Essays on Fiscal Policy in Australia

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Declaration

This thesis is a compilation of research undertaken between February 2015 and February 2021 at the Research School of Economics, The Australian National University, Canberra, Australia.

Chapters 2 and 3 were produced jointly with my supervisor Dr. Chung Tran. My contribution to each of these chapters was more than 50 percent. I took responsibility for data cleaning, primary analysis, and write-up of Chapter 2. Dr. Tran and I worked jointly on extensions and the write-up. The paper has been published in the Economic Record as "Tax Progressivity in Australia: Facts, Measurements and Estimates" (Tran and Zakariyya, 2021).

Dr. Tran took responsibility for the base model used for Chapter 3 while I was responsible for refining the model, analysis, and write-up. The paper was circulated as part of the "Colloquium on Pensions and Retirement Research, ARC Centre of Excellence in Population Ageing Research (CEPAR) 2019" and was peer-reviewed and presented at the "33rd Australian PhD Conference in Economics and Business (2020)".

Chapter 4 is in working paper format. I intend to submit for publication after addressing comments from thesis examiners.

Excluding the above exceptions, and where otherwise acknowledged, I certify that this thesis is my own work.

Canberra, 17 March 2021

Nabeeh Zakariyya

Acknowledgments

I dedicate this work to my parents, Hawwa Ismail and Ibrahim Zakariyya Moosa. I owe them an immeasurable debt, for kindling my love for learning, teaching me perseverance, and being there for me at every step. In these final stages of submitting my thesis, I acknowledge with appreciation how both my parents delayed and often forwent their own academic advancements to care for my brother and me. Words of dedication would not suffice their love, support, and sacrifice.

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Wal-hamdu lillaahi Rabbil Aalameen.

Abstract

This thesis comprises three papers that examine the role of income tax policy in Australia within the broader fiscal system.

The first paper (Chapter 2) studies trends in the Australian personal income tax system's progressivity after the introduction of "A New Tax System (Goods and Services Tax) Act 1999". It measures tax progressivity based on tax liability distribution across the income distribution using the Suits index. The index shows that Australia experienced a cycle of increasing and decreasing progressivity from 2001-2016.

Active tax policy with frequent adjustments to income brackets, marginal rates, and offset levels made the tax system more progressive before 2010, while inactive tax policy made it less progressive after 2010. This decline is due to the income tax code failing to adjust for income distribution changes. The paper finds that while indexing tax brackets to inflation can partially mitigate the decline in progressivity; it is not a full substitute for (annual) frequent discretionary adjustments to the tax code.

The second paper (Chapter 3) builds on the empirical findings in Chapter 2 and asks a broader question on the optimal design of the income tax system in Australia. To do so, it builds a dynamic general equilibrium, overlapping generations (OLG) model with skill heterogeneity and uninsurable labor productivity risk, calibrated to match the key features of the Australian economy. The paper applies the model to search for the personal income tax system's optimal progressivity, relying on a utilitarian social welfare criterion.

Results indicate that reducing the income tax system's progressivity reduces distortions on incentives to work and save, leading to improvements in aggregate efficiency and welfare. Under the welfare criterion, the optimal tax system is proportional with a tax rate of around 14

percent. The income tax system's optimal progressivity level is closely related to the design of a means-tested pension system. Interestingly, the optimal proportional tax code is robust to alternative means-tested age pension system designs.

The third paper (Chapter 4) moves from the welfare implications of income tax design to examining the fiscal limits to which the government could use the income tax system to raise tax revenues. It quantifies the fiscal space (the amount of additional tax revenue that can be potentially generated) by changing the progressivity and average level of taxation (tax level) of the Australian income tax code. Using an OLG model that matches key aggregate and distributional statistics of the Australian economy, it examines the Laffer curves for income tax progressivity and tax level in Australia. The peak of the Laffer curve defines the fiscal limit.

