offset changes in expected returns. Finally, transfers in the public and in the private sectors, as we discussed, will also attenuate the link between demographic structure and financial market returns in general, and between saving and demographic change in particular.

Until now, there has been no analytical framework that has allowed the importance of these three different channels by which individuals smooth consumption over their lives to be measured in a fully comprehensive way. In the next two sections, we show how the National Transfer Accounts (NTA) framework can be extended, using Generational Wealth Accounting (GWA), to provide precisely this complete picture. GWA also generates measures of transfers between living and unborn generations, which, in one sense, can be regarded as broad measures of saving, incorporating both the implicit saving (or, more usually, dissaving) caused by public and private transfer systems in the presence of demographic change, as well as explicit saving through accumulating financial assets.

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5 The National Transfer Accounts (NTA) framework

The National Transfer Accounts (NTA) constitute a complete, coherent and consistent accounting of economic flows from one age group or generation to another in a given calendar year. They are *complete* in the sense that all economic flows across ages are incorporated; those mediated by government (such as taxes, in-kind and financial transfers), those that occur both within and between households, and those that occur through the capital markets. They are *coherent* in that they are based around the System of National Accounts (SNA), and are *consistent* in that they are estimated to ensure that aggregate totals agree with those in the National Accounts. For an overview of the NTA framework, see Lee (1994).

The NTA are built around the following budget constraint. For each living individual, *i*, in the economy the following balance must hold in every period[5]:

$$\underbrace{y_i^a}_{\text{Asset Income}} + \underbrace{y_i^l}_{\text{Labour Income}} + (\underbrace{b_i^+}_{\text{Bequests Received}} + \underbrace{\tau_i^{p,+}}_{\text{Private Transfers Received}} + \underbrace{\tau_i^{g,+}}_{\text{Government Transfers Received}}) =$$

$$\underbrace{c_i^p}_{\text{Private Consumption}} + \underbrace{c_i^g}_{\text{Government Consumption}} + (\underbrace{\tau_i^{p,-}}_{\text{Private Transfers Paid}} + \underbrace{\tau_i^{g,-}}_{\text{Government Taxes}} + \underbrace{b_i^-}_{\text{Bequests Paid}}) + \underbrace{s_i}_{\text{Savings}} . \qquad (1)$$

Details of all the variable definitions are given in the NTA Manual (UN, 2013, p29-43). To simplify our discussion here, we shall assume that net transfers with the rest of the world are negligible. The corporate veil is effectively pierced so that asset income includes all returns to capital held by the private and household sector. Thus the sum over all individuals in the

[5] We note that the standard version of the NTA flow equation does not separately identify bequests. Most country teams in the NTA project have followed the approach of ignoring bequests altogether. This has the consequence that, while aggregate savings is correctly identified (and balanced back to national accounts), a portion of the savings that is attributed to older generations in fact represents bequests made to the young, while a corresponding portion of the dissavings of the young represents bequests received. We have chosen to identify bequests separately in order to emphasise their importance, given our later findings.

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economy of asset income and labour income equals Net National Income (NNI). Private transfers include both inter- and intra-household *inter-vivos* transfers. In equation (1), bequests are accounted for separately, but they could be regarded as a type of private transfer in the NTA framework.

The NTA are constructed from a rearrangement of equation (1) as

$$\underbrace{c_i^p + c_i^g - y_i^l}_{\text{Life Cycle Deficit}} = \underbrace{y_i^a - s_i}_{\text{Asset Based Reallocations}} + \underbrace{(b_i^+ - b_i^- + \tau_i^{p,+} - \tau_i^{p,-})}_{\text{Net Private Transfers}} + \underbrace{(\tau_i^{g,+} - \tau_i^{g,-})}_{\text{Net Government Transfers}}. \quad (2)$$

The left hand side is called the *life cycle deficit* and is the difference between consumption and labour income at a given age. The right hand side describes how this deficit is supported; either from asset income or by savings or dissaving (called asset-based reallocations in the NTA framework), net transfers within the private sector or from net transfers with the government.

NTA thus give a picture of the generational economy, which can be compared across countries. Findings of the NTA project to date can be found in Lee and Mason (2011). To summarise these very broadly, the profile of the life cycle deficit is similar across countries but how this life cycle deficit is supported differs dramatically. European countries depend more heavily on government based transfers, whereas the US depends more heavily on asset based reallocations with the UK somewhere in-between. There is a wide variety across developing economies but some depend almost exclusively on private transfers to redistribute resources. The elderly in East Asian economies, in particular, rely heavily on private transfers to support consumption in old age.

For the purposes of the analysis in this paper, the NTA framework has an important advantage: it allows the importance of the three main consumption smoothing mechanisms (capital markets, public transfers and private transfers) to be quantified in a manner that is consistent across countries, and consistent with the SNA. Note that in the previous sections of this paper, we have identified the presence of private and public transfers as a primary factor that determines the empirical macro- and micro-economic relationship between savings and demographic structure. However, the NTA framework suffers from an important disadvantage: it only quantifies flows in a given year. To quantify the role played by *future* transfers in determining current consumption requires a small extension. This extension is provided by Generational Wealth Accounts (GWA), which we turn to in the next section.

