AN ECONOMIC ANALYSIS OF THE EXISTING TAXATION OF PENSIONS (EET) VERSUS AN ALTERNATIVE REGIME (TEE)

Authors:

Dr Angus Armstrong, Prof E. Philip Davis and Dr Monique Ebell

National Institute of Economic and Social Research

2 Dean Trench Street, Smith Square

London, SW1P 3HE

020 7654 1925 (direct line)

a.armstrong@niesr.ac.uk

30th September, 2015

This work was commissioned by the Association of British Insurers as a response to the Government's consultation "Strengthening the incentive to save: a consultation on pensions tax relief" (Cm 9102). The National Institute of Economic and Social Research is an independent research institute and has had full control over, and takes full responsibility for, the contents of this paper.

EXECUTIVE SUMMARY

- The Government set out four principles that a pension reform should meet, in addition to being mindful of the macroeconomic consequences. In this paper we assess the economic consequences of changing from the existing EET to a TEE pension taxation system from two approaches. First, we review the economic and empirical literature, and second we construct a general equilibrium OLG model parametrized to UK data and tax system. Both approaches show consistent outcomes.

- In our view, personal savings will fall in all scenarios (i.e. of scenarios of varying pension subsidies under TEE) we considered. This will result in lower consumption, a lower capital stock and productivity and a higher real interest rate. Therefore, based on the principles and macroeconomic consequences set-out by the Government, our analysis suggests that the proposed policy change will deliver the opposite outcome. Personal savings are lower even where a pension subsidy of 50% is provided. Our modelling supports results reported in the academic literature.

- Another principle is that the proposal ought to be consistent with the Government's fiscal framework. The TEE system would lead to an immediate tax revenue gain from removing the current tax relief. This would improve today's headline fiscal deficit. However, this will be at the expense of tomorrow's fiscal accounts. We note that the only scenario where output (almost) and consumption return to the levels comparable to the current EET system are with a 50% government pension subsidy which would likely be detrimental on a Whole Government Accounts basis.

- We note that the EET system has superior risk sharing properties to TEE. By changing the taxation of pensions to TEE, the tax treatment will be similar to ISAs and housing wealth, but much less liquid. There is a risk of considerable substitution into other TEE savings, in particular housing.

- There is a dynamic inconsistency problem inherent in TEE because a future government can always reverse policy and remove the subsidy, or re-introduce taxation on pension income. Given the pension challenges ahead, a government cannot credibly commit not to exploit this time inconsistency. Given the inferior risk sharing and credible commitment problem, individuals are less, rather than more, able to take personal responsibility.

- The final principal proposed by the Government is that the policy is simple and transparent. We note that the transition from EET to TEE would require earmarking different pension pots of savings as accumulated under different tax regimes. The transitional costs for defined benefit pensions could be considerable (assuming they would be forced to pay additional top-ups out of taxed income). We are unconvinced that having separate pension savings under different tax regimes would be beneficial in terms of transparency and simplicity.

- We suggest that any further consideration of the merits of such a change in pension taxation is preceded by general equilibrium modelling analysis. This is the only framework which incorporates the full consequences of the behavioural changes. Published results would allow an open discussion of the possible consequences of such an important policy change, which is surely in the public interest. This analysis is a first stage. A full assessment would include life cycle incomes, more granular cohorts and uncertainty over income, future care costs and changes in future tax policy.

1. INTRODUCTION

An efficient pension system requires mechanisms for households to smooth consumption over time and to insure against risks. Yet households are confronted by imperfect information, complex choices and decision making, existing distortions in the tax system and many other barriers which prevent these mechanisms emerging in competitive markets. The design of pension taxes is far removed from perfect markets with complete information, and far into the realms of second and third best policy making.[1] Governments in all advanced countries intervene in pension markets at a number of stages (including providing a state pension).

The Government's consultation document (hereafter, HMT cm9102) raises the possibility of a substantial change in the taxation of pensions. This involves the timing of taxation. Pensions can be taxed (T) or exempt (E) at the point of saving, when asset returns arise or when pension income is drawn. The current UK system is abbreviated to EET: pension saving is exempt from income tax (and national insurance), returns on pension savings are exempt from tax when they occur but pension income is subject to income tax (although not national insurance). The proposal is to change to TEE: pension savings would be from taxed income and (presumably) after national insurance but with no further taxation. This would be akin to the tax treatment of an ISA, possibly with an additional top-ups or subsidies from the government.

The Government has four principles any reform should meet: (a) simple and transparent; (b) allows individuals to take personal responsibility for adequate savings for retirement; (c) encourage people to save more; and (d) in line with the Government's fiscal strategy. In addition, the Government noted that it must be mindful of the macroeconomic implications of reforms, the treatment of defined benefit and contribution pensions (especially in the public sector), the context of the wider tax system and the costs and implementation of any changes.

The taxation of pensions directly affects households' consumption and saving decisions, incentive to work, asset allocation decisions and government finances. It therefore matters for capital accumulation, productivity, economic growth, capital markets and welfare. The key point of this paper is that a robust analysis of the proposed changes requires a general equilibrium setting. The response of households and the consequences for the economy and government finances over time

[1] Second and third best worlds describe when one or more conditions for a competitive outcome are absent, and when policy makers lack full information for second best policy. For example, imperfect information requires distorting labour market outcomes in order to have insurance. See Barr and Diamond (2006).

must be fully specified. Reliance on a partial equilibrium analysis can be misleading.[2] The core of our analysis is based on the findings of a General Equilibrium Overlapping Generations (OLG) model presented in section 3 to incorporate the behavioural responses of households. We would strongly recommend that any consideration of these or alternative proposals are in this framework, albeit extended to include life cycle incomes and uncertainty.

(a) The UK pensions challenge

Advanced countries face a pension challenge arising from the increase in longevity. In the UK this has been combined with falling occupational and personal pensions, in particular defined benefit (DB) pension schemes. Since automatic enrolment in 2012, the trend has reversed. While only 9% to 10% have opted-out of their workforce pension, it is unclear whether this has been offset by reduced saving elsewhere and the overall impact on national saving.[3] The share of employees with defined benefit pensions has continued to decline. More than 70% of new occupational pensions are defined contribution (DC) pensions. This means households, rather than firms, are increasingly exposed to investment risk in their pensions and longevity risk (they live longer) and higher costs associated with old age. This has an important bearing on the taxation of pensions.

The extent of government involvement, or support for the pension system, inevitably depends on public finances. HMT Cm9102 suggests that the current taxation of pensions may cost £21.2bn in income taxes and £14bn in national insurance contributions each year.[4] This includes £7bn estimate for investment income tax exemption, but this would not be collected under the new proposal. The cost will be offset by higher taxes paid when pension incomes are drawn. While HMT Cm9102 acknowledges that the figures may misrepresent the true cost of the existing tax system, due to differences in the timing of payments and changes in tax rates (lower taxes reduce the estimate), this could be a substantial overstatement. Comparing the contributions of today’s workforce to today’s pensioners’ income (yesterday’s workforce) ignores wage inflation, population growth and changes in longevity.

The reform proposal would lead to an immediate increase in tax revenue for the Government. Whether this means an improvement on the fiscal balance depends on the size of the subsidy the government proposes to increase the attractiveness of pension saving. In our analysis we have

[2] A partial analysis will fall prey to the Lucas Critique and unintended consequences.
[3] HM Treasury (2015) p9.
[4] Indeed, Emmerson and Tanner (2000) suggest that the particularly lenient treatment of employer contributions, as well as the tax free lump sum, is a key factor making EET UK pensions more attractive than TEE vehicles such as ISAs.

carried out scenarios for different subsidies from 10% to 50% of pension saving. What should really matter for the Government is whether there is an improvement in the comprehensive or Whole Government Accounts which take into account future public pension liabilities. This is a more meaningful assessment of the fiscal consequences of the proposal rather than the headline deficit figure (which depends on the subsidy).

When deciding on changes to pension taxation, consideration must be given to appropriate risk sharing between governments and households. This is not an issue of higher expected cost, but smoothing out year to year uncertainties (upside and downside) which are much easier for a government that can always borrow. For an individual household year to year shocks can prove very difficult to manage, particularly if they occur in retirement. There is usually little possibility to return to work to top-up savings. Governments face a different budget constraint to households. Some risks (e.g. associated with financial failure or natural disasters) are best managed by a government. Some economists refer to this government function as the 'risk manager of last resort' as this is the fundamental role of government (along with defence). The risk sharing properties of pension tax regimes are important for welfare.

(b) Taxation of pensions

The taxation of pensions begins with the general principle of taxing saving.[5] A tax system which does not distort the decision of how much to consume today versus save and consume tomorrow would leave the after tax (and risk adjusted) real rate of return on savings assets unchanged. Abstracting from risk, the real rate of interest in equilibrium is equal to the subjective discount rate households apply to future consumption. In a competitive market, efficiency requires this to be tax free. Any returns above the risk free rate would be down to skill or luck and therefore subject to tax. Under the current EET system, there is some taxation of investment returns.[6] Higher returns will lead to a higher final pension which is subject to tax. Note that interest income is taxed on deposits (which discourages saving) and total returns (i.e. above real returns) on ISAs are not taxed which creates a distortion to save more.[7]

[5] A first best world is where there is perfect information, no barriers to entry and complete markets.
[6] Although investment returns are not taxed, corporation tax and stamp duty reduce the returns available to pension funds (dividend credits were repaid up to 1997).
[7] Regimes where investment income is taxed as well as contributions (TTE) or benefits (ETT) are comprehensive income tax regimes (they tax income equally regardless of source). This treats equally the different uses to which income may be put - saving is seen as just another commodity. However, it reduces the incentive to save by driving after tax rates of return below the before-tax rate.

There may of course be good reasons for taxing pensions more leniently. These include, first, that people are generally myopic and mistakenly under-save to generate the retirement living standards they prefer (Diamond 1977) and second, to encourage people to save to reduce their need for state pensions.[8] Moreover, since pension savings are usually illiquid, or cannot be accessed until retirement, there ought to be some compensation to prevent under-saving. Having no tax on returns is one approach. This is the rationale for up to one quarter of all pension contributions being accessible at retirement free of any tax. So one quarter of pensions are taxed EEE. This is to compensate for the illiquidity of pension savings. To replace this incentive under the TEE proposal, the Government would provide a pension subsidy at the point of saving (of an unspecified amount).

If the real rate of interest was suitably taxed, and there was one tax rate for all levels of income and no uncertainty then taxing income when it is earned or drawn as a pension would be the same. However, all tax systems are progressive and workers have some flexibility in the amount of work they supply.[9] Since income tends to be lower in retirement, this encourages workers to save more for retirement while working.[10] This is a distortion which encourages earlier and greater savings under EET than TEE. Emmerson (2014) points out that the EET system allows taxpayers an extra degree of freedom to smooth consumption over their life cycle: taxpayers with an accentuated life-cycle can smooth their income under EET to have the same welfare as a taxpayer with the same, but less pronounced, life-cycle income.

The EET has greater risk sharing properties than TEE. In a DC pension, if asset prices fall at the date of retirement this implies a loss of pension income. However, under the EET system this is partly offset by reduced income tax. Of course the opposite can also happen with excess returns. The growing prevalence of DC pensions draws another distinction between EET and TEE.

The change in tax regime must also be considered in the context of the treatment of other assets. UK households have just over £9.4tn in assets: housing wealth £4.2tn; pension and insurance assets £3.1tn; currency and deposits of £1.3tn; other financial assets of £0.6tn.[11] Housing wealth and ISAs are essentially taxed under the TEE tax regime, currency and deposits and other financial assets under a TTE regime and only pension assets under EET. If the tax regime were to change to TEE for

[8] A recent UK survey by the consultancy MGM Advantage showed that 80% of elderly workers underestimate average life span, with for example men aged 55 to 64 thinking they will live till 81 and women till 79, while ONS figures for 2012 show the true figures to be 86 for men and 89 for women (Uren 2015).
[9] Even 'flat tax' countries have an income threshold.
[10] In the UK it is estimated that only one in seven workers receiving higher rate tax relief during their working life will ever pay higher rate income tax during retirement.
[11] The definition of households includes non-profit institutions serving households. Data are from the ONS and for 2013 and other significant assets include receivables.

pensions, then this would remove the different tax property of pensions compared to other assets. The asset payoff features would be more homogenous with less scope for diversification. For example, the tax treatment of pensions would be closer to the tax treatment of housing. Storing wealth in a house has the advantage of being accessible (on disposal), whereas pensions are usually locked-up until retirement.

There are distributional consequences to the current EET system. Higher income earners gain the largest relief from income tax. While they are likely to pay more tax when drawing their pensions, they are overall likely to gain more than lower income earners from the EET relative to the TEE system. This is a consequences of the progressive tax system more than the difference in the timing of taxation (higher earners pay more tax and so inevitably get more relief). Distributional concerns can be addressed directly. Recent reforms limit the benefits of EET to the highest earners as employee contributions cannot exceed 100% of salary, and there is a limit for each individual of £40,000 on tax free contributions per annum and a cap on total accumulation of £1.25 million.[12]

When tax remission is in the future rather than being immediate, there is always the risk that future governments will act to raise taxes on pensions, ("reneging on the pension promise") thus making pension saving less attractive. Taxation will always be the right of the government, which includes the right to change policy in future. Given that it is well understood that there are pension challenges in the future, the possibility around other contingent risks (such as the financial sector) and the time lapse between current and future taxation policy, there is no commitment device to overcome this dynamic inconsistency problem. This is directly analogous to the motivation for making the Bank of England independent.[13] There is also a case of this opportunistic behaviour in New Zealand in the late 1980s which led to a collapse in pension saving (St John 2007).[14]

In addition, the regimes are not all equally easy to implement. Taxing contributions in TEE is by no means straightforward, especially for employer contributions which are often pooled across groups of employees with differing marginal tax rates, administration of which would be highly complex. In the transition, providers and schemes would have to segregate savings built up under the current EET tax regime from those built up under the new tax regime which would be costly and may add to

---

[12] This is the money value permitted for DC funds. The corresponding calculation for DB funds is that 20 times the pension in payment cannot exceed £1.25 million.