The paper finds that tax revenue increases when the tax code's curvature decreases (becomes less progressive). The income tax code's fiscal limit is with a flat income tax code at a tax rate of 95%. The associated fiscal space represents a 208% increase in income tax revenue. However, in general equilibrium, as the income tax rate increases, after-tax incomes decrease, leading to large reductions in consumption and, in turn, consumption tax revenue. As a result, the total tax revenue gain is significantly lower at 126%.

The paper also highlights the advantage of Australia being a small open economy when it comes to the revenue maximizing potential of income tax. The adverse incentive effects on household savings due to rising tax rates are mitigated by foreign capital inflows, preventing aggregate capital stock decline. The paper contrasts the small open economy case with the closed economy case that results in a Laffer curve peak at 60% and a smaller fiscal space of 116%.

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Chapter 1

Introduction

Of all the policy instruments at the government's disposal, fiscal policy stands out for its dual role. On the one hand, it could enhance economic efficiency via incentives to work, save and invest. On the other, it could ensure equity via social insurance that mitigates against the misfortunes of birth and bad luck. These two roles often conflict, resulting in trade-offs between equity and efficiency. Designing a fiscal system that strikes a harmonious balance between the two (an optimal fiscal system) is forever a critical policy task.

This thesis is my humble contribution to the optimal fiscal policy design in Australia. As nearly half of the fiscal system's revenue comes from personal income tax (Australian Government, The Treasury, 2020), my main focus is the Australian income tax system. One of the central themes of my thesis is the importance of contextualizing individual parts of the fiscal system within the whole. Thus, throughout the thesis, I examine the income tax system in the context of the overall tax and transfer system in Australia.

Progressivity and redistribution. The first paper (Chapter 2) examines the social insurance role of the income tax system and the overall tax and transfer system. A progressive income tax system - where the tax burden increases with income - plays a social insurance role. It relieves more impoverished individuals from a higher tax burden. A relief as such to those who experience unfavorable initial conditions or face idiosyncratic shocks acts as a partial insurance mechanism in incomplete insurance markets. It reduces the variance of income and consumption over the life cycle, ensuring a more equal distribution of income, wealth, and consumption.

For this reason, the first paper examines the progressivity of the Australian income tax system since 2001. My co-author and I measure progressivity from two alternative approaches - tax liability progression (how the tax rate increases with income) and tax liability distribution (how the tax burden is distributed across the income distribution). In the first approach, we estimate the tax code's progressivity using a parametric tax function with two parameters - one that determines the scale of income tax and another that determines progressivity. We find that this tax function closely approximates the Australian income tax code. However, the tax function's progressivity parameter only measures progressivity at a given point on the income scale. Thus, it is not a measure of overall progressivity.

In the second approach, we measure progressivity using the Suits (1977) index. Trends in the Suits index show a cycle of lesser and greater tax progressivity in Australia between 2001 and 2018. Active tax policy with frequent adjustments to income brackets, marginal rates, and offset levels drive the progressivity level before 2010. Inactive tax policy induces lower tax progressivity levels after 2010 as the income tax code fails to track the changes in market income distribution. We find that indexation to inflation can partially mitigate the decline in progressivity. However, it is not a full substitute for a proper tax indexation system with (annual) frequent adjustments.

However, as explained by Lambert (1985), tax progressivity is not the only factor affecting income redistribution. The scale of taxation and the progressivity and scale of the transfer system also impact post-government income inequality. We find that in Australia's case, income tax progressivity has limited impact on income inequality compared to the public transfer system. Moreover, the transfer system's size and structure played a more central role in redistribution in Australia during the period. Whereas, any effect from the tax system on overall redistribution is relatively small. This is an essential insight to the more extensive discussion on the equity-efficiency trade-offs within the broader fiscal system.

In this regard, given that the progressive income tax system already plays a relatively little role in overall redistribution, the question that follows is whether considerable efficiency gains could be made by reducing the level of progressivity without significantly compromising the social insurance role of the broader fiscal system.