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6 Generational Wealth Accounting (GWA)

GWA uses profiles of consumption, labour income and public and private transfers to estimate the expected discounted present value, for different generations, of human capital, and public and private transfer wealth. By including the value of assets owned by each generation in the accounts, they provide a complete picture of the total wealth available to each generation, and the uses to which this wealth is expected to be put. Unlike the classical LC/PIH, GWA does *not* assume that all consumption smoothing occurs through saving and dissaving at different ages. Instead, they allow the relative importance of market wealth, human capital wealth, and public and private transfer wealth to be quantified for each generation at a particular point in time.

GWA generalises previous results in a number of areas. Lee (1994), under the assumption that the economy is on a golden rule growth path[6], shows that the economy's stocks of wealth and capital can be estimated directly from the cross-sectional profiles.[7] Further, because the growth path is sustainable (albeit by assumption) no debts or gifts are passed on from living generations to the unborn; newborns' present value of future consumption equals the present value of their future labour income.

In one sense, GWA can be thought of as a relaxation of this assumption. Rather than assuming that interest rates are those consistent with a given equilibrium, this approach uses current expected interest rates and estimates whether current consumption plans are indeed sustainable. Further because the accounts look at consumption over the entire life course, GWA can also assess whether some generations have fared proportionally better than others.

[6] On the golden rule growth path savings are chosen so as to maximise consumption per capita. A well know results is that along this path the real interest rate is equal to population plus productivity growth rate, $r=n+\lambda$. Lee (1994) results can be generalised to all balanced growth paths at the cost of some complexity.

[7] For example, private sector wealth is the difference between the mean age of consumption and the mean age of labour income multiplied by average per capita consumption.

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Secondly, GWA can be thought of as a generalisation of Generational Accounting (GA), developed by Auerbach *et al* (1991). GA shows the relationship between individual generations and the public sector in expected discounted present value terms by comparing, for each generation, the current value of future expected transfers between that generation and the public sector. The inter-temporal budget constraint of the public sector then implies a net transfer, through the public sector between currently-living generations and the unborn. GA has been used extensively in assessing the sustainability of public finances (see, for example, the Office for Budget Responsibility's Fiscal Sustainability Reports prepared for the UK, OBR, 2015).

GWA extends GA by incorporating not only public transfers, but also private transfers, human capital and financial assets in their overall assessment of the resources available to each generation. In principle, this allows sustainability analysis to be conducted in a unified framework that makes allowance for *both* changes in savings rates (as in Khoman and Weale, 2008) and in changes in fertility (as in Lee, Mason, *et al*, 2014).

GWA is again based around the accounting identity (1), but now the balance is estimated over the remaining life course. If we index each quantity in equation (1) by *i* and *t* where *i* refers to the age of the representative individual in the base year and *t* refers to the year relative to the base year and denote by $n_{i,t}$ the number of the individuals aged *i* in the base year at time *t*, then it can be shown that (2) implies

$$\underbrace{\sum_{t=0}^{\infty} n_{i,t}\left(c_{i,t}^{p}+c_{i,t}^{g}\right)R^{-t}}_{\text{Present Value of cohort planned consumption}} =$$

$$\underbrace{n_{i,0}w_{i,0}}_{\text{Wealth held by cohort}} + \underbrace{\sum_{t=0}^{\infty} n_{i,t}y_{i}^{l}R^{-t}}_{\text{Cohort's Human Capital}} + \underbrace{\sum_{t=0}^{\infty} n_{i,t}\tau_{i,t}^{p}R^{-t}}_{\text{Present value of net private transfers}} + \underbrace{\sum_{t=0}^{\infty} n_{i,t}\tau_{i,t}^{g}R^{-t}}_{\text{Present value of net government transfers}} + \underbrace{\sum_{t=0}^{\infty} n_{i,t}b_{i,t}R^{-t}}_{\text{Present value of planned net bequests}} \quad (3)$$

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where $\tau^{p}_{i,t} = \left(\tau^{p,+}_{i,t} - \tau^{p,-}_{i,t}\right)$, $\tau^{g}_{i,t} = \left(\tau^{g,+}_{i,t} - \tau^{g,-}_{i,t}\right)$ and $b_{i,t} = \left(b^{+}_{i,t} - b^{-}_{i,t}\right)$ are net private transfers, net public transfers and net bequests respectively, *R* is equal one plus the real interest rate[8], and $w_{i,t}$ is all assets (financial and tangible) owned by an individual aged *i* in the base year in period *t*.[9] Because we have aggregated over all individuals of a given age, this inter-temporal budget identity is expressed at a cohort rather than an individual level[10] and should be satisfied for all cohorts in all years along a sustainable growth path.

Because all transfer systems, whether public or private, involve future transfers between the currently living and the currently unborn, projecting their future path requires the development of the future demographic structure of a population to be modelled using population projections. The transfers between the currently living and the currently unborn are then estimated using three inter-temporal budget constraints: the public-sector inter-temporal budget constraint, as assumed in GA, the private-sector inter-temporal budget constraint (all private transfers must, in expectation, sum to zero over all future years), and an aggregate inter-temporal budget constraint (the total of all consumption over the entire economy cannot, in expectation, exceed the total resources available to that economy). In any generation, the excess of resources over uses is treated as the expected discounted present value of future bequests. These bequests are allocated to subsequent generations using a waterfall approach, and any aggregate surplus or deficit is treated as an indicator of the sustainability – or lack thereof – of future anticipated consumption paths. For more details around the theory and implementation of GWA, please see McCarthy *et al* (2015).

[8] Obviously a term structure of interest rates could be used; however here we assume constant interest rates for simplicity.