[13] Kydland and Prescott (1977).

[14] As a consequence of the introduction of so-called "tax neutrality" with no tax benefits to pension saving, membership of occupational superannuation schemes (covering public and private sectors) fell between 1990 and 2005. Assets under management increased slowly in nominal terms and fell substantially in real terms. In 2005, pension assets were only 11.3% in New Zealand compared to 58% in Australia (St John 2007).

the burden of complexity for households. Employers with DB plans may face particular difficulties. If top-up payments are taxed under TEE the costs to firms of DB plans would rise markedly. Moreover, it is not clear whether TEE would also apply to national insurance contributions for employees and employers. Having different treatment would add to complexity, having the same treatment would be a considerable payroll tax. Labour mobility across countries could also be affected, since most other OECD countries have EET, making cross border pensions feasible.

2. LITERATURE SURVEY ON PENSION TAXATION AND THE MACROECONOMY

In this literature review, we summarise the published evidence on the different economic effects of the alternative pension taxation regimes. We start by noting that Yoo and de Serres (2005) report that 22 of 30 OECD countries use the EET regime. The conclusion is that most authors find EET is more economically beneficial, owing to tax deferment and the benefit of saving from pre-tax income. This benefit manifests itself in terms of the amount of pension saving, personal saving, national saving, the risk on retirement portfolios and their effect on capital markets and overall benefits to economic growth. Furthermore, we highlight evidence of beneficial risk sharing and the incentive to switch from pensions into more liquid alternative assets such as housing under TEE.

(a) Effects on pension saving

Whitehouse (1999) suggests that under the strict assumptions TEE and EET are equally optimal. However, this arises from unrealistic assumptions, as in Huang (2008), where no regular contributions are paid during accumulation, only an initial one, and thus the marginal tax rates during work and retirement are identical, making EET and TEE regimes equivalent. Most authors, including Beetsma et al. (2011), show that under realistic circumstances this equivalence breaks down. The marginal tax rate during retirement is typically lower than during working life. Hence, pension savings are more attractive under the EET regime and saving in this form is more likely to be chosen due to such tax deferment. Kudrna and Woodland (2012) provide an OLG model based on Australia where they simulate the effects of switching to an EET or TEE regime from TTE as the system stands now. They generally find EET to be superior.

In assessing TEE versus EET, Chen et al (2013) undertake a theoretical analysis that takes the composition of a pension fund's investment portfolio as given. In the context of their framework they show that taxing income after pension contributions have been paid (EET) raises social welfare, not only because there is additional investment in pension wealth (due to tax deferral and investment from pre-tax income) but also because pension wealth earns a higher rate of return (benefiting from the so-called “equity premium”). Meanwhile, the reduction in future taxes by paying pension contributions on after-tax income under TEE effectively only earns the risk-free rate of return through a reduction in the public debt. Hence, the EET regime is superior to the TEE regime.

In the light of these results, we now turn to the wider literature on the impact of funding on the macroeconomy, on the basis that changes in taxation from EET to TEE will reduce pension saving as suggested above. We provide evidence that higher pension savings implies that personal saving is higher, and that higher pension saving may also benefit national saving despite the offset in terms of lower government saving.

(b) Effects on personal saving

In considering whether pension savings tends to boost overall personal saving, a key question is whether rising pension assets simply offset lower other forms of personal saving. This may be seen as likely, given the usual economic assumption that people have a life-cycle savings plan that would not necessarily change by the form in which saving occurs. Nevertheless, in principle, pension saving could generate increased total personal saving via the following channels (for an overview, see Kohl and O'Brien (1998)):

- Pension assets are illiquid may mean that other household wealth may not be reduced one-to-one when pension assets increase. This is because households may not see such claims as a perfect substitute for liquid saving such as deposits. This argument is supported by the fact that many pension laws prohibit pensioners from mortgaging their future pension benefits.

- There may be liquidity constraints whereby some households are not free to borrow. This may imply that any forced saving (such as pension contributions) cannot be offset either by borrowing or by reducing discretionary saving. As observationally equivalent outcome is that the interaction between the need for retirement income and retirement security may increase saving in a growing economy, as workers increase saving to provide for an earlier planned retirement.

- The lower effective marginal income tax rate under EET will increase labour supply relative to TEE, all else equal. This will lead to a fall in the capital to labour ratio and a higher real interest rate and higher investment (and saving) and higher output and so private saving may not fully offset the increase in pension savings.

Looking at relevant theoretical contributions, Imrohoroglu et al (1998) use a dynamic OLG model to quantify the increases in the capital stock and savings from tax-favoured Individual Retirement Accounts (IRAs) in the United States. They find a 6% increase in the capital stock, albeit only 9% of IRA contributions are calculated to constitute additional saving.[15] Kitao (2010) extends Imrohoroglu,

[15] Their results indicate that the contribution limit is an important factor in explaining the effects of the IRA programs examined. Middle-aged workers in their model economy generally save substantially more than they are permitted to invest in IRAs when the contribution limit is similar to that in effect during the early 1980's; IRAs do not raise the marginal rate of return for such agents who would save substantially more than the contribution limit by accumulating ordinary assets. They suggest that the fact that a modest contribution limit appears to be binding for a substantial fraction of savers may explain why IRAs have a relatively small effect on aggregate saving in the model. This could be increasingly relevant in the UK if the lifetime contribution limit on tax free pension saving declines.

et. al. (ibid) to include a variable labour supply. The author finds that an IRA tax-favoured savings account can have a strong positive impact on savings and output in a dynamic general equilibrium OLG model, as it increases the effective after-tax return of saving.

As regards empirical work, on balance, research suggests that growth in pension saving boosts overall personal saving, but not one-to-one (i.e. there is some offset). A significant offset arises via declines in discretionary saving. Much of the literature is focused on the impact on household saving of the growth of U.S. DB funds, and on balance it suggests an increase in personal saving of around 0.35–0.5 results from every unit increase in pension fund assets (Pesando 1992). As regards DC funds, Poterba, Venti, and Wise (1996) suggest that individual pension accounts in the US (401(k)'s) have added to aggregate saving consistent with the theoretical work noted above. Tax incentives are one important reason, but employer matching of contributions, payroll deduction schemes, and information seminars may also be relevant factors in encouraging overall private saving by this route. Reisen and Bailliu (1997) examined data from 11 countries, including both advanced OECD and emerging market economics (EMEs).

Reisen and Bailliu (1997), examine pension reform in 11 countries, including both advanced OECD and emerging market economics (EMEs). They find that the impact from unfunded to funded pension schemes on saving is positive in all cases, but significantly larger for EMEs than in OECD countries. This was thought to reflect the less developed capital markets that mean individuals are unable to borrow in order to offset pension saving that they are obliged to make. On the other hand, even in a liberalized financial system as in the UK, such credit constraints will affect lower-income individuals particularly, as they have no assets to pledge and less secure employment. Therefore institutional saving will tend to boost their overall saving particularly markedly (for evidence, see Bernheim and Scholz (1992)).

(c) Effects on national saving

This section outlines work on the impact of pension reforms on overall national saving (government and the private sector). While the evidence so far suggests that EET systems result in higher private savings, the consequence for national saving depends on the response of governments. On balance, the evidence suggests a positive effect.

James (1996) argues that one main advantage of World Bank multi-pillar model approach to assessing the impact of pension reform is that national saving as well as personal saving could be boosted. But any effect of pension fund growth on personal saving could be offset at the level of national saving by the impact on public finances of the costs of tax subsidies to personal saving. For example in Pesando (1992) as cited above, the cost to the public sector of the tax incentives to pension funds reduces the overall benefit of pension saving to national savings to around 0.2 per unit as compared to 0.5 per unit for personal saving.

Nevertheless, Lopez Murphy and Musalem (2004) using a panel of 43 industrial, and developing countries find evidence suggesting that the accumulation of pension fund financial assets might indeed increase national saving, when these funds are the result of a mandatory pension program. The boost to personal saving is greater than the increased borrowing the public sector has to undertake. By contrast, national saving might be less affected when pension funds are the result of a public program, implemented to foster voluntary pension saving, as is effectively the case in the UK.

(d) Effects on financial markets

Abstracting from the question of whether pension reform indeed boosts saving, it is useful to also view pension reform more broadly as aiding financial market depth, which may also stimulate growth. An EET tax regime implies that the government assumes some of the risk of the pension portfolio, a beneficial risk sharing mechanism for households allowing them to accept more risk than otherwise. This section shows that this is indeed the case, with pension savings leading to increased supply of equity and long term (as opposed to short term) debt or bank deposit finance, as well improved corporate governance.

The implication is that pension funding via EET increases the supply of long-term funds to capital markets. There may be increases in the supply of equities, long term corporate bonds and securitised debt instruments and a reduction in the supply of bank deposits. A lower cost of equity finance can be beneficial to economic and financial stability as it implies lower debt/equity ratios in the corporate sector. This may be contrasted with the likely boost to house prices which may arise from a switch to TEE as discussed below.

Catalan et al (2000) sought to identify empirically whether there is a Granger-causality relation between capital markets and contractual savings (i.e. whether rises in the former consistently preceded increases in the latter). They used two capital market indicators, stock market capitalisation and stock market value traded across 26 countries, among which 6 are developing countries. They gave evidence that contractual saving institutions, e.g. pension funds, Granger-cause capital market development in this sense. The potential benefits of developing contractual saving sectors are, however, stronger for developing countries than for developed countries.

As noted, such overall shifts to long term assets should tend to reduce the cost and increase the availability of equity and long term debt financing to companies, and hence may raise productive capital formation. Particularly for existing firms with small equity bases, there may be important competitive advantages to be reaped from equity issuance in terms of growth potential as well as reducing risks of financial distress in case of economic downturn; furthermore, long-term debt finance is correlated with higher growth for manufacturing firms (Caprio and Demirgüç-Kunt 1998).

There may also be beneficial influences of pension fund growth on long term debt finance (which may attenuate changes to the debt/equity ratio). In a cross country estimation, Impavido et al (2003) found a positive relationship between contractual saving assets and bond market capitalisation/GDP, whereby a 1 per cent increase in the former leads to a 0.4 per cent rise in the latter. On the other hand, they include public as well private bond issuance to proxy bond market development, where the former is driven by government needs rather than being mainly influenced by the state of demand. Improving on this, Hu (2004) shows empirically that growth of pension funds stimulates private bond finance, notably in developing countries, both in the short and long run.

There is a growing literature on the positive impact of corporate governance initiatives on performance. For example Faccio and Lasfer (2000) show that the monitoring role of UK pension funds is concentrated among mature and low-performing firms. Furthermore, in the long run, the firms in which pension funds have large stakes markedly improve their stock returns (see also Wahal 1996, Del Guercio and Hawkins 1999). Bijlsma et al (2014) suggest that growing pension savings lead to deeper capital markets. They study this effect using data on 69 industrial sectors in 34 OECD countries for the period 2001-2010 through an approach that allows for the interaction of financial development with industry dependence on external finance.[16] They found a significant impact of higher level of pension savings on growth in industrial sectors that are more dependent on external finance, which means higher pension saving may boost economic growth more generally.

(e) Effects on economic growth

A number of empirical papers suggest that there is a positive effect of pension savings on growth directly and via total factor productivity (TFP).[17] A reform to TEE, if it reduces pension saving, may put these wider economic benefits in jeopardy.

---

[16] Technically, this is a difference-in-differences approach that also takes into account unobserved heterogeneity by including country-time, industry-time and industry-country fixed effects.

[17] Kudrna and Woodland (2012) note that in their model of pension tax reform, TEE reduces labour supply due to reduced working hours of middle-age and older working households that face increased income tax rates as contributions are treated under the progressive income taxation. On the other hand, the shift to the EET regime leads initially to higher per capita labour supply, because the current middle-age and older working households supply more labour in order to boost their pension savings.

Davis (2006) undertook empirical work focusing on the nexus of pension funds, population ageing and TFP. Does ageing lead to lower productivity, and can pension funds offset such a tendency by leading to a more dynamic economy as suggested above? Using data for 72 countries, he found pension funds impact positively on TFP. He also found an offsetting negative effect on productivity from ageing, which funding is indeed able at least partly to offset, if past relationships continue to hold. The overall implication for policymakers is that care is needed in tax changes in view of benefits to economic growth that pension funding can bring, especially in the context of adverse effects on economic performance that may arise from ageing.

Further evidence on a link from pension fund assets to economic growth indicators, covering 35 countries is provided in Hu (2004). His work again favours a strong positive link between pension assets and TFP. He suggested that a direct effect (additional to that via financial development) might link to lesser labour distortions following pension reform, and pension funds' increasing participation in corporate governance, thus improving corporate performance at the firm level and economic productivity on the macro level as suggested above.[18]

Davis and Hu (2008) used a dataset covering 38 countries to investigate the direct link between pension assets and economic growth Results showed that a rise in pension assets boosts output per worker initially and then follow a gradual decline, but during the whole specified period, the effect remains positive. The positive effect on output per worker of a shock to pension assets is larger in EMEs and also remains significant for longer than in advanced countries. Furthermore, a positive average long run relationship between pension assets and economic growth across countries is suggested by other advanced econometric approaches estimated with the same dataset.[19]

Bijlsma et al (2013), estimated the relationship between the change in the ratio of pension assets to GDP and economic growth itself, in a range of countries. They found a statistically significant and robust link, suggesting a rise in GDP of 0.24-0.30 percentage points occurs for every 10% rise in the ratio of pension assets to GDP. A larger effect was found in countries such as the UK and the Netherlands with established funded systems of pension provision. These relationships are stable, and there was no indication that a system of funded pensions makes countries more vulnerable during the financial crisis.

---

[18] Estimation results for investment and growth per se are ambiguous and not significant. A further regression for the impact of pension assets on growth over 1996-2002 using initial pension fund assets in 1996 as the causal variable is successful in terms of all three indicators.
[19] Dynamic heterogeneous models and dynamic ordinary least squares models.