Equity and efficiency trade-off. The second paper moves to a more thorough examination of the equity-efficiency trade-off within the framework of dynamic general equilibrium, overlapping generations model with skill heterogeneity and uninsurable labor productivity risk. To model the progressive income tax system, we use a parametric tax function estimated in Chapter 2, and search over different values of the progressivity parameter to determine the income tax code that yields the highest utilitarian social welfare. We find the highest social welfare level is attained under a proportional income tax code at a flat rate of 14% with no tax-free threshold. This implies that the adverse incentive effects of high marginal tax rates dominate the redistribution/insurance effects in our general equilibrium model economy.

We explicitly model the public transfer system alongside the income tax system in the spirit of contextualizing income tax within the broader fiscal system. In particular, we include Australia's means-tested age pension system in detail and approximate all other public transfers to match income quantiles by age. We find that our optimal proportional income tax code is robust to the pension system's alternative designs. However, when we eliminate the model's public transfer system, the optimal income tax system is no longer proportional. This suggests that a proportional income tax in our benchmark model is only optimal contingent on the other sources of social insurance provided by public transfer programs.

We find that the income tax system's progressivity strongly influences the optimal design of the pension system. Social welfare is highest when the income test taper rate is at 10% under the optimal income tax code. This is much lower than the current taper rate of 50%. The welfare effects of lower taper rates are more pronounced at higher tax progressivity levels. However, lower taper rates result in higher social welfare than a universal pension system. This suggests that, conditional on the existence of a public pension system, the presence of means-testing strengthens its social insurance role.

Fiscal limit of income taxation. The final paper (Chapter 4) examines an equally important fiscal policy issue - the tax system's revenue-maximizing potential. Using an extension of the model used in Chapter 3, I examine the revenue implications of changes to the income tax code using Laffer curves. I focus on two main concepts derived from the Laffer curve - (1) fiscal limit and (2) fiscal space. The fiscal limit of the income tax code is at the Laffer curve peak where total tax revenue reaches a maximum. Fiscal space gives the difference between this maximum tax revenue and the current (benchmark) revenue amount. It measures the government's capacity to raise revenue to meet its spending commitments without compromising fiscal sustainability.

I find that tax revenue increases as progressivity decreases. This is mainly due to a reduction in the tax-free threshold and a rise in tax rates. Reducing progressivity reduces disincentives to increase labor supply and increases labor income. Maximal revenue is achieved under a flat income tax code with a tax rate of 95% (fiscal limit). Total tax revenue is at 126% of the benchmark at the fiscal limit. This gives the overall fiscal space in terms of total tax revenue.

The extremely high tax rate at the limit signifies the advantages of being a small open economy. Due to perfect capital mobility, as the tax rate increases, the aggregate stock of capital due to adverse incentive effects on household savings is mitigated by foreign capital inflows. This maintains wages and the interest rate at benchmark levels. I contrast this with a closed economy version of the model where there are no inflows or outflows of capital from the economy. The closed economy's fiscal limit is with a flat income tax code at a tax rate of 60%.

I also find that, raising the personal income tax rate leads to more considerable gains in total revenue than raising the consumption tax rate. Moreover, increasing the tax rate on company profits above the benchmark rate leads to a decrease in total tax revenue. Hence, among the current taxation sources in the Australian tax system, the personal income tax code has the most potential to increase government revenue.

Limitations and future research. Chapter 5 concludes the thesis by putting results in perspective. I highlight the general messages relevant to fiscal policy discussions. Importantly, I raise caveats of the present analysis, and explain crucial directions for further research on fiscal reform.