[9] We note that GWA include transfer wealth in household balance sheets. This is in marked distinction to, for instance, Piketty (2013), and important because transfer wealth has very different distributional and growth characteristics from other forms of wealth. This will be the subject of future work.

[10] This is necessary to account correctly for bequests.

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Panel A: Austria: 2008

Age in 2008	Resources				Uses					Net financing of EDPV of future consumption				
	YL	W	TGI	TFI	CG	CFF	CFU	TGO	TFO	YL	W	TG	TFXB	B
0-9	47%	0%	36%	17%	19%	39%	0%	34%	8%	81%	0%	4%	4%	11%
10-19	52%	0%	34%	14%	15%	39%	0%	37%	9%	95%	1%	-5%	-4%	12%
20-29	55%	3%	34%	8%	13%	38%	0%	39%	10%	107%	7%	-9%	-12%	8%
30-39	51%	8%	37%	3%	13%	38%	0%	38%	12%	102%	16%	-1%	-14%	-2%
40-49	41%	13%	42%	4%	13%	37%	0%	34%	15%	81%	26%	16%	-9%	-14%
50-59	23%	19%	55%	4%	15%	38%	0%	29%	18%	43%	35%	48%	-2%	-23%
60-69	4%	23%	70%	3%	18%	38%	0%	23%	21%	8%	40%	83%	-1%	-30%
70-79	1%	29%	68%	3%	19%	31%	0%	18%	32%	1%	57%	99%	-3%	-55%
80-89	0%	38%	60%	2%	17%	23%	0%	14%	46%	0%	94%	116%	-6%	-104%
90-99	0%	49%	49%	1%	14%	17%	0%	10%	59%	0%	159%	128%	-9%	-178%

Panel B: Slovenia: 2010

Age in 2008	Resources				Uses					Net financing of EDPV of future consumption				
	YL	W	TGI	TFI	CG	CFF	CFU	TGO	TFO	YL	W	TG	TFXB	B
0-9	44%	0%	34%	22%	21%	37%	0%	31%	11%	76%	0%	6%	7%	11%
10-19	51%	0%	32%	17%	17%	37%	0%	33%	13%	95%	1%	-3%	-5%	12%
20-29	57%	4%	30%	9%	14%	36%	0%	35%	15%	115%	7%	-10%	-18%	6%
30-39	53%	9%	33%	5%	14%	35%	0%	34%	18%	110%	18%	-1%	-21%	-6%
40-49	41%	12%	42%	5%	16%	36%	0%	30%	18%	78%	24%	23%	-11%	-15%
50-59	19%	19%	56%	5%	19%	39%	0%	23%	19%	33%	33%	57%	0%	-23%
60-69	3%	25%	67%	4%	23%	39%	0%	17%	22%	5%	41%	83%	2%	-31%
70-79	1%	28%	68%	3%	26%	34%	0%	14%	26%	1%	48%	89%	1%	-39%
80-89	0%	37%	60%	3%	26%	26%	0%	12%	36%	0%	72%	93%	0%	-65%
90-99	0%	47%	51%	2%	25%	19%	0%	9%	47%	0%	107%	95%	0%	-103%

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Panel C: Spain: 2008														
Age in 2008	Resources				Uses					Net financing of EDPV of future consumption				
	YL	W	TGI	TFI	CG	CFF	CFU	TGO	TFO	YL	W	TG	TFXB	B
0-9	47%	0%	34%	19%	19%	31%	11%	28%	11%	84%	0%	5%	11%	0%
10-19	50%	0%	28%	21%	15%	38%	4%	30%	12%	90%	1%	-6%	1%	15%
20-29	55%	4%	26%	15%	12%	40%	0%	33%	14%	105%	8%	-15%	-15%	17%
30-39	52%	9%	28%	11%	12%	38%	0%	33%	16%	103%	17%	-11%	-19%	10%
40-49	43%	15%	34%	8%	14%	39%	0%	32%	15%	82%	28%	3%	-14%	1%
50-59	26%	24%	41%	9%	15%	38%	0%	27%	20%	48%	46%	27%	-3%	-18%
60-69	7%	34%	49%	10%	17%	35%	0%	20%	27%	13%	65%	55%	2%	-35%
70-79	1%	42%	50%	7%	18%	30%	0%	17%	35%	1%	85%	69%	2%	-58%
80-89	0%	54%	41%	5%	16%	23%	0%	13%	48%	0%	135%	72%	2%	-109%
90-99	0%	66%	30%	4%	12%	17%	0%	9%	62%	0%	228%	71%	2%	-201%

Panel D: UK: 2008														
Age in 2008	Resources				Uses					Net financing of EDPV of future consumption				
	YL	W	TGI	TFI	CG	CFF	CFU	TGO	TFO	YL	W	TG	TFXB	B
0-9	51%	0%	33%	16%	18%	30%	12%	27%	12%	92%	0%	3%	5%	0%
10-19	57%	0%	32%	10%	16%	28%	14%	29%	13%	112%	0%	-3%	-10%	0%
20-29	56%	2%	30%	13%	14%	33%	7%	31%	15%	110%	3%	-7%	-20%	15%
30-39	47%	7%	29%	17%	15%	39%	0%	31%	15%	86%	13%	-2%	-18%	21%
40-49	38%	19%	33%	10%	17%	41%	0%	30%	12%	66%	32%	5%	-10%	7%
50-59	20%	38%	35%	7%	19%	37%	0%	24%	20%	36%	68%	21%	-2%	-22%
60-69	5%	48%	40%	7%	21%	33%	0%	18%	28%	9%	90%	41%	0%	-39%
70-79	1%	47%	48%	4%	26%	29%	0%	14%	30%	1%	84%	60%	-2%	-43%
80-89	0%	44%	53%	3%	31%	27%	0%	13%	29%	0%	75%	68%	-3%	-41%
90-99	0%	43%	54%	3%	33%	26%	0%	12%	29%	0%	73%	70%	-2%	-41%

Table 4: Generational Wealth Account-implied portfolio allocations of resources, uses and implied net financing of future consumption. See text for field descriptions.