(f) Effect on risk sharing

EET is superior to TEE in terms of risk sharing across generations and between retirees and the government. For households, EET reduces their full exposure to a fall in asset prices on retirement. Assuming that financial markets are correlated with housing wealth (the main source of wealth for UK households) a positive covariance would mean that the erosion to risk sharing from TEE would be more than simply for the pension portfolio.[20]

Beetsma et al (2011) show that the government shares with households in the asset market risk under the EET regime, as it risks to get lower taxes if asset prices are low in retirement. This can be seen as economically beneficial. It also potentially increases the appropriate risk level of the pension fund's portfolio, which may be beneficial in terms of long term asset returns and consequent attractiveness of pension saving. This result implies that EET provides more risk capital to the capital markets, which is favourable for entrepreneurship and also implies a more stable corporate sector with potentially a lower debt/equity ratio.

Similarly, Romaniuk (2013) analyses the optimal pension fund portfolio assuming people seek to maximise utility in retirement. The taxes levied under the TEE regime do not affect the amount of portfolio risk, while those under the EET tended to increase risk, consistent with risk sharing with the state. A quantitative impact of development of pension funds on capital markets must arise mainly from differences in behaviour from the personal sector. Pension funds in most cases hold a greater proportion of equities and bonds as a proportion of their assets than households do.[21]

Chen et al (2013) consider the role of intergenerational risk-sharing through retirement income and public debt under EET and TEE (public debt is higher under EET due to tax deferral). It is shown that the potential for intergenerational risk-sharing depends substantially on which taxation regime prevails, with EET involving more beneficial risk sharing across generations than TEE. For example, under TEE low asset prices in retirement mean lower pensions and lower tax revenue to repay public debt (due to the covariance).

(g) Effects on demand for housing

Pensions are typically given tax privileges relative to other forms of saving, inter alia, to offset their illiquidity (they are often locked-up until retirement). In the context of the possible reform of the pension taxation regime from EET to TEE, there is no benefit to pension saving as a form of

---

[20] This arises because VAR(X+Y)=VAR(X)+VAR(Y)+2Cov(V,Y).

[21] For example, in 2013 the share of equities and mutual funds in UK household portfolios was 12% compared with 44% for pension funds.

accumulation of wealth which is unavailable till retirement, as opposed to a much more liquid ISA or housing (which also benefits from TEE treatment). This implies that a shift from EET to TEE would affect the relative attractiveness of pension saving. Given that housing is the most attractive form of holding wealth, the projected ongoing shortage of housing and the potential tax / liquidity advantage in favour of housing, there is a real risk that lower pension saving would be accompanied by greater demand for housing driving house prices higher. The switch in wealth could be considerable with a meaningful impact on house prices and possibly even financial stability. This would transfer wealth from the young to the old thereby deepening the pension challenges noted in Section 1 facing the country. This is one reason why the government subsidy to encourage pension saving under TEE would have to be substantial.

3. MODELLING THE EFFECTS OF TEE VERSUS EET

The question we aim to answer in this section is the impact on personal savings and the overall macroeconomy of switching from an EET to a TEE pension tax system. Higher personal saving is one of the four principles the Government explicitly states for the reforms, along with being mindful of the economic consequences (HMT cm9102 and see Section 1). To make an informed assessment requires understanding the impact on the change in consumption, labour supply, real interest rates and investment. In Section 2 we noted that most evidence in the academic literature on TEE is that private savings fall. However, all economies and pension systems are different and the impact will be economy specific. In this section we develop a general equilibrium OLG model to examine the impact of moving from EET to a TEE pension taxation system.

Another principle for assessing a possible switch in pension tax policy is its consistency with the government's fiscal strategy. We assume that any change in government revenue is offset through changes in government spending (and consumption taxes) to have a balanced impact on the budget.

OLG models are ideally suited for the analysis of life-cycle issues such as pensions, as they allow several cohorts or generations to be alive and interacting at once. General equilibrium allows us to capture all the complex feedback effects between taxes, savings decisions, and other variables such as investment, productivity, output (GDP), wages and interest rates. However, we note at the outset that we have made some important simplifications to make the model tractable and solvable while illustrating the key relationships. In particular we abstract from uncertainty and we do not include a bequest motive.[22] Adding uncertainty would be particularly useful as this would highlight the importance of risk sharing discussed in Section 2.

(a) Model setup

In each period a cohort of identical individuals is born. Individuals live for 3 periods with certainty. They work for the first 2 periods, and retire in the remaining period. We take period length to be 20 years, for a working life of 40 years. Individuals seek to maximise utility from consumption, and disutility from supplying labour. Our agents maximize the discounted sum of lifetime utilities:

---

[22] Bequests clearly occur, but the strength of the bequest motive is open to question. Dynan, Skinner and Zeldes (2004) show that households report only 8% of bequests are due to wishing to bequeath an estate. So-called 'accidental bequests' occur if savings are held for precautionary reasons and death happens first.

$$\max_{\{c_s,l_s\}_{s=1}^{S}} \sum_{s=1}^{3} \beta^{s-1} u(c_s, l_s) = u(c_1, l_1) + \beta u(c_2, l_2) + \beta^2 u(c_3, l_3)$$

Working-aged agents choose how much labour to supply, how much to consume and by extension how much to save for retirement. Saving take the form of long-term pension savings, which may not be accessed until retirement.[23]

A working agent of productivity type j's budget constraint in lifecycle period $s = 1{,}2$ and at date t is:

$$(1 + \tau_c) c_{s,j,t} + s_{s,j,t} = w_{j,t} l_{s,j,t} - T\left(w_{j,t} l_{s,j,t}, s_{s,j,t}\right)$$

where $c_{s,j,t}$ is consumption of a type j agent in life period s at date t, $s_{s,j,t}$ are fixed or non-accessible long-term pension savings, $w_{j,t}$ is the date t wage for an agent with productivity type j, with $w_{j,t} = \rho_j w_t$. Labour supply $l_{s,j,t}$ is elastic for the first two periods, and is assumed to be zero in the third and final period. Income tax liabilities $T\left(w_{j,t} l_{s,j,t}, s_{s,j,t}\right)$ depend upon labour income, and possibly on the amount of pension savings.

Pension savings accumulate into a pension capital stock

$$k_{s,j,t+1} = k_{s,j,t}(1 + r_{t+1} - \delta) + s_{s,j,t}(1 + \tau_b)$$

where $k_{s,j,t+1}$ is the pension capital stock for type j agent in life period s at the beginning of date $t + 1$, r_{t+1} is the rate of return on capital, δ is the depreciation rate, and τ_b is a top-up or subsidy to pension savings under the TEE system. Under EET $\tau_b = 0$. Agents begin life with zero capital, so $k_{1,j,t} = 0$. As they also do not wish to leave any bequests, so $k_{4,j,t+3} = 0$.

The pension capital stock follows the accumulation equations:

$$k_{2,j,t+1} = s_{1,j,t}$$

$$k_{3,j,t+2} = k_{2,j,t+1}(1 + r_{t+2} - \delta) + s_{2,j,t+1}$$

$$k_{4,j,t+3} = k_{3,j,t+2}(1 + r_{t+3} - \delta) + s_{3,j,t+2} = 0$$

where δ is the period-to-period rate of depreciation of the capital stock. Agents are not allowed to draw down their pensions until retirement, so we impose the restriction that pension savings for the working aged must be non-negative: $s_{1,j,t}, s_{2,j,t+1} \geq 0$.

[23] We allow for fully accessible short-term savings, which are not tax-advantaged. Such fully accessible short-term savings are made out of taxed income, the returns are taxed, but any income withdrawn is tax-free (taxed, taxed, exempt or TTE). In a model with certainty, however, there is no reason to use short-term savings, as there are no short-run fluctuations in income to even out or insure against. Agents do not use them as a long-run savings vehicle, because they provide a lower after-tax return than the tax-advantaged pension.

In retirement period $s = 3$, individuals consume pension savings $k_{3,j,t+2}(1 + r_{t+3} - \delta)$, along with a tax-financed state pension $\tilde{b}$. The income drawn from pension savings may be taxed.[24]

$$(1 + \tau_c)c_{3,j,t+2} = (1 + r_{t+3} - \delta)k_{3,j,t+2} + \tilde{b} - T\left((1 + r_{t+3} - \delta)k_{3,j,t+2}\right)$$

(b) Modelling UK pension taxation

In this section we consider the two tax relief regimes for long-term pension savings. We begin by summarising three different types of tax payers and the UK income tax and NIC regime.

Income tax is progressive. The tax relief offered by EET depends upon the individual's tax rate and income. We allow for three types of agents, who represent the average basic rate, higher rate and additional rate taxpayers. Agents differ by their productivity with $\rho_1 < \rho_2 < \rho_3$, and as a result their wages also differ with the lowest productivity agent earning least $w_1 < w_2 < w_3$. Wages are chosen to match average incomes in each tax band.[25] The shares of each type of agent in the economy are chosen to match HMRC data on numbers taxpayers in each tax band.[26] 78.4% of working aged tax-payers pay the basic rate, while 20.1% are in the higher rate band, and 1.5% are additional rate taxpayers with taxable incomes in excess of £150,000 annually (see Table 1).

Table 1: The UK Tax System and Average Incomes within Each Tax Band

	UK Tax System				Working-Aged Individuals	
	Income	**Income Tax Rate**	**NI Rate**	**NI Rate Pensioners**	**Average Income**	**Share of Working Age**
Tax-free	< £10,600	0%	0%	0%	-	-
Basic rate	£10,600 to £42,465	20%	12%	0%	£21,920	78.4%
Higher Rate	£42,466 to £150,000	40%	2%	0%	£54,191	20.1%
Additional Rate	> £150,000	5%	2%	0%	£257,965	1.5%

Taxes are modelled on the UK income tax system. Income up to £10,600 is tax-free, income between £10,600 and £42,465 is taxed at the basic rate of 20%, income between £42,466 and £150,000 is taxed at the higher rate of 40%, while income in excess of £150,000 is taxed at the 45% upper rate

24 We assume that pension income is subject to income tax but not National Insurance contributions.

25 HMRC, Income Tax Liabilities Statistics, 2011-12 to 2014-15, Table 2.6 reports tax liabilities in each band, from which taxable income can be inferred. Average pension contributions for each band, from HMRC Table 3.8, are added to taxable income to obtain gross incomes.

26 Total numbers of individuals in each tax band can be calculated from HMRC Table 2.6. We are interested in the total numbers of working aged individuals in each tax band, so we subtract pensioners with taxable income, using data from HMRC Table 3.8.

(see Table 1). In addition, basic rate income is subject to National Insurance (NI) at a rate of 12%, while income in excess of the higher rate threshold of £42,465 is subject to a lower NI rate of 2%. Income of pensioners is subject to income tax, but not to NI. We assume 3 types of tax-payer corresponding to average income earners within each of the income tax bands. For example, the basic rate taxpayer has the average income taken across all UK basic rate taxpayers.

As summarised in Section 1, under the current EET system a fraction of pension income (currently 25%) can be drawn down as a tax-free lump-sum making that sum effectively EEE. Under TEE contributions to the pension are made out of taxed income and possibly topped up by a pension savings subsidy of τ_b. In the remainder of this section, we model the implications of switching from EET to TEE, for a range of top-up subsidies τ_b to pension savings under TEE.

(c) Exempt-Exempt-Taxed (EET) – Current UK system

Under the EET regime, pension savings $s_{s,j,t}$ can be deducted from taxable income. Under the UK tax system, the working aged agent's budget constraints become:

$$(1+\tau_c)c_{1,j,t} + s_{1,j,t} = w_{j,t}l_{1,j,t} - \tau_l^j\left(w_{j,t}l_{1,j,t} - s_{1,j,t}\right) + T_j \tag{1}$$

$$(1+\tau_c)c_{2,j,t+1} + s_{2,j,t+1} = w_{j,t+1}l_{2,j,t+1} - \tau_l^j\left(w_{j,t+1}l_{2,j,t+1} - s_{2,j,t+1}\right) + T_j \tag{2}$$

where τ_l^j is agent j's marginal tax rate, and T_j is a lump-sum term which accounts for lower rates of tax on the first tranches of income.[27] T_j satisfies;

$$T_j = \begin{cases} \tau_{l,1}\bar{y}_1 & basic\ rate \\ \tau_{l,1}\bar{y}_1 + \tau_{l,2}\bar{y}_2 & higher\ rate \\ \tau_{l,2}\bar{y}_2 + \tau_{l,3}\bar{y}_3 & additional\ rate \end{cases}$$

Substituting out for savings, working age budget constraints become:

$$(1+\tau_c)c_{1,j,t} = \left(1-\tau_l^j\right)w_{j,t}l_{1,j,t} - \left(1-\tau_l^j\right)k_{2,j,t+1} + T_j \tag{1'}$$

$$(1+\tau_c)c_{2,j,t} = \left(1-\tau_l^j\right)w_{j,t+2}l_{2,j,t+1} - \left(1-\tau_l^j\right)\left[k_{3,j,t+2} - k_{2,j,t+1}\left(1+r_{t+2}^f - \delta\right)\right] + T_j \tag{2'}$$

Agents are not allowed to draw down their pensions until retirement, so we impose the restriction that pension savings for the working aged must be non-negative: $s_{1,j,t}, s_{2,j,t+1} \geq 0$. This translates into restrictions on the pension capital stocks: $k_{2,j,t+1} \geq 0$ and $k_{3,j,t+2} \geq k_{2,j,t+1}\left(1+r_{t+2}^f - \delta\right)$.

[27] The tax functions are derived in Annex 1.

In retirement period 3, all savings and the state pension (financed out of tax revenues) are consumed. 25% of pension savings are tax-free under the UK's current EET system, while the remainder is taxed as income. Agents also receive a fixed state pension $\tilde{b}$ which is taxable. This leaves the retirement budget constraint as:

$$(1+\tau_c)c_{3,j,t+2} = (1+r_{t+3}-\delta)k_{3,j,t+2}\left(1-\tau_{l,j,ret}0.75\right) + \tilde{b}\left(1-\tau_{l,j,ret}\right) + T_{j,ret} \tag{3}$$

where once again $T_{j,ret}$ is a lump-sum refund of personal allowance at agent *j*'s retirement tax band, and $\tau_{l,j,ret}$ is the marginal tax rate in retirement for agent type j. For agents whose retirement income is below the lower rate threshold of £10,600, $\tau_{l,j,ret} = T_{j,ret} = 0$.