Chapter 2

Tax Progressivity in Australia: Facts, Measurements and Estimates

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2.1 Introduction

Since the introduction of A New Tax System (Goods and Services Tax) Act 1999 there have been several reviews and debates on further reforming Australia's income tax system.[1] A major focus of these reviews and debates is on the progressivity of the tax system. In a progressive tax system, tax liability rises with income. Tax progressivity has efficiency and equity implications that induces strong opinions on how progressive that tax system ought to be. More recently, political battle lines have been drawn over the tax cuts legislated under the Treasury Laws Amendment (Personal Income Tax Plan) Act 2019. A premise often put forth in favour of such tax cuts is that Australia's income tax system is too progressive such that high earners are paying too much tax. Given these ongoing debates, there is much need to measure and examine trends

[1] Recent notable reviews include the "Henry Tax Review" (Henry et al., 2010) and "Better Tax System, Better Australia" Australian Government, The Treasury (2015).

in Australia's income tax progressivity.

How progressive is Australia's income tax system? How has the progressive level changed after tax reforms? How has it evolved over time since the Goods and Services Tax Act 1999? Answering these fundamental questions is important for evidence-based debate on budget and tax reforms in Australia. However, a sound scientific measure of tax progressivity is essential to better understand the level of, and trends in, tax progressivity in Australia. In this paper, we study the evolution of tax progressivity of the Australian personal income tax system since 2001. Our goal is to provide metrics that can be used to consistently evaluate and monitor trends in the progressivity of the personal income tax system over time.

Our empirical analysis employs two data sets: Household, Income and Labour Dynamics in Australia Survey (HILDA) and confidentialised unit records of individual income tax returns from the Australian Tax Office (ATO). HILDA is a nationally representative longitudinal study of Australian households and includes rich data on household incomes, taxes, public transfers and demographics. For that reason, we rely on HILDA as a primary data source. For comparison, we use administrative data of individual sample files from tax returns from the Australian Tax Office (ATO). The ATO tax data consists of over 2 million units representative of the entire population of tax payers.[2]

We first document the distributions of income and tax liabilities and properties of the joint distributions of income and tax liabilities across households and over time. We also calculate the effective average and marginal tax rates that individuals face. We discuss how income distribution and taxes have changed since 2001. We next construct various metrics for measuring the Australian personal income tax system's progressivity level.

In theory, metrics for measuring tax progressivity generally measure the extent to which tax liability increases with income. However, there is no clear consensus on how to measure tax progressivity in practice. The variety of metrics for measuring tax progressivity can be summarized into two main perspectives: (i) how tax liability increases as income rises (tax liability progression); and (ii) how tax liability is distributed across the income distribution (tax liability distribution).

[2]We have two sets of results estimated from HILDA and ATO data. The former is reported in the main text, while the latter is reported in Appendix. We find that the two results are fairly consistent with each other.

The tax progression approach has a long tradition in public finance going back to Pigou (1929) and Slitor (1948). According to this approach, a tax system is progressive if the additional tax burden on an additional unit of income exceeds the average tax burden at that income level. This implies an elasticity of tax liability greater than unity, which is equivalent to a positive gap between marginal and average tax rates. This approach is popular in policy making in Australia (e.g., see Henry et al. (2010) and Australian Government, The Treasury (2015)). Recent developments in the literature estimate elasticities of tax liability using a parametric tax function commonly used in the public finance literature (e.g., see Jakobsson (1976) and recently Heathcote, Storesletten and Violante (2017*b*)). However, to the best of our knowledge we are not aware of estimations of this tax function for Australia. In order to fill this void we estimate the parametric tax function using HILDA and ATO data. Our results show that the tax function well represents the Australian income tax code.[3] Importantly, our estimates of the tax elasticity indicate that the level of tax progressivity has been lower, compared to the level in 2001. This result is consistent with a common belief in Australia since the introduction of the Goods and Services Tax Act. Interestingly, our estimates show an upward trend in tax progressivity in recent years.