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For the purposes of this paper, we have calculated GWA for four European economies: Austria, Slovenia, Spain and the UK, each in a single year. These are presented in panels A-D of Table 4. Since the theory of GWA is still being developed, these calculations should be regarded as highly provisional and preliminary. All results are therefore illustrative, rather than final.

We use demographic projections based on Eurostat (2013), and asset profiles produced for euro zone countries by Hammer (2015) using the Eurosystem Household Finance and Consumption Survey. UK asset holdings are from the Wealth and Asset Survey produced by the Office for National Statistics. Public and private-sector transfers are obtained from NTA profiles produced by the relevant country teams.[11] We assume that the discount rate will exceed the growth rate for all economies by a constant 2% p.a. For this work, we do not incorporate current announced changes to transfers systems in each country – such as future changes in retirement ages, eligibility and pension generosity. Instead, we assume that transfer systems remain as they currently are, in perpetuity. Incorporating these features will be the subject of future work.

Using these assumptions, we use the GWA framework to calculate the total resources available to each generation, and the uses to which each generation puts these resources. Resources are split between the expected discounted present value of future labour income (YL), the value of assets owned by each cohort (W), the expected discounted present value of transfers received from the public sector in cash and kind (TGI) and the expected discounted present value of private transfers received in cash and kind (TFI), here including the expected discounted present value of future

[11] For the UK, McCarthy and Sefton (2010), for Spain, Patxot *et al* (2015), for Slovenia, Sambt *et al* (2010) and for Austria, Hammer (2014).

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bequests. Uses, on the other hand, are split between the consumption of publicly-provided goods and services (CG), private consumption (CF), taxes paid to the public sector (TGO) and transfers made to other generations (TFO), including bequests. In order to assess how future consumption is financed, we also calculate the portfolio composition of the financing of the expected discounted present value of future consumption by netting TGI and TGO and TFI and TFO. This, then, implies a pattern of borrowing from, and saving in respect of, future generations through public and private transfer systems. These implied measures of off-market transfers can be thought of as implied savings measures, not through the 'bank of mom and dad', but rather through the 'bank of the unborn'.

We first discuss the composition of total resources. For the youngest cohort of Austrians in 2008, labour income made up nearly half (47%) of their resources, with the balance made up of public transfers (36%) and private transfers (17%). In each country the portfolio composition of total resources changes systematically among older cohorts: the proportion of labour income falls, reaching close to zero for those aged 60 or older, while the proportion of assets rises, reaching as much as 66% of total resources for the oldest Spaniards. In all countries, the expected discounted present value of future public-sector transfers starts around one-third of total resources, reaching a peak around age 70-79 (except for the UK, due largely to health care) and then falling again. In all countries, private transfers make up around one fifth of total resources for the very youngest cohort, and falls systematically with age, reaching levels close to zero for the very oldest cohortd. For the young, these transfers are a combination of current and future parental support and bequests. Since few aged people in western economies receive support from their children, private transfers for them are very low. A notable difference between the countries with generous pay-as-you-go public pension systems (Austria, Slovenia, Spain) and the UK is that after retirement, the proportion of resources made up of assets rises in those countries, but falls in the UK. This is because older cohorts in these countries tend to support most of their consumption from their pensions, and hence do not dissave. Older cohorts in the UK, at least in 2007, owned fewer assets than those on the verge of retirement, possibly due to the significant funded pension system of the UK, which, as discussed above, may have resulted in effective dissaving at older ages in that country.

We now turn to the composition of uses. In the GWA framework, available resources can be used in a number of ways. They can be consumed, they can be used to pay taxes to the public sector, or they can be paid over as private transfers to other generations. In Table 4, consumption is divided into three parts. CG denotes the expected discounted present value of future consumption of goods and services provided in kind by the public sector. This may include health care, education, long-term care, public housing, law and order, defence and other public services. CFF denotes the portion of the expected discounted present value of future private consumption – all other consumption – that is financed by existing resources. CFU, on the other hand, denotes the portion of private consumption that is unfinanced by existing resources. This is only relevant in the UK and Spain, where younger cohorts do not have sufficient resources in expected discounted present value terms to finance their total future expected consumption paths, making the waterfall assumption about the distribution of bequests as we have discussed. In the other countries, available resources suffice, and so CFU is 0 for all generations. TGO denotes the expected discounted present value of future taxes, and TFO denotes the expected discounted present value of future transfers made to other cohorts. In all countries, CG starts at around 20% of total future uses. It then falls slightly as educational expenditure is exhausted, and then rises in old age, reflecting future public health care and long-term care. The rise is most extreme in the UK, where for the very oldest, CG represents around one third of total uses. In Slovenia it is around one quarter, and in Spain and Austria it is lower than that – less than one seventh in both countries. This largely reflects differences in health-care financing in the different countries. CF starts at around 40% in most countries, falling gradually with age, and TG starts at around one-third of total uses, rising slightly for those of working age, and then falling again for the elderly cohorts. This is a consequence of the fact that the majority of taxes are paid by those of working age, rather than those who have retired. In the UK and Spain, CFU – the unfinanced portion of private consumption – is around 10% of total uses for the youngest cohort. In Spain, the next youngest living cohort also has some unfinanced consumption, while in the UK the next two living cohorts we examine do.