To solve the household's problem we assume standard preferences over consumption and leisure, which satisfy:

$$u(c) = \frac{(c^{\gamma}(1-l)^{1-\gamma})^{1-\sigma}}{1-\sigma}$$

Agent type *j*'s date t optimisation problem is:

$$\max_{\substack{k_{1,j,t+1},k_{2,j,t+2}\\ l_{1,j,t},l_{2,j,t+1}}} \frac{\left(c_{1,j,t}{}^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta\frac{\left(c_{2,j,t+1}{}^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta^2\frac{\left(c_{3,j,t+2}{}^{\gamma}\right)^{1-\sigma}}{1-\sigma}$$

subject to budget constraints (1), (2) and (3), as well as to the non-negativity constraints for pension savings:

$$s_{1,j,t} = k_{2,j,t+1} \geq 0$$

$$s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}\left(1+r_{t+2}^{f}-\delta\right) \geq 0$$

This leads to four Euler equations. The first two Euler equations describe the individual's optimal labour-leisure choice in the two working-aged periods $s = 1,2$:

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}w_{j,t} = \frac{1-\gamma}{\gamma}\frac{c_{1,j,t}}{1-l_{1,j,t}} \tag{4}$$

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}w_{j,t+1} = \frac{1-\gamma}{\gamma}\frac{c_{2,j,t+1}}{1-l_{2,j,t+1}} \tag{5}$$

The second two Euler equations describe the individual's optimal consumption-savings choice in the two working-aged periods $s = 1,2$. At each date, individuals weight the benefits between current and future consumption to find the optimal savings and capital stocks. For an interior solution (i.e. strictly positive savings in both periods, $s_{1,j,t} > 0$ and $s_{2,j,t+1} > 0$), the Euler equations for pension capital stocks are:

$$1 = \beta \left(\frac{1-l_{2,j,t+1}}{1-l_{1,j,t}}\right)^{(1-\gamma)(1-\sigma)} \left(\frac{c_{2,j,t+1}}{c_{1,j,t}}\right)^{\gamma(1-\sigma)-1} (1 + r_{t+2} - \delta) \tag{6}$$

$$1 = \beta \left(\frac{1}{(1-l_{2,j,t+1})}\right)^{(1-\gamma)(1-\sigma)} \left(\frac{c_{3,j,t+2}}{c_{2,j,t+1}}\right)^{\gamma(1-\sigma)-1} (1 + r_{t+3} - \delta) \frac{(1-0.75\tau_{l,j,ret})}{(1-\tau_l^j)} \tag{7}$$

In the model economies, we sometimes encountered corner solutions (no longer a trade-off between consumption), in which some types of individuals choose to set second period pension savings to zero. For a corner solution with $s_{2,j,t+1} = 0$, the pension savings Euler equations are:

$$\frac{(1-\tau_l^j)}{(1+\tau_c)} \gamma (1 - l_{1,j,t})^{(1-\gamma)(1-\sigma)} (c_{1,j,t})^{\gamma(1-\sigma)-1} = \beta \frac{(1-\tau_l^j)}{(1+\tau_c)} \gamma \left(c_{2,j,t+1}\right)^{\gamma(1-\sigma)-1} (1 + r_{t+2} - \delta) + \beta \mu_{j,t+1} (1 + r_{t+2} - \delta) \tag{8}$$

$$\frac{(1-\tau_l^j)}{(1+\tau_c)} \gamma (c_{2,j,t+1})^{\gamma(1-\sigma)-1} (1 - l_{2,j,t+1})^{(1-\gamma)(1-\sigma)} = \beta \frac{(1-0.75\tau_{l,j,ret})}{(1+\tau_c)} \gamma (c_{3,j,t+2})^{\gamma(1-\sigma)-1} \cdot (1 + r_{t+3} - \delta) - \mu_{j,t+1} \tag{9}$$

where $\mu_{j,t+1} < 0$ is a Lagrange multiplier and $s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}\left(1 + r_{t+2}^f - \delta\right) = 0$.

(d) Taxed-Exempt-Exempt (TEE) – possible system

Under the TEE regime with elastic labour supply, a young agent's budget constraint shows pension savings are made out of taxed income:

$$c_{1,j,t} + s_{1,j,t} = w_{j,t} l_{1,j,t} (1 - \tau_l^j) + T_j \tag{10}$$

$$c_{2,j,t+1} + s_{2,j,t+1} = w_{j,t+1} l_{2,j,t+1} (1 - \tau_l^j) + T_j \tag{11}$$

Agents own the capital stocks, which accumulate during their working life as:

$$k_{s+1,j,t+1} = k_{s,j,t}(1 + r_{t+1} - \delta) + s_{s,j,t}(1 + \tau_b)$$

where τ_b is a 'top-up' or subsidy to long-term pension savings, of the kind which has been suggested by the PPI and mentioned as a possibility by HMT. In line with these proposals, we assume that τ_b is the same for all agents. Agents begin life with zero capital $k_{1,j,t} = 0$. They also do not wish to leave any bequests, so $k_{4,j,t+3} = 0$.

The pension capital stocks follow the accumulation equations:

$$k_{2,j,t+1} = s_{1,j,t}(1 + \tau_b)$$

$$k_{3,j,t+2} = k_{2,j,t+1}(1 + r_{t+2} - \delta) + s_{2,j,t+1}(1 + \tau_b)$$

where δ is the period-to-period rate of depreciation of the capital stock. Agents are not allowed to draw down their pensions until retirement, so we impose the restriction that pension savings for the working aged must be non-negative: $s_{1,j,t}, s_{2,j,t+1} \geq 0$. Substituting out for savings in the working-aged budget constraints for TEE with pension savings top-up rate τ_b becomes:

$$c_{1,j,t} + \frac{k_{2,j,t+1}}{1+\tau_b} = w_{j,t}\left(1 - \tau_l^j\right) + T_j \tag{10'}$$

$$c_{2,j,t+1} + \frac{k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta)}{1+\tau_b} = w_{j,t+1}\left(1 - \tau_l^j\right) + T_j \tag{11'}$$

In retirement, agents consume their accumulated pension and accessible capital stocks. Agents also receive a state pension of $\tilde{b}$ each period, which is financed out of tax revenues. The budget constraint for retirement periods $\bar{s}+1, \ldots \bar{s}+n = S$ becomes:

$$c_{3,j,t+2} = (1 + r_{t+3} - \delta)k_{3,j,t+2} + \tilde{b} \tag{12}$$

Since pension income is not taxable under TEE, the only taxable income is the state pension $\tilde{b}$. However, the full state pension lies below the personal allowance, so we assume that it is not taxed.

To solve the individual's problem, the agent chooses capital stocks $k_{2,j,t+1}, k_{3,j,t+2}$ and labour supplies $l_{1,j,t}, l_{2,j,t+1}$ to maximize:

$$\max_{\substack{k_{1,j,t+1},k_{2,j,t+2}\\ l_{1,j,t},l_{2,j,t+1}}} \frac{\left(c_{1,j,t}{}^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta\frac{\left(c_{2,j,t+1}{}^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta^2\frac{\left(c_{2,j,t+1}{}^{\gamma}\right)^{1-\sigma}}{1-\sigma}$$

subject to the budget constraints (10), (11) and (12), and the non-negativity constraints on pension savings: $s_{1,j,t} \geq 0$ and $s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}(1 + r_{t+2} - \delta) \geq 0$

Solving this problem (Annexe 3) leads to four Euler equations. The first two Euler equations describe the individual's optimal labour-leisure choice in the working-aged periods $s = 1,2$:

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}w_{j,t} = \frac{1-\gamma}{\gamma}\frac{c_{1,j,t}}{1-l_{1,j,t}} \tag{13}$$

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}w_{j,t+1} = \frac{1-\gamma}{\gamma}\frac{c_{2,j,t+1}}{1-l_{2,j,t+1}} \tag{14}$$

The second two Euler equations describe the individual's optimal consumption-savings choice in the two working-aged periods $s = 1,2$. At each date, individuals weight the benefits between current and future consumption to find the optimal savings and capital stocks. For an interior solution (i.e. strictly positive savings in both periods, $s_{1,j,t} > 0$ and $s_{2,j,t+1} > 0$), the Euler equations for pension capital stocks are:

$$1=\beta\left(\frac{1-l_{2,j,t+1}}{1-l_{1,j,t}}\right)^{(1-\gamma)(1-\sigma)}\left(\frac{c_{2,j,t+1}}{c_{1,j,t}}\right)^{\gamma(1-\sigma)-1}(1+r_{t+2}-\delta) \tag{15}$$

$$1=\beta\left(\frac{c_{3,j,t+2}}{c_{2,j,t+1}}\right)^{\gamma(1-\sigma)-1}\left(\frac{1}{(1-l_{2,j,t+1})}\right)^{(1-\gamma)(1-\sigma)}(1+r_{t+3}-\delta)(1+\tau_b) \tag{16}$$

In the TEE model economies, we sometimes encountered corner solutions, in which some types of individuals choose to set second period pension savings to zero. For a corner solution with $s_{2,j,t+1}=0$, the pension savings Euler equations are:

$$\gamma\frac{(1-l_{2,j,t+1})^{(1-\gamma)(1-\sigma)}(c_{2,j,t+1})^{\gamma(1-\sigma)-1}}{(1+\tau_c)(1+\tau_b)}=\beta\gamma\frac{(c_{3,j,t+2})^{\gamma(1-\sigma)-1}}{(1+\tau_c)}(1+r_{t+3}-\delta)-\mu_{j,t+1} \tag{17}$$

$$\gamma\frac{(1-l_{1,j,t})^{(1-\gamma)(1-\sigma)}(c_{1,j,t})^{\gamma(1-\sigma)-1}}{(1+\tau_c)(1+\tau_b)}=$$

$$\beta\left[\gamma\frac{(1-l_{2,j,t+1})^{(1-\gamma)(1-\sigma)}(c_{2,j,t+1})^{\gamma(1-\sigma)-1}}{(1+\tau_c)(1+\tau_b)}+\mu_{j,t+1}\right](1+r_{t+2}-\delta) \tag{18}$$

where $k_{3,j,t+2}=k_{2,j,t+1}(1+r_{t+2}-\delta)$ and $\mu_{j,t+1}<0$ is the Lagrange multiplier.[28]

(e) Firms

There is a unit measure of identical, perfectly competitive firms. Firms employ labour at wage w_t and capital at rental rate r_{t+1}. The firm's period t problem is:

$$\max_{L_t,K_t} A_t(L_t)^{1-\alpha}(K_t)^{\alpha}-r_tK_t-w_tL_t$$

where labour L_t is effective labour, weighted by agents' productivities.

$$w_tL_t=\sum_{s=1,2}\sum_{j=1,2,3}w_t\pi_j\rho_jl_{s,j,t}$$

This leads to aggregate factor prices which are equal to their marginal products.

$$r_t=\alpha A_t\left(\frac{K_t}{L_t}\right)^{\alpha-1} \tag{19}$$

$$w_t=(1-\alpha)A_t\left(\frac{K_t}{L_t}\right)^{\alpha} \tag{20}$$

This implies that an individual with productivity ρ_j has a wage rate $w_{j,t}=\rho_jw_t$.

[28] The Lagrange multiplier on a constraint is the shadow value of the constraint, or a measure of how much utility agents would be willing to give up to loosen the constraint in question.

(f) Government

There is no government debt, so the government must run a balanced budget, financing state pension expenditures B_t and other government expenditures G_t out of current tax revenues. Under EET, tax revenues are raised on labour income net of pension savings, on 75% of retirement income, and from the consumption tax. This leads to the government budget constraint:

$$G_t + B_t = \left[\sum_{j=1,2,3} \pi_j \begin{pmatrix} \tau_l^j (w_{j,t} l_{1,j,t} - s_{1,j,t}) - T_j + \tau_l^j (w_{j,t} l_{2,j,t} - s_{2,j,t}) - T_j \\ +0.75 \tau_{l,ret}^j k_{3,j,t} - T_{j,ret} \end{pmatrix}\right] + \tau_C C_t \quad (21)$$

Under TEE, tax revenues are composed of labour income tax revenues, net of the pension savings subsidy, and consumption tax revenues. The government's budget constraint is given by

$$\bar{G} + \bar{B} = \left[\sum_{j=1,2,3} \pi_j \left(\tau_l^j w_{j,t} l_{1,j,t} - T_j + \tau_l^j w_{j,t} l_{2,j,t} - T_j\right)\right] - \tau_b S_t + \tau_c C_t \quad (22)$$

Government expenditures are assumed to enter separably into agents' utility, so they do not show up in the optimisation problems.

(g) Market Clearing

There are three markets: goods, labour and capital. Market clearing conditions for labour and capital markets are

$$L_t = \sum_{j=1,2,3} \sum_{s=1}^{2} \pi_j \rho_j l_{s,j,t} = \sum_{j=1,2,3} \pi_j \rho_j \left(l_{1,j,t} + l_{t,j,2}\right) \quad (23)$$

$$K_t = \sum_{j=1,2,3} \sum_{s=2}^{3} \pi_j k_{s,j,t} = \sum_{j=1,2,3} \pi_j \left(k_{2,j,t} + k_{3,j,t}\right) \quad (24)$$

Recalling that initial pension savings are zero, $k_{1,j,t} = 0$, and labour supply in retirement is also zero, $l_{t,j,3} = 0$. By Walras' law, the goods market clearing condition is redundant:

$$Y_t = C_t + S_t + B_t + G_t$$

where S_t is aggregate savings/investment, B_t are aggregate pension payments, and G_t is government spending.

(h) Equilibrium

In an equilibrium, all household types choose pensions savings and labour supply optimally, firms maximize profits, the government balances its budget and markets clear.