Differently, the tax liability distribution approach measures tax progressivity in terms of how tax liabilities are unevenly allocated across the income distribution. In essence, this measures the share of tax paid by individuals relative to their share of total income. A more progressive tax system is one where the tax liabilities are distributed more unequally toward the higher end of the income distribution. Suits (1977) and Kakwani (1977) generalize this idea and formulate a tax progressivity index, called the Suits index and Kakwani index. The Suits index is in essence a relative concentration coefficient for tax contribution inequality. It has values between $+1$ and -1. In a proportional tax system, where everyone pays the same share of their income in tax, the Suits index would be 0. A negative value indicates a regressive tax system; meanwhile, a positive value indicates a progressive tax system. The tax system is most regressive when the Suits index is -1, and most progressive when the Suits index has a value of $+1$, where the entire tax burden is allocated to members of the highest income group. Closer to $+1$ on the

[3] Heathcote, Storesletten and Violante (2017*b*) also find this parametric tax function fits the US income and tax data very well. **?** estimate a similar tax function for several OECD countries.

Suits index, the more progressive the income tax system.

Our estimates of the Suits progressivity index show different trends in tax progressivity. The level of tax progressivity changes year to year and tends to move in a cycle of greater and lesser tax progressivity, namely tax progressivity cycle. Specifically, there is a general downward trend from 2001 to 2006, followed by a sharp rise till 2009 and 2010, and then another decline afterwards. Our estimates of the Kakwani index also show a similar pattern of tax progressivity cycle. The fluctuated series of the Suits progressivity index have been found in the previous literature, using different datasets. Smith (2001) finds levels of tax progressivity measured in terms of the Suits index are peaked in the early 1950s, followed a decline till the late 1970s, and then stayed relatively steady until 1997. Herault and Azpitarte (2015) find progressivity of the Australian tax system has declined from a peak value in 1997 and then increased in 2007 and 2009.

The discrepancies in trends in tax progressivity in Australia are interesting; however, they are not surprising results because of differences in measurement. Intuitively, the tax liability progression approach provides a "local" metric that measures how tax liabilities progress at certain points of the income distribution, which is technically equivalent to a relative distance between marginal and average tax rates at a certain income level. However, it does not provide an overall view of how much tax liabilities are distributed across different income groups. The Suits and Kakwani indices fill this gap as they are "global" metrics that measure the distribution of tax liabilities relative to income distribution. Thus, the two approaches are complementary and provide us different perspectives on tax progressivity in Australia.

Importantly, the tax liability distribution approach is analytically flexible and enable us to conduct a wide range of counterfactual analysis. We can identify the quantitative role of the driving factors behind trends in tax progressivity. We show that the tax progressivity cycle was driven by the lack of automatic indexation and a cycle of active and inactive tax policy. This results in a mismatch between the income tax code and the changes to the income distribution. During periods of active tax policy, frequent adjustments to the income thresholds for the statutory tax schedule and the Low Income Tax Offset lead to increased tax progressivity levels. However, when tax policy is left inactive (during periods of infrequent or no adjustments to the tax code), progressivity declined. In such periods, bracket creep as changes in the income distribution pushed more taxpayers onto higher tax brackets. We find that if income tax thresholds had been indexed to the consumer price index (CPI), it could have eliminated bracket creep and partially maintained a relatively stable level of tax progressivity in the early 2000s. However, it would have failed to mitigate the decline in tax progressivity in the long run, where the real income growth is more pronounced. In short, indexation to the CPI is not a full substitute for an active tax policy that has frequent adjustments to the tax schedule to keep the income tax code in line with income distribution dynamics.

In extension, we examine the income tax system's redistributive role in the wider context of the overall tax-transfer system. We estimate the redistributive effect of taxes and transfers by measuring the difference in the Gini coefficient of pre-and post-tax and transfer incomes. While tax progressivity plays a crucial role in the overall redistribution, it is relatively small compared to the redistributive effect of the transfer system. In addition, while tax progressivity governs the tax system's redistributive impact, overall redistribution from the tax-transfer system depends mostly on the size of transfers. Our findings provide another empirical evidence for the debate on the role of income taxes and transfers in mitigating income inequality. Herault and Azpitarte (2015) examine the redistributive impact between 1994 and 2009, using the Australian Survey of Income and Housing Costs (SIHC). They find that after reaching a peak value in the late 1990s, the redistributive effect of the tax and transfer system declined sharply. Our estimates resulting from HILDA data indicate a similar decline in redistributive role of the tax and transfer system between 2001 and 2009. However, we find this trend reverses after 2010.