Transfers to other generations consume an ever-increasing fraction of total uses for the older cohorts, except in the UK. For younger people, transfers reflect mostly transfers to children, or the expected discounted present value of these. For the older cohorts, an increasing fraction is attributable to bequests. For the very oldest, the vast majority of transfers are in the form of bequests. In Austria, Slovenia and Spain, transfers make up more than half of the total uses of older generations, again reflecting their generous pension systems. In the UK, the fraction is around one-third.

Finally, we examine the composition of how each generation finances its future consumption. In the third set of columns in Table 4, we therefore net TGO off TGI and TFO off TFI. The two left-most columns in the final third of Table 4 show the proportion of future consumption, whether public or private, that is financed by labour income and assets. In Austria, Slovenia and Spain, labour income finances only around four-fifths or less of the expected discounted present value of future consumption of the very young. The balance is mainly financed by bequests, shown separately here, and other public and private transfers. For older cohorts, the proportion financed by labour income rises, while public and private transfers become negative, indicating that child-bearing cohorts expect to pay more to other generations through the public and private transfer systems than they expect to receive in return. Bequests fall in importance as older cohorts become more likely to be net payers of bequests than recipients.

Private transfers other than bequests were not generally important in this group, reflecting the well-known phenomenon that in Western countries, elderly people continue financing their children through small transfers, in net terms, as long as they are alive. This is in marked contrast to countries in East Asia (not shown here), where parents are on average heavily dependent on their children for support in old age. In our sample of countries, private transfers other than bequests reach a peak in child-bearing age, and fall gradually thereafter.

In Austria, Slovenia and Spain we observe an interesting pattern among the older cohorts: private assets become an ever-increasing fraction of future consumption, exceeding 100% of future consumption for the very old in all of them. Bequests, on the other hand, become significantly negative, also exceeding 100% of the expected discounted present value of future consumption. What drives this process is the generous publicly-financed pay-as-you-go pension systems in these countries that appear to support a large fraction of the consumption of older generations, shown in the column marked TG. For instance, in 2008, Austrians aged between 70 and 79 expected to receive, in present value terms, around 100% of future consumption in *net* transfers from the public sector, and the very old, around 128% of their future consumption. For this group of countries, it would therefore appear that savings are largely financing bequests rather than being used for life cycle purposes. This pattern appears most extreme in Spain, where private savings represented 228% of future consumption for the very old, and expected bequests around 201%.

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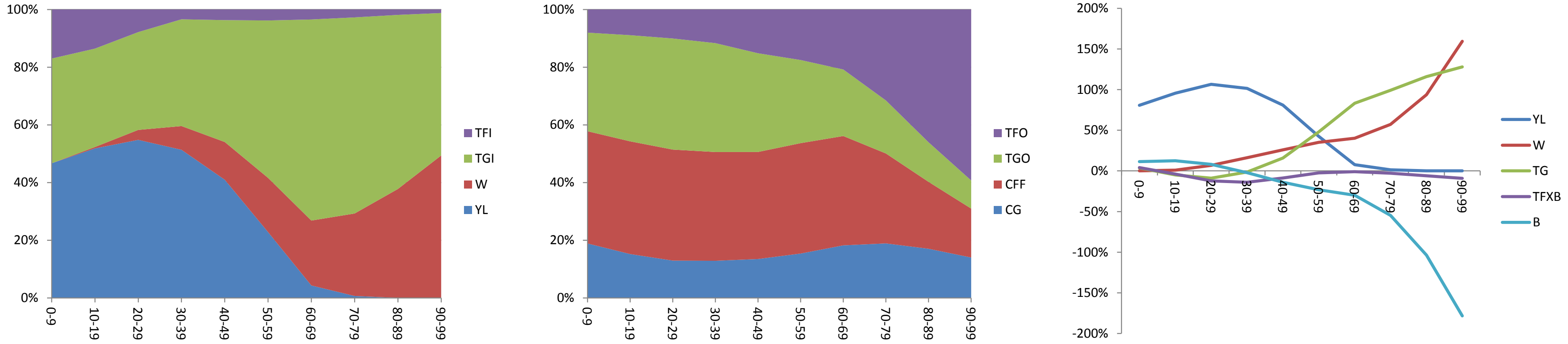
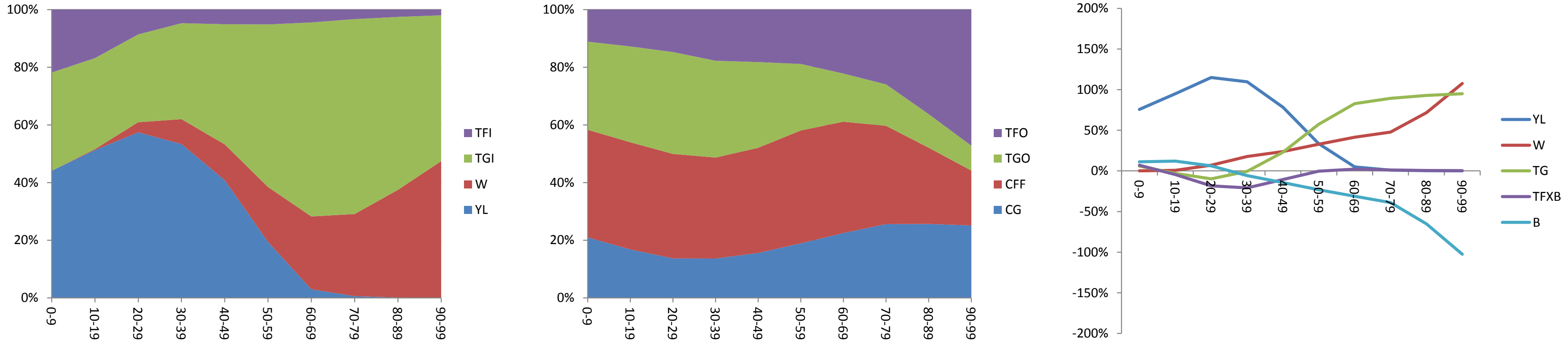
The pattern in the UK is quite different. The UK relies very heavily on a funded pension system, which for older cohorts is still defined benefit (DB), but which for younger cohorts outside the public sector has shifted decisively towards a DC system. There, expected bequests are not sufficient to ensure that younger generations are able to finance their expected consumption plans. For this reason, labour income finances most of their future consumption. For older cohorts, assets and bequests become significant, being sufficient to finance the expected discounted present value of child-rearing costs (TFXB). As individuals age, public transfers become significant, but they are not sufficient to cover more than two-thirds of future consumption. Instead, the difference is made up by private savings. These are still more than sufficient to make up the difference, leaving around 40% of the expected discounted present value of future consumption as a bequest.