For each tax system (EET and TEE) there are twelve non-linear functional equations in the twelve variables $\left(k_{2,j,t+1}, k_{3,j,t+2}, l_{1,j,t}, l_{2,j,t}\right)_{j=1,2,3}$. We evaluate the twelve equations at the steady state and solve the system of non-linear equations using Matlab's *fsolve* routine.

4. RESULTS

Parameters are set in line with key data on the UK economy. Productivities are set so that labour earnings of the three agent types match those of the average basic rate, higher rate and additional rate taxpayer. Shares of agent types in the economy also match the shares of working-aged taxpayers in each tax band. Setting the state pension to 20% of the average labour earnings is equivalent to setting it to £116 weekly, roughly in line with state pension rates. The weight on leisure is chosen so that agents work approximately 1/3 of their time. Period length is 20 years. The other parameters are entirely standard and usual values used in the applied economics literature.

Parameter	Description	Value
σ	Consumption smoothing	1.5
γ	Weight on leisure	0.36
β	Discount factor, 0.99 annually	0.99^{20}
A	Technology level, normalise	2
α	Capital share of income	36%
δ	Depreciation rate, ≈0.10 annually	0.90
(ρ_1, ρ_2, ρ_3)	Productivities	(0.727, 1.797, 8.553)
(π_1, π_2, π_3)	Shares of agents in economy	(0.784, 0.201, 0.015)
τ_c	Consumption + excise tax rate	0.33
$\tilde{b}$	State pension	$20\% \cdot w\bar{l}$

(a) Headline aggregate results

The macroeconomic results from the simulation exercise are shown in Table 4a and 4b and illustrated in Figure 4a. The first vertical column shows the variable of interest (cited in Section 3) and column 2 shows the model results under the current EET system. The steady state values are well within expected levels. The next six columns show the variable outcomes for the TEE taxation system under different scenarios for the pension subsidy (to compensate for pension illiquidity). Comparing the two tax systems is easiest in Table 4b where the EET values have been standardised at 100, therefore the difference with the TEE variables are percentage variation.

Moving from EET to TEE leads to declines in aggregate GDP, investment (savings), productivity and real wages, and to an increase in the real interest rate up to a pension subsidy of 50%. Aggregate consumption also falls in all the TEE cases, except for the most generous pension tax subsidy of 50%. These are strong results and consistent with most of the findings cited in the literature review in Section 2. We note that for a subsidy of 20% the decline in consumption is 6% and this is without the impact of inferior risk sharing properties of EET or the possible substitution into other TEE assets such as housing. While the government function has been set-up to have no impact on debt issuance, the higher real interest rate would result in higher interest payments on government debt.

The intuition for the results is that the shift from EET to TEE shifts the tax burden to working-aged agents, reducing the after-tax income that they can allocate between consumption and savings. As a result, both consumption and savings fall. The lower saving reduces the amount of investment and results in a smaller steady state capital stock. The fall in the capital to labour ratio implies a higher real interest rate, lower labour productivity and a lower real wage rate.

An income effect would induce agents to increase labour supply, to recoup some of the income lost due to the tax changes. However, the fall in real wages also causes the price of leisure to fall, depressing labour supply by the substitution effect. In the aggregate, the income and substitution effects are roughly equal leading to little change in the labour supply. However, as we see below, the labour supply response by each cohort is markedly different.

(b) Intergenerational effects

In the model, agents wish to front-load their savings into the first part of their working life, in order to benefit from the 'accumulation effect'. That is, agents recognise that a given amount of savings made as a younger working aged person makes a greater contribution to future pension income than the same amount of savings made as an older working aged person. The desire to front-load savings, coupled with the desire to smooth consumption over the lifetime, makes the agents' budget constraint particularly tight whilst younger working-aged. That is, all other things equal, the shadow value of increasing income is higher for the young working aged.

Shifting from EET to TEE front-loads the income tax burden, away from retirees and especially onto younger working aged agents, taking income away from younger agents just at the point when their budget constraint is tightest. The impact of moving to TEE on after-tax incomes, labour supply and saving is illustrated in Figure 4b and Tables 4c and 4d respectively. Younger agents compensate for this withdrawal of resources to some extent by increasing their labour supply, despite a lower wage (Figure 4c).The saving of working aged agents drops strongly (Figure 4d) for three reasons:

1) The greater tax burden in the first period of working life means that these working aged agents have less after-tax income to allocate between consumption and savings, so they save less.

2) The lack of taxation when old means that agents can save less than under EET in order to achieve the same retirement consumption.

3) The higher interest rate under TEE means that agents need to save less than under EET to achieve the same retirement capital stock, reducing savings.

Consumption patterns also shift. Agents consume less while working and (relatively) more when retired (Tables 4c and 4d). When the TEE subsidy to pension savings reaches 40%, consumption in retirement rises in absolute terms compared to EET. However, lifetime consumption still declines, as the increase in retirement consumption is outweighed by working aged declines. Moreover, the increases in retirement consumption are almost exclusively due to increases in retirement consumption by the richest 1.5%, with retirement consumption dropping for basic and higher rate taxpayers in all but the (unrealistic) 50% tax subsidy case (Tables 4e and 4f).

(c) Distributional consequences of the shift to TEE

While the TEE system does shift some income tax burden from basic and higher rate taxpayers onto the highest earning additional rate taxpayers, it does so at the cost of reducing lifetime consumption for lower earning basic rate and higher rate taxpayers for all but the most generous tax-subsidy TEE case. If the subsidy to pension savings is 20%, then the basic rate taxpayer's lifetime consumption falls to 95.6% of its EET level. Additional rate taxpayers are also made worse off, with the exception of the scenarios in which the subsidy to pension savings is 40% or greater. Savings drop most for the highest earners, and least for the lowest earning basic rate taxpayer.

5. CONCLUSION

The Government consultation paper (HMT cm9102) sets out four principles that reform of pension taxation should meet, as well as being mindful of the macroeconomic consequences (in particular on long-term investment and financial markets). Reforms must be:

- simple and transparent;
- allow individuals to take personal responsibility;
- build on the success of auto-enrolment and encourage new people to save more;
- be sustainable and in line with the government's long term fiscal strategy.

We have presented conceptual, empirical and modelling evidence to assess whether the proposal of changing the taxation of pensions from the current EET system to TEE (plus a government subsidy) is likely to meet these principles. We created a general equilibrium OLG model with parameter values matching the UK economy to test the evidence from the literature within a UK context.

In a country with a progressive taxation system and a flexible labour supply EET will, in general, result in higher pension saving. While there is some offset in other forms of saving, personal saving is found to be higher under EET. These findings are supported by our modelling analysis. Personal savings and output were lower under a TEE system in all reasonable scenarios of subsidies. Even with a 20% pension subsidy output is estimated to be 9% lower under TEE when all transitions are complete. Our distribution analysis suggests the consequences are greatest for younger cohorts.

The EET has superior risk sharing properties and higher saving leads to more investment in equities and long-term debt. As well as providing greater funding for higher risk investment, deeper and longer term capital markets and improved pension fund governance have been found to lead to improvements in productivity. Our modelling analysis shows lower investment and productivity under a TEE pension taxation system than the status quo. Higher real interest rates under TEE would lead to higher funding costs for the government.

By changing the taxation of pensions to TEE, the tax treatment will be similar to ISAs and housing wealth, but much less liquid. There is a risk of considerable substitution into other TEE savings, in particular housing. This can only be offset by a significant subsidy to encourage pension saving.

There is a dynamic inconsistency problem inherent in TEE because a future government can always reverse policy and remove the subsidy, or re-introduce taxation on pension income. Given the pension challenges ahead, a government cannot credibly commit not to exploit this time inconsistency. Given the inferior risk sharing and credible commitment problem, individuals are less, rather than more, able to take personal responsibility.

Table 4a: EET vs TEE - Aggregate variables, levels

Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
Y	1.096	0.936	0.967	0.997	1.032	1.058	1.081
K	0.309	0.203	0.223	0.243	0.266	0.282	0.298
I	0.208	0.119	0.134	0.150	0.173	0.186	0.199
C	0.574	0.511	0.525	0.539	0.551	0.565	0.579
L	0.703	0.697	0.697	0.696	0.696	0.700	0.703
Y/L	1.558	1.343	1.388	1.432	1.483	1.512	1.539
w	0.927	0.801	0.828	0.854	0.881	0.899	0.915
r annual	1.6%	2.9%	2.6%	2.3%	2.0%	1.9%	1.7%
T	0.314	0.306	0.307	0.308	0.308	0.307	0.304

Where Y = output, K = capital stock, I = investment, C = consumption, L = labour supply, Y / L = productivity, w = real wage rate, r is the annual interest rate and T is aggregate tax revenues.

Table 4b: EET vs TEE - Aggregate variables, % of EET levels

Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
Y	100.0	85.4	88.2	91.0	94.2	96.5	98.6
K	100.0	65.7	72.2	78.6	86.1	91.3	96.4
I	100.0	57.2	64.4	72.1	83.2	89.4	95.7
C	100.0	89.0	91.5	93.9	96.0	98.4	100.9
L	100.0	99.1	99.1	99.0	99.0	99.6	100.0
Y/L	100.0	86.2	89.1	91.9	95.2	97.0	98.8
w	100.0	86.4	89.3	92.1	95.0	97.0	98.7
r annual	1.6%	2.9%	2.6%	2.3%	2.0%	1.9%	1.7%
T	100.0	97.5	97.8	98.1	98.1	97.8	96.8
T_1	100.0	176.6	166.0	154.3	140.4	125.5	112.8
T_2	100.0	94.7	98.2	101.6	105.3	107.0	105.3
T_3	100.0	0.0	0.0	0.0	0.0	0.0	0.0
T_C	100.0	89.4	91.5	94.2	96.3	98.9	101.1

T are aggregate tax revenues, T_1 are the tax revenues collected from the younger cohort of working aged agents, T_2 from the middle cohort of the older working aged, and T_3 from pensioners. T_C are the tax revenues from consumption and excise taxes. The top panel presents the results in units of the consumption good. The bottom panel presents results for TEE as a percentage of the corresponding EET equilibrium value, with the exception of the annual interest rate.

Table 4c: EET vs TEE - Cohort analysis, levels

Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
w	0.927	0.801	0.828	0.854	0.881	0.899	0.915
L_1	0.377	0.391	0.391	0.391	0.392	0.387	0.382
L_2	0.326	0.305	0.305	0.305	0.304	0.313	0.321
wL_1	0.376	0.337	0.349	0.359	0.371	0.373	0.375
wL_2	0.326	0.262	0.270	0.279	0.290	0.304	0.317
S_1	0.115	0.074	0.076	0.078	0.081	0.078	0.075
S_2	0.036	0.000	0.000	0.000	0.001	0.010	0.018
C_1	0.161	0.136	0.141	0.145	0.150	0.154	0.158
C_2	0.175	0.156	0.161	0.166	0.171	0.172	0.174
C_3	0.238	0.219	0.224	0.228	0.230	0.239	0.248
T_1	0.047	0.083	0.078	0.073	0.066	0.059	0.053
T_2	0.057	0.054	0.056	0.058	0.060	0.061	0.060
T_3	0.021	0.000	0.000	0.000	0.000	0.000	0.000

Table 4d: EET vs TEE - Cohort analysis, % of EET levels

Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
w	100.0	86.4	89.3	92.1	95.0	97.0	98.7
L_1	100.0	103.7	103.7	103.7	104.0	102.7	101.3
L_2	100.0	93.6	93.6	93.6	93.3	96.0	98.5
wL_1	100.0	89.6	92.8	95.5	98.7	99.2	99.7
wL_2	100.0	80.4	82.8	85.6	89.0	93.3	97.2
S_1	100.0	64.3	66.1	67.8	70.4	67.8	65.2
S_2	100.0	0.0	0.0	0.0	2.8	27.8	50.0
C_1	100.0	84.5	87.6	90.1	93.2	95.7	98.1
C_2	100.0	89.1	92.0	94.9	97.7	98.3	99.4
C_3	100.0	92.0	94.1	95.8	96.6	100.4	104.2
T_1	100.0	176.6	166.0	155.3	140.4	125.5	112.8
T_2	100.0	94.7	98.2	101.8	105.3	107.0	105.3
T_3	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Cohort 1 is younger working aged, cohort 2 is older working aged and cohort 3 is retirement. . The top panel presents the results in units of the consumption good. The bottom panel presents results for TEE as a percentage of the corresponding EET equilibrium value, with the exception of the annual interest rate.