We also highlight the quantitative importance of accounting for household heterogeneity when measuring tax progressivity using household survey data. The magnitude of such tax distribution index as Suits or Kakwani index is sensitive to the parametrization of the adult equivalence scale. Taxes and transfers depend on age, family structure, and various other demographic factors. While accounting for household demographics shifts down the Suits index trends, the cyclical pattern obtained from the household level data is similar to the one obtained from the individual-level data. Thus, the tax progressivity cycle is robust to measuring income and tax at the individual and household levels.

Finally, our findings have implications for the topical debate on inequality and tax reforms in Australia, which recently has animated many Australians. Both sides of politics appear certain about reforming the progressive tax and transfer (fiscal) system to address inequality. However, to the best of our knowledge, there has been no clear understanding of how progressive the fiscal system is in recent years. Our findings fill in that gap and also highlight the importance of sound policy research in the first place and its implications for better policy debate and outcome.

Related studies. We now position our study in the previous studies examining fiscal progressivity and redistribution in Australia. We are not the first to investigate tax progressivity in Australia but the first to apply both tax progression and tax distribution measures to Australia's context.

One of the earliest papers that examined tax progressivity in Australia is by Kakwani (1977), in which the author examined income tax statistics for Australia (1962 – 1972), Canada (1966 – 1972), Britain (1959 – 1967) and the United States (1958 – 1970). Kakwani found that there were relatively small differences in the degrees of income inequality before and after tax, except for the US. He also found that during the period, Australia had the highest degree of tax progressivity compared to the other advanced economies. Hodgson (2014) explores the relationship between personal income tax rates and means tested transfer payments in Australia from 1970 to 2014. She documents the major reforms in taxes and transfers during that period. She argues that the Australian tax and transfer system shifted from one with highly progressive tax rates coupled with universal benefits to flatter tax rates coupled with more targeted and means tested benefits.

Smith (2001) applies the tax distribution approach and provides a comprehensive study on tax progressivity in Australia. She estimates the degree of income tax progressivity from 1917 to 1997 from Australian official income taxation statistics, using 3 indices of tax progressivity - the Kakwani (1977) index, Suits (1977) index and Musgrave and Thin (1948) index. She finds a peak in tax progressivity in the early 1950s on the Kakwani and Suits indices and a strong decline till the late 1970s followed by a relatively steady trend until 1997. She also finds that only a slight temporary increase in progressivity was associated with tax reforms in the 1970s and 1980s. The results with Musgrave and Thin index were ambiguous in direction with occasional peaks. Smith (2001) only uses taxation statistics and does not extend beyond 1997. Herault and Azpitarte (2015) use the Australian Survey of Income and Housing Costs (SIHC) from 1994 and 2009. They find the Kakwani index declined from a peak value of 0.27 in 1997 to 0.23 in 2005, and increased in 2007 and 2009. We extend the tax distribution approach to a more recent and important period since the introduction of New Tax System Act 1999. We employ two new datasets: survey data (HILDA) and administrative data (ATO sample of tax records). We show that the levels of tax progressivity in Australia have been deteriorated sharply after 2010.

Our paper is related to a number of empirical studies on the redistributive effects of the Australian tax and transfer system. Whiteford (2010; 2014), Wilkins (2014*b*) and Herault and Azpitarte (2015) are notable studies that examine trends in the redistribution and progressivity of both taxes and transfers in Australia. Whiteford (2010) provides a detailed examination of the progressivity of the Australian transfer system together with taxes by examining the ratio of transfers paid to the poorest quintile to those paid to the richest quintile between the mid 1990s to 2005 and the concentration coefficient for transfers from 1980 to 2000. He concludes that Australia has one of the most progressive systems of direct taxes of any OECD country. Wilkins (2014*b*) studies income inequality between 2001 and 2010, using the Survey of Income and Housing (SIH) and the Household Income and Labour Dynamics in Australia (HILDA) survey. He shows that the effect of taxes on reducing income inequality declined in all income series used in the analysis. Wilkins (2014*b*) and Whiteford (2010; 2014) are descriptive in essence and focus more on summary statistics of redistribution at various income levels rather than on examining measures of progressivity.