The results in Table 4 are shown in graphical form in Figure 4. The first graph in each country shows the aggregate composition of remaining lifetime resources for each generation, between labour income, private wealth, public transfers and private transfers, including bequests. In no country does the total of labour income and private wealth comprise more than 50% of total resources for the entire population. Only focusing on savings as in the LC/PIH, is clearly incorrect. The second graph shows the uses to which resources are put. Again, consumption makes up only around half of uses: the rest is either public or private transfers made to other generations. The final chart for each country shows the portfolio composition of the expected discounted present value of future consumption by netting off the private and public transfers in uses and resources.



Panel A: Austria



Panel B: Slovenia

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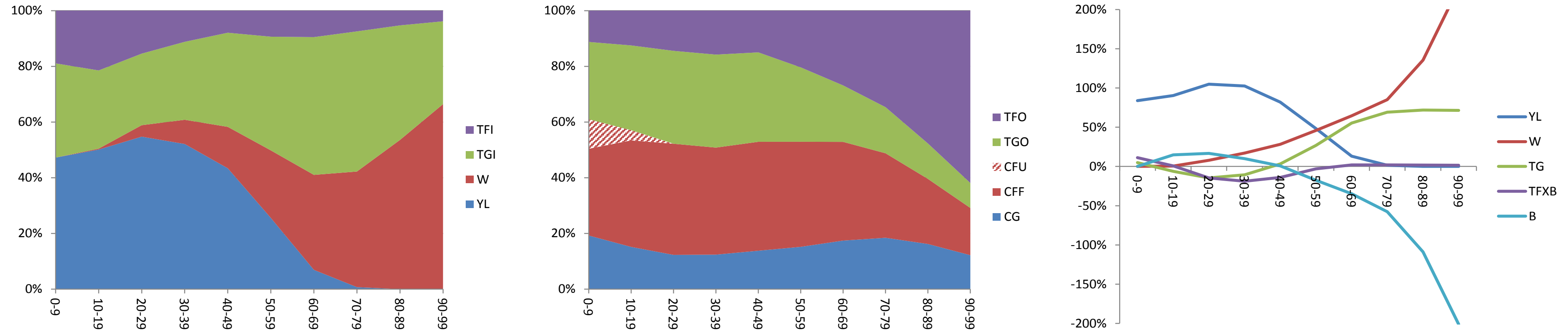
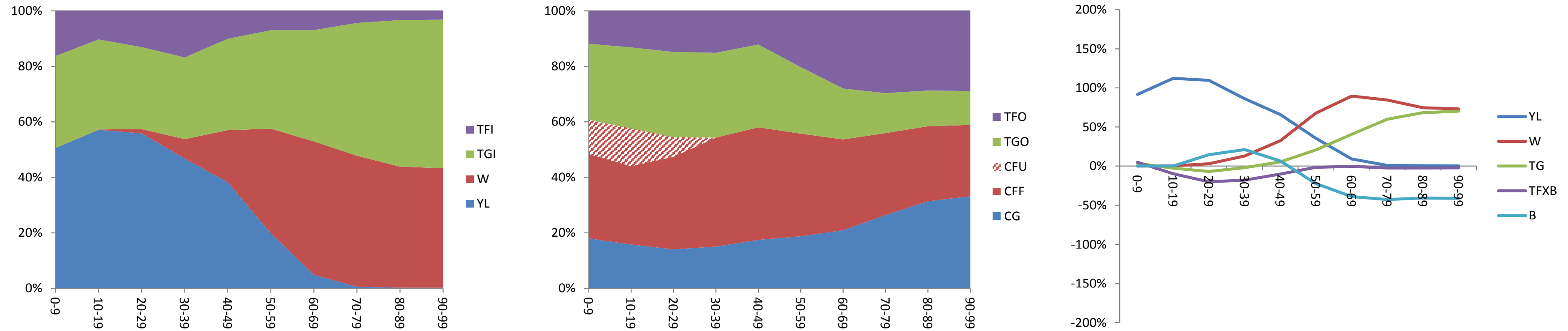