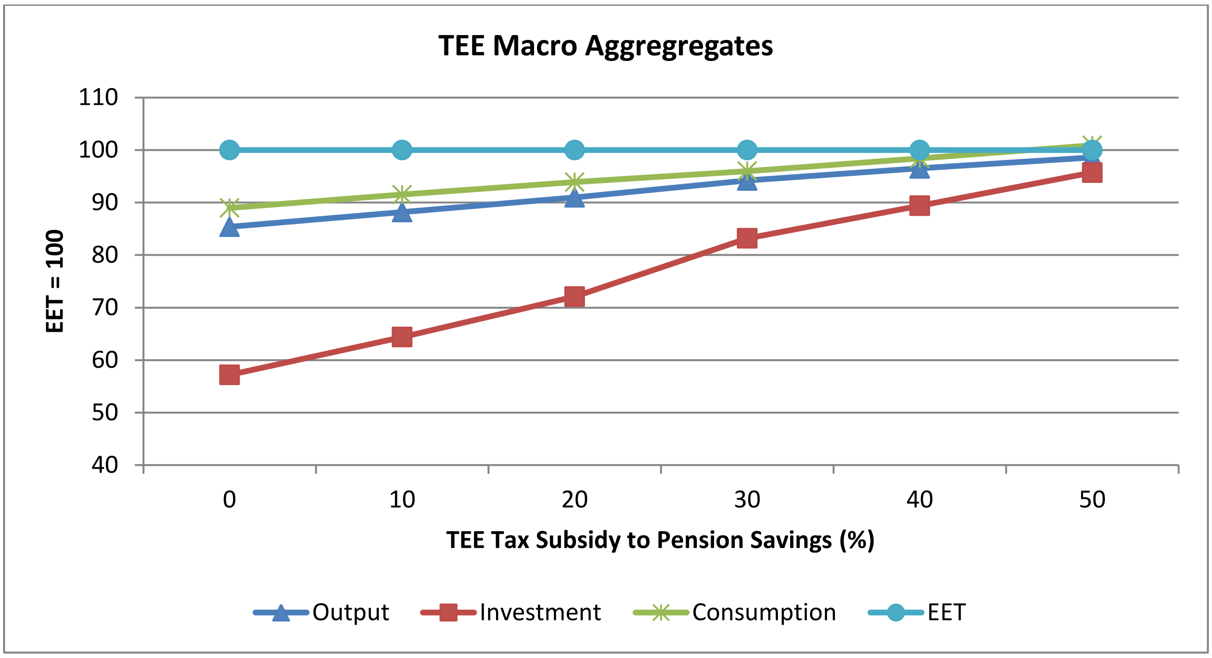
Table 4e: EET vs TEE - Distributional analysis, levels

Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
L_{basic}	0.700	0.695	0.695	0.695	0.693	0.696	0.699
L_{higher}	0.709	0.697	0.697	0.697	0.704	0.708	0.710
L_{addtl}	0.788	0.779	0.779	0.779	0.785	0.788	0.790
S_{basic}	0.095	0.052	0.054	0.055	0.056	0.060	0.063
S_{higher}	0.278	0.122	0.126	0.130	0.145	0.153	0.161
S_{addtl}	1.361	0.567	0.587	0.606	0.661	0.696	0.726
C_{basic}	0.433	0.384	0.395	0.405	0.414	0.425	0.435
C_{higher}	0.904	0.804	0.827	0.848	0.864	0.887	0.909
C_{addtl}	3.538	3.236	3.326	3.410	3.499	3.592	3.681
T_{basic}	0.0755	0.049	0.046	0.043	0.040	0.036	0.031
T_{higher}	0.0676	0.054	0.054	0.053	0.052	0.050	0.047
T_{addtl}	0.0324	0.034	0.034	0.035	0.035	0.035	0.034

Table 4f: EET vs TEE - Distributional analysis, % of EET levels

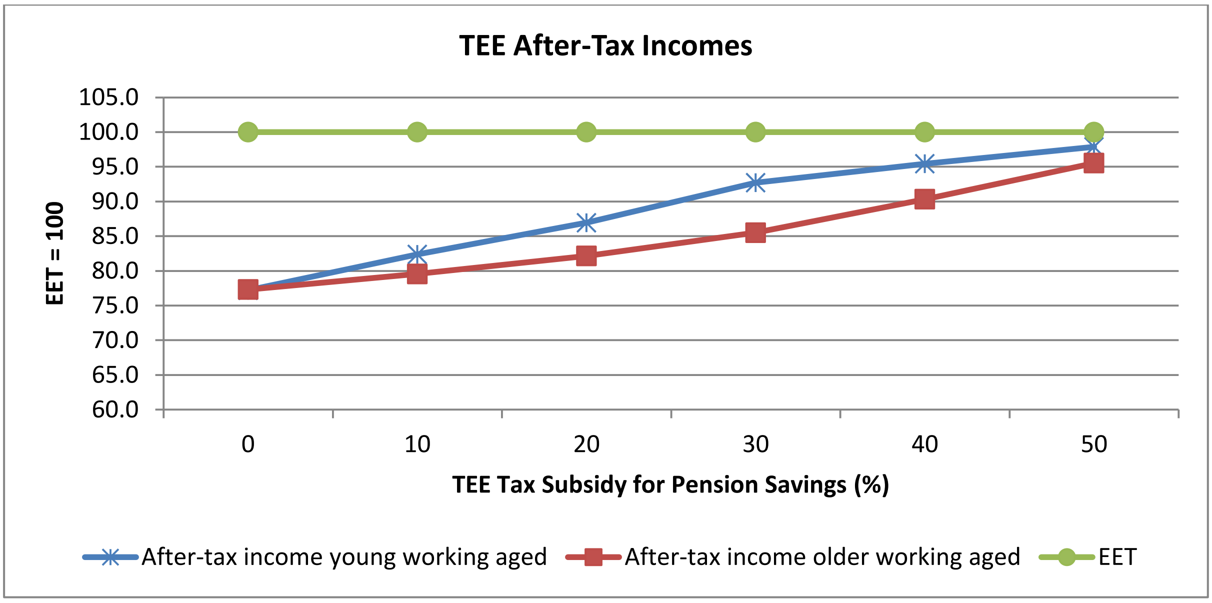
Variable	EET	TEE					
		$\tau_b = 0\%$	$\tau_b = 10\%$	$\tau_b = 20\%$	$\tau_b = 30\%$	$\tau_b = 40\%$	$\tau_b = 50\%$
L_{basic}	100.0	99.3	99.3	99.3	99.0	99.4	99.9
L_{higher}	100.0	98.3	98.3	98.3	99.3	99.9	100.1
L_{addtl}	100.0	98.9	98.9	98.9	99.6	100.0	100.3
S_{basic}	100.0	54.7	56.8	57.9	58.9	63.2	66.3
S_{higher}	100.0	43.9	45.3	46.8	52.2	55.0	57.9
S_{addtl}	100.0	41.7	43.1	44.5	48.6	51.1	53.3
C_{basic}	100.0	88.7	91.2	93.5	95.6	98.2	100.5
C_{higher}	100.0	88.9	91.5	93.8	95.6	98.1	100.6
C_{addtl}	100.0	91.5	94.0	96.4	98.9	101.5	104.0
T_{basic}	100.0	64.9	60.9	57.0	53.0	47.7	41.1
T_{higher}	100.0	79.9	79.9	78.4	76.9	74.0	69.5
T_{addtl}	100.0	104.9	104.9	108.0	108.0	108.0	104.9

Figure 4a: Key macroeconomy aggregates



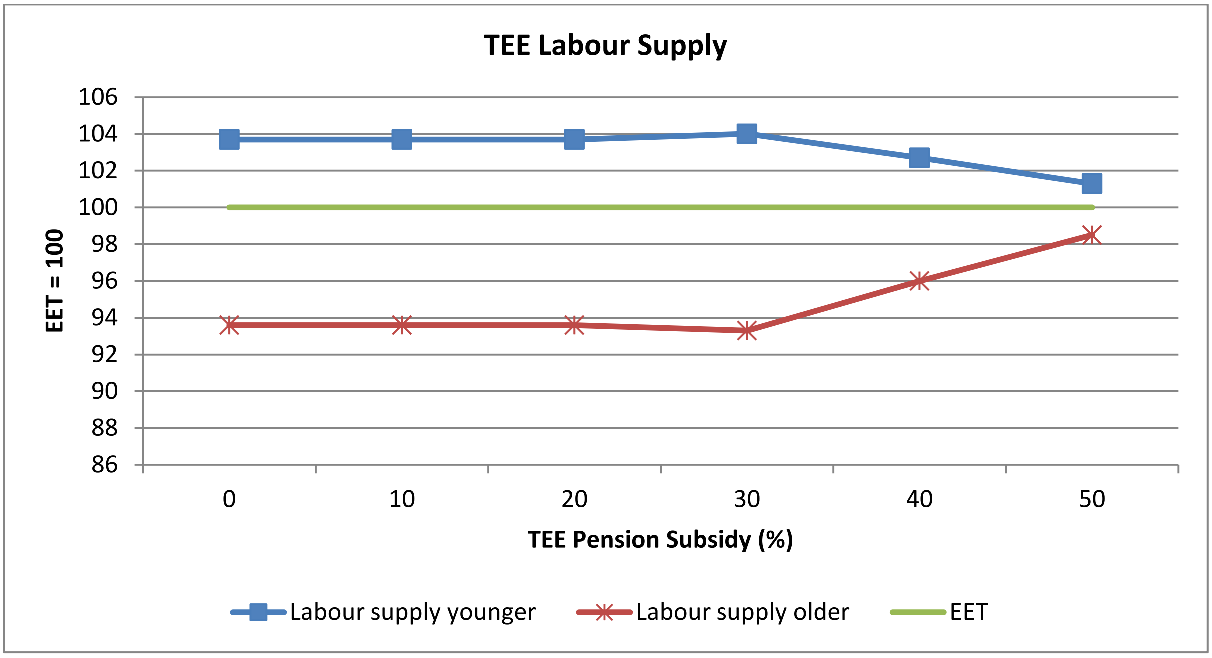
Key macroeconomics aggregates under TEE, with varying TEE pension subsidy rates τ_b. All values are expressed relative to the corresponding EET outcome, with EET outcomes normalised to 100. For example, output under TEE with a pension subsidy of 20% drops to 91% of its EET level.

Figure 4b: After tax incomes by cohort



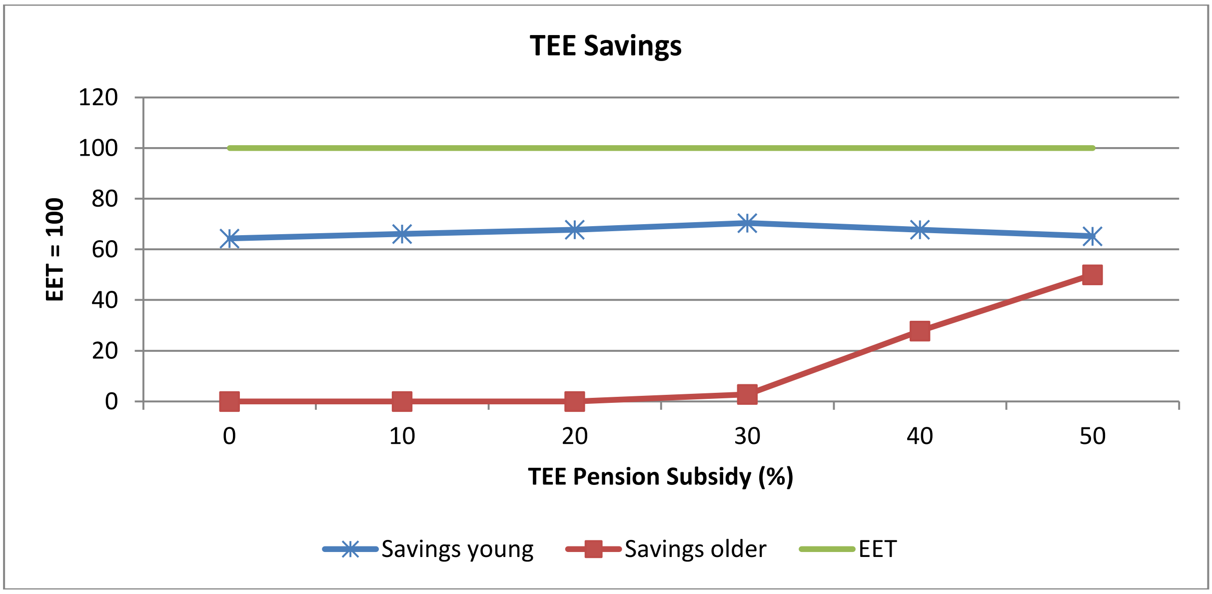
After-tax incomes under TEE, with varying TEE pension subsidy rates τ_b. All values are expressed relative to the corresponding EET outcome, with EET outcomes normalised to 100.

Figure 4c: Labour supply by cohort



Labour supply under TEE, with varying TEE pension subsidy rates τ_b. All values are expressed relative to the corresponding EET outcome, with EET outcomes normalised to 100.

Figure 4d: Private savings by cohort



Savings under TEE, with varying TEE pension subsidy rates τ_b. All values are expressed relative to the corresponding EET outcome, with EET outcomes normalised to 100.

ANNEX 1: DERIVING THE TAX FUNCTION FOR THE UK TAX SYSTEM UNDER EET PENSION TAX RELIEF

Under the EET regime, pension savings $s_{s,j,t}$ can be deducted from taxable income. As a result, the basic rate taxpayer has tax function:

$$T_1 = T(w_{1,t}l_{s,1,t}, s_{s,1,t}) = \tau_{l,1}(w_t l_{s,1,t} - s_{s,1,t} - \bar{y}_1)$$

where $\bar{y}_1$ is the lower income threshold for income tax of £10,600 and $\tau_{l,1} = 20\% + 12\% = 32\%$ is the combined income tax and NI rate in the basic rate income band.[29]

The higher rate tax payer pays the basic rate on income in the basic rate band, and higher rate on income in excess of the higher rate threshold of $\bar{y}_2 = £42{,}465$, giving her the tax function:

$$T_2 = T(w_{2,t}l_{s,2,t}, s_{s,2,t}) = \tau_{l,1}(w_{2,t}l_{s,2,t} - s_{s,2,t} - \bar{y}_1) + \tau_{l,2}(w_{2,t}l_{s,2,t} - s_{s,2,t} - \bar{y}_2)$$

where $\tau_{l,2}$ is the combined NI and income tax rate in excess of the basic rate, so that. $\tau_{l,2} = 40\% + 2\% - \tau_{l,1} = 10\%$.

The additional rate taxpayer pays 47% (45% income tax + 2% NI) on income in excess of the additional rate threshold of $\bar{y}_3 = £150{,}000$. As a result, the additional rate taxpayer's tax liabilities are described by

$$\begin{aligned} T_3 &= T(w_{3,t}l_{s,3,t}, s_{s,3,t}) \\ &= \tau_{l,1}(w_{3,t}l_{s,3,t} - s_{s,3,t}) + \tau_{l,2}(w_{3,t}l_{s,3,t} - s_{s,3,t} - \bar{y}_2{}^*) \\ &+ \tau_{l,3}(w_{3,t}l_{s,3,t} - s_{s,3,t} - \bar{y}_3) \end{aligned}$$

where $\tau_{l,3} = 5\%$ and $\bar{y}_2{}^* = £31{,}785$ and $\bar{y}_3 = £150{,}000$. The reason for the lower 'higher rate' threshold is that tax-free personal allowance is phased out beginning at incomes of £100,000.

A general form for the tax function is:

$$\begin{aligned} T_j &= T(w_{j,t}l_{s,j,t}, s_{s,j,t}) \\ &= \tau_{l,1} max\{0, w_{j,t}l_{s,j,t} - s_{s,3,t} - \bar{y}_1\} + \tau_{l,2} max\{0, w_{j,t}l_{s,j,t} - s_{s,j,t} - \bar{y}_2\} \\ &+ \tau_{l,3} max\{0, w_{j,t}l_{s,j,t} - s_{s,j,t} - \bar{y}_3\} \end{aligned}$$

As a result, the basic rate working aged agent's budget constraints becomes:

$$(1+\tau_c)c_{s,1,t} + (1-\tau_{l,1})s_{s,1,t} = (1-\tau_{l,1})w_{j,t}l_{s,1,t} + \tau_{l,1}\bar{y}_1$$

The higher rate working –aged agent's budget constraint is:

$$(1+\tau_c)c_{s,2,t} + (1-\tau_{l,1}-\tau_{l,2})s_{s,2,t} = (1-\tau_{l,1}-\tau_{l,2})w_{2,t}l_{s,2,t} + \tau_{l,1}\bar{y}_1 + \tau_{l,2}\bar{y}_2$$

[29] The actual lower earnings threshold for National Insurance is slightly lower than £10,600.

Finally, the additional rate taxpayer's budget constraint is:

$$(1+\tau_c)c_{s,3,t} + (1-\tau_{l,1}-\tau_{l,2}-\tau_{l,3})s_{s,3,t} = (1-\tau_{l,1}-\tau_{l,2}-\tau_{l,3})w_{3,t}l_{s,3,t} + \tau_{l,1}\bar{y}_1 + \tau_{l,2}\bar{y}_2 + \tau_{l,3}\bar{y}_3$$

To account for the withdrawal of the personal allowance for additional rate taxpayers, we could exclude the $\tau_{l,1}\bar{y}_1$ term.

$$T_j = \begin{cases} \tau_{l,1}\bar{y}_1 \ \ \textit{basic rate} \\ \tau_{l,1}\bar{y}_1 + \tau_{l,2}\bar{y}_2 \ \ \textit{higher rate} \\ \tau_{l,2}\bar{y}_2 + \tau_{l,3}\bar{y}_3 \ \ \textit{additional rate} \end{cases}$$

Taxpayer type	**Agent type *j***	**Marginal tax rate τ_l^j (working age)**	**Lump-sum T_j**
Basic rate	1	32%	$\tau_{l,1}\bar{y}_1$
Higher rate	2	42%	$\tau_{l,1}\bar{y}_1 + \tau_{l,2}\bar{y}_2$
Additional rate	3	47%	$\tau_{l,2}\bar{y}_2^* + \tau_{l,3}\bar{y}_3$

Marginal tax rates are given as:

$$\tau_l^j = \begin{cases} \tau_{l,1} = 32\% \\ \tau_{l,1} + \tau_{l,2} = 42\% \\ \tau_{l,1} + \tau_{l,2} + \tau_{l,3} = 47\% \end{cases}$$

where $(\tau_{l,1}, \tau_{l,2}, \tau_{l,3}) = (32\%, 10\%, 5\%)$ and the lump-sum reimbursements are given by:

$$T_j = \begin{cases} \bar{y}_1\tau_{l,1} \\ \bar{y}_1\tau_{l,1} + \bar{y}_2\tau_{l,2} \\ \bar{y}_2\tau_{l,2} + \bar{y}_3\tau_{l,3} \end{cases}$$

Each $\bar{y}_j$ represents the threshold at which its tax band begins:
$(\bar{y}_1, \bar{y}_2, \bar{y}_3) = (10600,\ 41{,}765, 150{,}000)$.

Substituting out for savings, working age budget constraints become:

$$(1+\tau_c)c_{1,j,t} = (1-\tau_l^j)w_{j,t}l_{1,j,t} - (1-\tau_l^j)k_{2,j,t+1}^f + T_j \quad (1)$$

$$(1+\tau_c)c_{2,j,t} = (1-\tau_l^j)w_{j,t+2}l_{2,j,t+1} - (1-\tau_l^j)\left[k_{3,j,t+2}^f - k_{2,j,t+1}^f(1+r_{t+2}^f-\delta)\right] + T_j \quad (2)$$

In retirement period 3, all accumulated savings and the state pension (financed out of tax revenues) are consumed. 25% of pension savings are tax-free, while the remainder is taxed as income. All accessible savings may be consumed tax-free. Agents also receive a fixed state pension $\tilde{b}$ which is low enough to not be taxed. This leaves the retirement budget constraint as:

$$(1 + \tau_c)c_{3,j,t+2} = (1 + r_{t+3} - \delta)k^f_{3,j,t+2}(1 - \tau_{l,j,ret}0.75) + \tilde{b} + T_{j,ret} \quad (3)$$

where once again $T_{j,ret}$ is the lump-sum refund of personal allowance at agent j's retirement tax band, and $\tau_{l,j,ret}$ is the marginal tax rate in retirement for agent type j.

ANNEX 2: SOLVING THE INDIVIDUAL'S OPTIMISATION PROBLEM, EET

Under EET, agent type j's date t optimisation problem is:

$$\max_{k,l} \frac{\left(c_{1,j,t}{}^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta\frac{\left(c_{2,j,t+1}{}^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \beta^2\frac{\left(c_{3,j,t+2}{}^{\gamma}\right)^{1-\sigma}}{1-\sigma}$$

subject to budget constraints

$$(1+\tau_c)c_{1,j,t} = \left(1-\tau_l^j\right)w_{j,t}l_{1,j,t} - \left(1-\tau_l^j\right)k_{2,j,t+1} + T_j \tag{1}$$

$$(1+\tau_c)c_{2,j,t} = \left(1-\tau_l^j\right)w_{j,t+2}l_{2,j,t+1} - \left(1-\tau_l^j\right)\left[k_{3,j,t+2} - k_{2,j,t+1}\left(1+r_{t+2}^f-\delta\right)\right] + T_j \tag{2}$$

$$(1+\tau_c)c_{3,j,t+2} = (1+r_{t+3}-\delta)k_{3,j,t+2}\left(1-\tau_{l,j,ret}0.75\right) + \tilde{b}\left(1-\tau_{l,j,ret}\right) + T_{j,ret} \tag{3}$$

as well as to the non-negativity constraints for accessible capital stocks and pension savings:

$$s_{1,j,t} = k_{2,j,t+1} \geq 0$$

$$s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta) \geq 0$$

The Lagrangian is:

$$L = \frac{\left[\left(\frac{\left(1-\tau_l^j\right)w_{j,t}l_{1,j,t} - \left(1-\tau_l^j\right)k_{2,j,t+1} + T_j}{(1+\tau_c)}\right)^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}$$

$$+\beta\frac{\left[\left(\frac{\left(1-\tau_l^j\right)w_{j,t}l_{2,j,t+1} + \left(1-\tau_l^j\right)\left(k_{2,j,t+1}(1+r_{t+2}-\delta)\right) - \left(1-\tau_l^j\right)k_{3,j,t+2} + T_j}{(1+\tau_c)}\right)^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}$$

$$+\beta^2\frac{\left[\frac{(1+r_{t+3}-\delta)k_{3,j,t+2}\left(1-\tau_{l,j,ret}0.75\right) + T_{j,ret} + \tilde{b}}{(1+\tau_c)}\right]^{\gamma(1-\sigma)}}{1-\sigma} - \lambda_{j,t}k_{2,j,t+1}$$

$$-\mu_{j,t+1}\beta\left(k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta)\right)$$

with accompanying complementary slackness conditions:

$$\mu_{j,t+1} \leq 0$$

$$k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta) \geq 0$$

$$\mu_{j,t+1}\left(k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta)\right) = 0$$

$\lambda_{j,t+1} \leq 0$

$k_{2,j,t+1} \geq 0$

$\lambda_{j,t+1} k_{2,j,t+1} = 0$

First order conditions for labour supply (labour-leisure choice) for each j.

$$\frac{\partial L}{\partial l_{2,j,t+1}} = \beta \left[(c_{2,j,t+1})^{\gamma} (1 - l_{2,j,t+1})^{1-\gamma} \right]^{-\sigma} \left[(1 - l_{2,j,t+1})^{1-\gamma} \gamma (c_{2,j,t+1})^{\gamma-1} \frac{(1-\tau_l^j)}{(1+\tau_c)} w_{j,t} - (c_{2,j,t+1})^{\gamma} (1-\gamma)(1 - l_{2,j,t+1})^{-\gamma} \right] = 0$$

$$\frac{\partial L}{\partial l_{1,j,t}} = \left[(c_{1,j,t})^{\gamma} (1 - l_{1,j,t})^{1-\gamma} \right]^{-\sigma} \left[(1 - l_{1,j,t})^{1-\gamma} \gamma (c_{1,j,t})^{\gamma-1} \frac{(1-\tau_l^j)}{(1+\tau_c)} w_{j,t} - (c_{1,j,t})^{\gamma} (1-\gamma)(1 - l_{1,j,t})^{-\gamma} \right] = 0$$

This leads to **two labour-leisure Euler equations**.

$$\frac{(1-\tau_l^j)}{(1+\tau_c)} w_{j,t} = \frac{1-\gamma}{\gamma} \frac{c_{1,j,t}}{1 - l_{1,j,t}}$$

$$\frac{(1-\tau_l^j)}{(1+\tau_c)} w_{j,t+1} = \frac{1-\gamma}{\gamma} \frac{c_{2,j,t+1}}{1 - l_{2,j,t+1}}$$

First order conditions for pension capital stocks (consumption-savings choice):

$$\frac{\partial L}{\partial k_{2,j,t+1}} = -\frac{(1-\tau_l^j)}{(1+\tau_c)} (1 - l_{1,j,t})^{1-\gamma} \gamma (c_{1,j,t})^{\gamma-1} \left((c_{1,j,t})^{\gamma} (1 - l_{1,j,t})^{1-\gamma} \right)^{-\sigma} + \beta (1 - l_{2,t+1})^{1-\gamma} \gamma (c_{2,j,t+1})^{\gamma-1} \left((c_{2,j,t+1})^{\gamma} (1 - l_{2,j,t+1})^{1-\gamma} \right)^{-\sigma} \frac{(1-\tau_l^j)}{(1+\tau_c)} (1 + r_{t+2} - \delta) - \lambda_{j,t} + \beta \mu_{j,t+1} (1 + r_{t+2} - \delta) = 0$$

$$\frac{\partial L}{\partial k_{3,j,t+2}} = -\beta \frac{(1-\tau_l^j)}{(1+\tau_c)} (1 - l_{2,j,t+1})^{1-\gamma} \gamma (c_{2,j,t+1})^{\gamma-1} \left((c_{2,j,t+1})^{\gamma} (1 - l_{2,j,t+1})^{1-\gamma} \right)^{-\sigma} + \beta^2 \gamma (c_{3,j,t+2})^{\gamma(1-\sigma)-1} (1 + r_{t+3} - \delta) \frac{(1 - 0.75\tau_l^j)}{(1+\tau_c)} - \beta \mu_{j,t+1} = 0$$

This leads to two Euler conditions for an interior solution for pension savings:

$$1 = \beta \left(\left(\frac{c_{2,j,t+1}}{c_{1,j,t}} \right)^{\gamma} \left(\frac{1 - l_{2,j,t+1}}{1 - l_{1,j,t}} \right)^{1-\gamma} \right)^{1-\sigma} \left(\frac{c_{2,j,t+1}}{c_{1,j,t}} \right)^{-1} (1 + r_{t+2} - \delta)$$

$$1=\beta\left(\frac{1}{\left(1-l_{2,j,t+1}\right)}\right)^{(1-\gamma)(1-\sigma)}\left(\frac{c_{3,j,t+2}}{c_{2,j,t+1}}\right)^{\gamma(1-\sigma)-1}(1+r_{t+3}-\delta)\frac{\left(1-0.75\tau_{l,j,ret}\right)}{\left(1-\tau_l^j\right)}$$

For a corner solution with $s_{2,j,t+1}=0$ and $\mu_{j,t+1}<0$, the pension savings Euler equations are:

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}\gamma\left(\left(c_{1,j,t}\right)^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right)^{1-\sigma}\left(c_{1,j,t}\right)^{-1}$$

$$=\beta\gamma\left(\left(c_{2,j,t+1}\right)^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}\left(c_{2,j,t+1}\right)^{-1}\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}(1+r_{t+2}-\delta)$$

$$+\beta\mu_{j,t+1}(1+r_{t+2}-\delta)$$

$$\frac{\left(1-\tau_l^j\right)}{(1+\tau_c)}\gamma\left(c_{2,j,t+1}\right)^{-1}\left(\left(c_{2,j,t+1}\right)^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}$$

$$=\beta\gamma\left(c_{3,j,t+2}\right)^{\gamma(1-\sigma)-1}\cdot(1+r_{t+3}-\delta)\frac{\left(1-0.75\tau_{l,j,ret}\right)}{(1+\tau_c)}-\mu_{j,t+1}$$

and in addition $s_{2,j,t+1}=k_{3,j,t+2}-k_{2,j,t+1}(1+r_{t+2}-\delta)=0$.