Panel C: Spain



Panel D: the UK

Figure 4: Vertical axis shows portfolio composition for different generations (horizontal axis) of total lifetime resources (left-hand graph), total lifetime uses (middle graph) and the financing of the expected discounted present value of future consumption (right-hand graph). See text for field descriptions and assumptions.

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These graphs are a direct analogue to Figure 2, and illustrate the extent to which transfers influence the composition of the wealth of different generations. In most countries, labour income makes up more than 100% of future consumption for the middle-aged, and, among the older cohorts, public transfers, rather than financial wealth, comprise the rest. Except in the UK, financial wealth is largely used to finance bequests, rather than future consumption. This has striking implications in a number of areas.

We note that these results are aggregates for entire cohorts. Clearly, there will be compositional differences within each cohort that we have not examined. For instance, for the very poor, government and possibly private transfers will comprise a greater fraction of resources than for the very rich. Looking at uses, the poor will spend less on government transfers and private transfers than the rich.Financial wealth in particular (and therefore bequests), is also much more unequally held than either transfer wealth or human capital. This implies that even though a particular cohort may, in aggregate, be able to sustain its future anticipated consumption path as a consequence of bequests, there may be many poorer members of the cohort who are unable to do so, and other richer members who will have sufficient assets to bequeath on to their own heirs. Exploring these important patterns will be the subject of future work.

Having a complete picture of all resources, and all uses, for each generation, allows us to examine the long-term sustainability of these consumption paths, as well as the implicit transfers between unborn and living generations implied by the patterns of transfer systems and consumption. As discussed above, these transfers can be thought of as the aggregate loans from and deposits with the 'bank of the unborn' that are required in order for observable consumption patterns to be sustainable.

% GDP	Austria 2010	Slovenia 2010	Spain 2008	UK 2007
Public sector debt/GDP	-82%	-38%	-39%	-44%
Public transfers	-297%	-329%	-87%	-157%
Private transfers *ex* bequests	123%	143%	135%	196%
Bequests	83%	95%	0%	0%
TOTAL TRANSFER TO UNBORN	-173%	-131%	9%	-5%
Aggregate net resources for living generations	0%	0%	-71%	-239%
% total CF for living generations	(0%)	(0%)	(-5%)	(-14%)
% total YL for living generations	(0%)	(0%)	(5%)	(14%)
TOTAL SUSTAINABILITY	-173%	-131%	-62%	-244%

Note: All figures not in brackets are shown as %GDP. Total sustainability measure is the sum of the total transfer to the unborn and the implied change in CF for living generations. % total CF for living generations is calculated as the implied change in CF for all living generations on the previous line divided by the total CF for living generations. % total YL for living generations is calculated as the negative of the implied change in CF for all living generations divided by the total YL for living generations.

Table 5: Aggregate GWA-implied transfers to and from the unborn, including sustainability measures

In Table 5, we present (in the first panel) the transfers to and from future generations that are implied by the patterns of resources and uses that are presented in Table 4 and (in the second panel) aggregate sustainability measures. All figures in the first panel are expressed as a percentage of current GDP. The first component of aggregate transfers to the unborn is the current public sector debt. By assumption, this is passed on to the unborn. The second component is the aggregate implicit debt passed on through the public sector transfer system. In all cases, this is negative, representing a debt passed by the living to the unborn: the consequence of continued public-sector borrowing to sustain public-sector transfer systems.

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In the case of Austria, unborn generations will receive a debt from current generations equal to 297% of GDP, and in Slovenia, the debt is similar, equal to 329% of GDP. For Spain and the UK, the transfers are smaller: 87% of GDP for Spain and 157% of GDP for the UK. However, these transfers are partly offset by assets that the unborn will receive through the private transfer system, in the form of *inter vivos* transfers – largely, in this group of countries, future transfers from currently-living parents to their unborn children – and bequests. *Inter vivos* transfers are largest in the UK, at 196% of GDP, and smallest in Austria, at 123% of GDP. Spain and Slovenia are between these. The difference between countries probably reflects the different importance of the public sector in looking after children. The unborn in Austria can expect to receive bequests worth in aggregate around 83% of GDP, and in Slovenia around 95% of GDP. In Spain and the UK, as already discussed, bequests are not sufficient to allow future generations to continue to consume as they might currently expect, indicating that in aggregate, the unborn can expect to receive no bequests from those currently living. The total transfer to the unborn, representing the sum of public sector debt, public sector transfers, *inter vivos* private-sector transfers and bequests, varies significantly across countries. In Austria and Slovenia, it is significantly negative, indicating that the unborn can expect to receive a debt from current generations equal to 173% of GDP in the case of Austria and 131% of GDP in the case of Slovenia. The total transfer to the unborn for Spain and the UK is negligible.