ANNEX 3: SOLVING THE INDIVIDUAL'S PROBLEM, TEE

Under TEE, the individual chooses capital stocks $k_{2,j,t+1}, k_{3,j,t+2}$ and labour supplies $l_{1,j,t}, l_{2,j,t+1}$ to maximize:

$$\max_{\substack{k_{1,j,t+1},k_{2,j,t+2}\\ l_{1,j,t},l_{2,j,t+1}}} \frac{\left(c_{1,j,t}{}^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma}+\beta\frac{\left(c_{2,j,t+1}{}^{\gamma}\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma}+\beta^{2}\frac{\left(c_{2,j,t+1}{}^{\gamma}\right)^{1-\sigma}}{1-\sigma}$$

subject to the budget constraints (10), (11) and (12), and the non-negativity constraints on pension savings: $s_{1,j,t} \geq 0$ and $s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}(1 + r_{t+2} - \delta) \geq 0$

The Lagrangian is:

$$L = \frac{\left[\left(w_{j,t}l_{1,j,t}\frac{(1-\tau_l^j)}{(1+\tau_c)}-\frac{k_{2,j,t+1}}{(1+\tau_b)(1+\tau_c)}+\frac{T_j}{(1+\tau_c)}\right)^{\gamma}\left(1-l_{1,j,t}\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}$$

$$+\beta\frac{\left(\left(w_{j,t+1}l_{2,j,t+1}\frac{(1-\tau_l^j)}{(1+\tau_c)}-\frac{k_{3,j,t+2}-k_{2,j,t+1}(1+r_{t+2}-\delta)}{(1+\tau_c)(1+\tau_b)}+\frac{T_j}{(1+\tau_c)}\right)^{\gamma}\cdot\left(1-l_{2,j,t+1}\right)^{1-\gamma}\right)^{1-\sigma}}{1-\sigma}$$

$$+\beta^{2}\frac{\left(\frac{(1+r_{t+3}-\delta)k_{3,j,t+2}+\tilde{b}}{(1+\tau_c)}\right)^{\gamma(1-\sigma)}}{1-\sigma}$$

$$-\lambda_{j,t}k_{2,j,t+1}-\beta\mu_{j,t+2}\left(k_{3,j,t+2}-k_{2,j,t+1}(1+r_{t+2}-\delta)\right)$$

with accompanying complementary slackness conditions

$$\mu_{j,t+1} \leq 0$$

$$k_{3,j,t+2} - k_{2,j,t+1}(1 + r_{t+2} - \delta) \geq 0$$

$$\mu_{j,t+1}\left(k_{3,j,t+2} - k_{2,j,t+1}(1 + r_{t+2} - \delta)\right) = 0$$

$$\lambda_{j,t+1} \leq 0$$

$$k_{2,j,t+1} \geq 0$$

$$\lambda_{j,t+1}k_{2,j,t+1} = 0$$

First order conditions for labour-leisure choices:

$$\frac{\partial L}{\partial l_{1,j,t}} = \left[(c_{1j,t})^{\gamma}(1-l_{1,j,t})^{1-\gamma}\right]^{-\sigma}\left[(1-l_{1,j,t})^{1-\gamma}\gamma(c_{1,j,t})^{\gamma-1}\frac{(1-\tau_l^j)}{(1+\tau_c)}w_{j,t} - (c_{1,j,t})^{\gamma}(1-\gamma)(1-l_{1,j,t})^{-\gamma}\right] = 0$$

$$\frac{\partial L}{\partial l_{2,j,t+1}} = \beta\left[(c_{2,j,t+1})^{\gamma}(1-l_{2,j,t+1})^{1-\gamma}\right]^{-\sigma}\left[(1-l_{2,j,t+1})^{1-\gamma}\gamma(c_{2,j,t+1})^{\gamma-1}\frac{(1-\tau_l^j)}{(1+\tau_c)}w_{j,t} - (c_{2,j,t+1})^{\gamma}(1-\gamma)(1-l_{2,j,t+1})^{-\gamma}\right] = 0$$

which reduces to two Euler equations for labour leisure choice:

$$\frac{(1-\tau_l^j)}{(1+\tau_c)}w_{j,t} = \frac{(1-\gamma)}{\gamma}\frac{c_{1,j,t}}{1-l_{1,j,t}}$$

$$\left[\frac{(1-\tau_l^j)}{(1+\tau_c)}w_{j,t} = \frac{c_{2,j,t+1}}{1-l_{2,j,t+1}}\frac{(1-\gamma)}{\gamma}\right]$$

First order conditions for pension savings:

$$\frac{\partial L}{\partial k_{3,j,t+2}} = -\beta\left((c_{2,j,t+1})^{\gamma}(1-l_{2,j,t+1})^{1-\gamma}\right)^{-\sigma}\gamma(c_{2,j,t+1})^{\gamma-1}(1-l_{2,j,t+1})^{1-\gamma}\frac{1}{(1+\tau_c)(1+\tau_b)} + \beta^2\gamma(c_{3,j,t+2})^{\gamma(1-\sigma)-1}\frac{1}{(1+\tau_c)}(1+r_{t+3}-\delta) - \beta\mu_{j,t+1} = 0$$

$$\frac{\partial L}{\partial k_{2,j,t+1}} = -\left((c_{1,j,t})^{\gamma}(1-l_{1,j,t})^{1-\gamma}\right)^{-\sigma}\gamma(c_{1,j,t})^{\gamma-1}(1-l_{1,j,t})^{1-\gamma}\frac{1}{(1+\tau_c)(1+\tau_b)} + \beta\left((c_{2,j,t+1})^{\gamma}(1-l_{2,j,,t+1})^{1-\gamma}\right)^{-\sigma}\gamma(c_{2,j,t+1})^{\gamma-1}(1-l_{2,j,t+1})^{1-\gamma}\frac{1}{(1+\tau_c)(1+\tau_b)}(1+r_{t+2}-\delta) - \lambda_{j,t} + \beta\mu_{j,t+1}(1+r_{t+2}-\delta) = 0$$

which reduce to two Euler equations for an interior solution in the two pension savings choices:

$$1 = \beta\left(\left(\frac{c_{2,j,t+1}}{c_{1,j,t}}\right)^{\gamma}\left(\frac{1-l_{2,j,t+1}}{1-l_{1,j,t}}\right)^{1-\gamma}\right)^{1-\sigma}\left(\frac{c_{2,j,t+1}}{c_{1,j,t}}\right)^{-1}(1+r_{t+2}-\delta)$$

$$1 = \beta\left(\frac{c_{3,j,t+2}}{c_{2,j,t+1}}\right)^{\gamma(1-\sigma)-1}\left(\frac{1}{(1-l_{2,j,t+1})}\right)^{(1-\gamma)(1-\sigma)}(1+\tau_b)(1+r_{t+3}-\delta)$$

For a corner solution, in which $s_{2,j,t+1} = k_{3,j,t+2} - k_{2,j,t+1}(1+r_{t+2}-\delta) = 0$ and $\mu_{j,t+1} < 0$:

$$\gamma\left(1-l_{2,j,t+1}\right)^{(1-\gamma)(1-\sigma)}\left(c_{2,j,t+1}\right)^{\gamma(1-\sigma)-1}\frac{1}{(1+\tau_c)(1+\tau_b)}$$
$$=\beta\gamma\left(c_{3,j,t+2}\right)^{\gamma(1-\sigma)-1}\frac{1}{(1+\tau_c)}(1+r_{t+3}-\delta)-\mu_{j,t+1}$$

$$\gamma\left(1-l_{1,j,t}\right)^{(1-\gamma)(1-\sigma)}\left(c_{1,j,t}\right)^{\gamma(1-\sigma)-1}\frac{1}{(1+\tau_c)(1+\tau_b)}$$
$$=\beta\gamma\left(1-l_{2,j,t+1}\right)^{(1-\gamma)(1-\sigma)}\left(c_{2,j,t+1}\right)^{\gamma(1-\sigma)-1}\frac{1}{(1+\tau_c)(1+\tau_b)}(1+r_{t+2}-\delta)$$
$$+\beta\mu_{j,t+1}(1+r_{t+2}-\delta)$$

REFERENCES

Attanasio O P and DeLeire T, (2002) “The effect of individual retirement accounts on household consumption and national saving”, The Economic Journal, 112 (7) 504–538

Beetsma, R.M.W.J., Lekniute, Z., & Ponds, E.H.M. (2011). “De gevolgen van het pensioen- akkoord voor de staatsschuld”. ESB, 96(123).

Bernheim, B.D. and Scholz, J.K. (1992), "Private saving and public policy", National Bureau of Economic Research Working Paper No. 4213.

Bijlsma M, F Haaijen and C van Ewijk, (2014) "Economic growth and funded pension systems," CPB Discussion Paper 279, CPB Netherlands Bureau for Economic Policy Analysis.

Caprio G and Demirgüç-Kunt A (1998), "The role of long term finance; theory and evidence", World Bank Research Observer, 13, 171-189

Catalan, M., G. Impavido and A. R. Musalem; (2000); Contractual savings or stock market development: which leads? Social Protection Discussion Paper Series No. 0020; The World Bank.

Chen D, Beetsma R, Ponds E and Romp W (2014), “Intergenerational Risk-Sharing through Funded Pensions and Public Debt”, CESIFO WORKING PAPER NO. 4624

Davis, E.P. (1995), "Pension Funds, Retirement-Income Security and Capital Markets, an International Perspective", Oxford University Press.

Davis E P (2002), "Institutional investors, corporate governance, and the performance of the corporate sector", Economic Systems, 26, 203-229

Davis, E. P.; (2003); Financial development, institutional investors and economic performance; in ed C A E Goodhart, Financial Development and Economic Growth, Palgrave

Davis E P (2006), “How will ageing affect the structure of financial markets?” in “Demography and Ageing” ed Kent C G-20/Reserve Bank of Australia

Davis E P and Hu Y (2006), "Saving, funding and economic growth", in Oxford Handbook of Pension Reform and Investment, eds G Clark, A Munnell and M Orszag

Davis, E. P. and Hu, Y. (2008). “Does funding of pensions stimulate economic growth?” Journal of Pension Economics and Finance, 7 (2), p. 221--249.

Del Guercio D and Hawkins J, (1999), “The motivation and impact of pension fund activism”, Journal of Financial Economics, 52, 293-340

Diamond P A (1977), "A framework for social security analysis", Journal of Public Economics, 8, 275 98.

Emmmerson C (2014), “Taxation of private pensions”, in “The Green Budget 2014, IFS, London

Emmerson C and Tanner S (2000), “A note on the tax treatment of private pensions and individual savings accounts”, Fiscal Studies, 21, 65-74

Faccio M and Lasfer M A (2000), “Do occupational pension funds monitor companies in which they hold large stakes?”, Journal of Corporate Finance, 6, 71-85

HM Treasury (2015), “Strengthening the incentive to save: a consultation on pensions tax relief” UK Government Paper Cm 9102

Holzmann, R.; (1997); “Pension Reform, Financial Market and Economic Growth, Preliminary Evidence from Chile”; International Monetary Fund Staff Papers; June; International Monetary Fund, Washington.

Hu Y (2005), “Pension Reform, Economic Growth and Financial Development- An Empirical Study “, Economics and Finance Working Paper 05-05, Brunel University

Huang, J. (2008). Taxable and tax-deferred investing: a tax-arbitrage approach. Review of Financial Studies, 21(5), 2174-2207.

Imrohoroglu, A, S Imrohoroglu and D H. Joines, (1998), "The Effect of Tax-Favored Retirement Accounts on Capital Accumulation," American Economic Review 88(4), 749-68

Impavido, G., A. R. Musalem and T. Tressel; (2003); The Impact of Contractual Savings Institutions on Securities Markets; World Bank Policy Research Working Paper 2948; January. The World Bank.

James, E.; (1996); Providing Better Protection and Promoting Growth: A Defence of Averting the Old Age Crisis; International Social Security Review; Vol. 49 No 3.

Kydland, E and E.C. Prescott; (June 1977). Rules Rather than Discretion: The Inconsistency of Optimal Plans. Journal of Political Economy *85 (3): 473–492*

Kitao S, (2010), "Individual Retirement Accounts, Saving and Labor Supply," Economics Letters 108(2), 197-200

Kohl, M. and P. O'Brien; (1998); The Macroeconomics of Ageing, Pensions and Savings: A Survey; Economic Department Working Paper No. 200; OECD, Paris.

Kudrna G and Woodland A,(2012). "Progressive Tax Changes to Private Pensions in a Life-Cycle Framework," Working Papers 201209, ARC Centre of Excellence in Population Ageing Research (CEPAR), Australian School of Business, University of New South Wales.

Lopez Murphy, P and Musalem, A R.(2004), "Pension funds and national saving", Policy Research Working Paper No. 3410, The World Bank.

McCarthy, D. and A. Neuberger; (2004); Pensions Policy: Evidence on Aspects of Savings Behaviour and Capital Markets; Centre for Economic Policy Research; London.

ONS (2014). "Pension Trends – Chapter 8: Pension Contributions, 2014 Edition" Office of National Statistics

Pesando J E (1992), "The economic effects of private pensions", in "Private pensions and public policy", Organisation for Economic Cooperation and Development, Paris.

Poterba, J., S. Venti and D. Wise; (1996); How retirement savings programs increase savings; Journal of Economic Perspectives; Vol. 10; pp91-112.

Rajan R G and Zingales L (1998), "Financial Dependence and Growth", American Economic Review, 88, 559-586

Reisen, H. and J. Bailliu; (1997); Do Funded Pensions Contribute to Higher Aggregate Savings; A Cross-Country Analysis; OECD Development Centre Technical Papers No. 130; OECD, Paris.

Romaniuk, K. (2013). Pension fund taxation and risk-taking: should we switch from the EET to the TEE regime? Annals of Finance, 9(4), 573-88.

St. John S (2007) "New Zealand's Experiment in Tax Neutrality for Retirement Saving" The Geneva Papers on Risk and Insurance. Issues and Practice, Vol. 32, No. 4, Special Issue on the Future of Pensions (the Four Pillars), pp. 532-552

Uren A (2014), "You'll probably life loneger than youthought", This is Money website, http://www.thisismoney.co.uk/money/pensions/article-2598791/Four-five-underestimate-long-theyre-likely-live.html

Wahal S (1996), "Public pension fund activism and firm performance", Journal of Financial and Quantitative Analysis, 31, 1-23.

Walker, E. and F. Lefort; (2002); Pension reform and capital markets: are there any (hard) links? Social Protection discussion paper No. 0201; January; The World Bank.

Whitehouse, E.R. (1999). The Tax treatment of funded pensions. MPRA Paper, 14173.

Yoo, K.-Y., de Serres, A. (2005): Tax treatment of private pension savings in OECD countries. OECD Economic Studies No. 39, 73–110

Zandberg, E., & Spierdijk, L. (2013). Funding of pensions and economic growth: are they really related?. Journal of Pension Economics & Finance, 12(2), 151-167