However, in Spain and the UK, aggregate net resources for the living are insufficient to sustain future anticipated consumption paths. In the case of the UK, the amount is material: absent other changes, private consumption will need to fall by 239% of GDP, while in Spain, it needs to fall by 71% of GDP. Either the future consumption of living generations must fall, or their future labour income must rise, or a combination. In both cases, the quantum of each change is similar: private consumption should fall by 5%

for all living generations in Spain, or labour income should rise by the same amount, while in the UK, aggregate consumption needs to fall by a much greater 14%, or aggregate labour income rise by 14%.

We note that a fall in aggregate consumption may cause tax revenues to fall, worsening the position of the public sector, while a rise in labour income could have the opposite effect. Our analysis does not account for these feedback effects.

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7 Conclusion

This paper investigates the empirical and theoretical relationship between saving and demographic structure. Canonical theoretical results, such as the life-cycle/permanent income hypothesis (LC/PIH), suggest that, in the absence of inter-generational consumption-sharing mechanisms other than individual saving, there should be a very strong relationship between age and saving behaviour. Very young individuals should borrow against future income; those in middle age should save, while the old should liquidate their savings, all to support a steady level of permanent consumption over their whole lives. This, in turn, implies that there should be a strong relationship between demographic structure and aggregate savings rates, and between demographic change and the returns on financial assets, particularly if the capital stock of the economy – and hence the quantity of financial assets – is fixed.

Micro-economic survey data partly support the predictions of the LC/PIH, at least for individual savings rates: these peak in most countries in late middle age (between 40 and 60 years of age). However, besides the dissaving caused by annuities and defined benefit pensions, the evidence that old people in particular dissave to support their consumption is limited. Also, few people appear to borrow to sustain their consumption when they are very young. At a macro-economic level, there is evidence that aggregate national savings rates *are* affected by demographic structure, with countries that have a high proportion of working-age people having higher savings rates. However, demographic structure does not, by itself, explain a significant fraction of the differences in savings behaviour between different countries. In some studies, demographic structure explains as little as 11% of the variation in savings rates across countries. Finally, there appears to be little empirical support for theoretical predictions of the LC/PIH for returns on financial assets: researchers have struggled to find a significant relationship between changes in demographic structure and the rate of return on financial assets.

Besides statistical issues, part of the explanation may lie in the fact that individual saving is only one mechanism by which individuals are able to smooth consumption over their lives. Kotlikoff and Summers (1981) first raised the issue of transfer wealth in the context of the LC/PIH. Using the framework developed by the National Transfer Accounts (NTA) project, we calculate comprehensive wealth accounts by generation for four European countries, called Generational Wealth Accounts (GWA). The theory of these accounts is still being developed, so results presented here should be regarded as highly tentative. However, our results illustrate the relative importance of three channels in supporting future consumption: private saving, public transfer systems, such as publicly-provided old-age pensions, medical and educational expenditure, and private transfers, such as bequests and *inter-vivos* transfers.

Of the four countries we examine – Austria, Slovenia, Spain and the UK – we find that the pension system, and to a lesser extent, the financing of old-age health care, and of raising the young, are crucial determinants of the relationship between savings and demographic structure, and of the role of savings in the economy. In the first three countries, pay-as-you-go publicly financed pension systems mean that older people do not need to rely on their savings to support their consumption. Instead, public transfers are responsible for smoothing almost all their consumption. Assets are mainly used for bequests. As a consequence, living generations pass down a significant asset to the unborn through the private transfer system, but an even more significant liability through the public system. The UK, which relies on a funded pension system, is different. There, individuals rely on savings to support around a third of their consumption in retirement. As a

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consequence, bequests only account for around two-thirds of asset holdings, rather than all of them as in the other countries.

This arrangement has a number of significant implications. High reliance on public transfer systems in particular implies that demographic developments are crucial determinants of sustainability. Transfer systems – whether public or private – are extremely sensitive to demographic change, and, arguably, more sensitive than private savings for the reasons we have discussed. A greater reliance on private savings may therefore reduce demographic vulnerability. One channel by which European countries could limit the effect of population ageing could be by increasing the role played by private saving and encouraging international diversification of investments to take advantage of differences in demographic structure between countries. However, a significant reliance on private savings should not be taken to indicate that sustainability is necessarily increased: in our sample, the UK seems to be the least sustainable consumption paths, even though it relies most heavily on private savings to smooth consumption. Rather, our results suggest that countries that rely on private savings to a greater extent – Spain and the UK – may experience sustainability problems *earlier* than countries that rely more on public transfers. Market mechanisms may therefore provide price signals to individuals earlier than off-market mechanisms such as public sector transfers.

Our results also provide some tentative explanation for the empirical analysis in the earlier sections of the paper: even in the UK, individual savings are *not* the most important channel by which individuals smooth consumption over their lives. Public transfers are, arguably, the most important, while private transfers are also significant. This explains why demographic structure appears to explain so little of the cross-country variation in macro-economic data on aggregate savings rates and why the empirical relationship between asset returns and demographic change is so weak. Our analysis also provides some empirical support for the contention of Ricardo (1820) and Barro (1974) that private transfer systems – including saving – at least partially offset the role played by public transfer systems. Examining only one such system – whether public sector transfers, as in the case of generational accounting, or private transfers, as in the case of an analysis of savings behaviour or bequests – provides at best a partial picture of the aggregate transfers between generations, and the consequent sustainability of an economy given demographic change.

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