Our study overlaps with Herault and Azpitarte (2015) that examines trends in the redistributive impact of the tax and transfer system between 1994 and 2009 using the Australian Survey of Income and Housing Costs (SIHC). They measure the redistributive effect as per Reynolds and Smolensky (1977). They also compare the Gini index of pre-fiscal income (before tax and transfers) to post-fiscal income (after tax and transfers). They find that after reaching a peak value in the late 1990s, the redistributive effect of the tax and transfer system declined sharply. Differently, we HILDA and ATO data and find a similar declining trend in the redistributive effect from 2001 to 2009. However, when we go beyond 2009 we find a reversed tax progressivity trend.

There is a large literature on inequality in Australia. For example, Leigh (2005) derives long-run inequality series from tax data. Wilkins (2015) documents trends in income inequality in Australia using household survey data and find a slight increase in income inequality over recent years. Chatterjee, Singh and Stone (2016) examine the rise in labour income inequality over the past decade using HILDA. Kaplan, Cava and Stone (2018) document the facts on consumption and income inequality among households in Australia, emphasizing the role of the rents imputed to home owners for conclusions about inequality. Differently, we document the joint distribution of income and tax liability using ATO data and also HILDA data. Our focus is different as we aim to estimate the progressivity level of the Australian personal income tax system.

The paper is structured as follows. Section 2 provides an overview of Australia's personal income tax system. Section 3 provides a description of the datasets and descriptive statistics. Section 4 presents two measures of tax progressivity and estimates and examines the driving forces behind the changes in tax progressivity. Section 5 presents extensions. Section 6 concludes. Appendices report additional results and further discussion.

2.2 The Australian personal income tax system

2.2.1 Overview

Australia ranks among those countries with the lowest overall tax burden (as measured by total tax revenue as a percentage of GDP). Personal income taxes are the most important revenue source of the Australian tax system. The tax revenue collected from personal income as a percentage of GDP has been considerably higher than the OECD average. It accounts for nearly 40 per cent of all tax revenue, the second highest among the OECD countries after Denmark (OECD 2018)

The core components of the Australian income tax system includes a progressive income tax schedule with statutory marginal tax rates that increase from one specified income threshold to another, levies, concessions and tax offsets. The progressive tax schedule is applied to total taxable income after deducting eligible expenses incurred in generating that income.

While the progressive tax schedule is fairly simplistic, tax offsets, levies and concessions are more complex and often subject to different rates, thresholds, taper rates and means tests. The low-income tax offset (LITO) is available in full for individuals below a specified low income threshold, and then gradually tapered above that till a specified high income threshold. In addition to the LITO, there are a number of other tax offsets that apply to specific demographic groups such as the senior Australians and pensioners tax offset (SAPTO) and employment termination payments tax offset Hodgson (2014). The personal income tax system also includes certain levies and concessions on certain types of incomes, i.e., capital gains and superannuation. A permanent levy called the Medicare levy is applied at a flat rate on the entire taxable income beyond a certain income threshold. In addition to the Medicare levy, a Medicare levy surcharge applies on those individuals above a specified income threshold without private health insurance.

2.2.2 Major changes to the personal income tax (2001 - 2016)

The structure of the Australian income tax system has changed dramatically during the 2000s. This change was mainly due to the landmark legislation titled A New Tax System (Goods and Services Tax) Act 1999 in which the Goods and Services Tax (GST) was introduced so as to reduce the reliance on income tax. Within each complex component of the income tax, rates, thresholds and taxable income have gone through periodical adjustments often on an yearly basis. In this section, we highlight the major changes that have influenced progressivity of the tax system during the period[4].

The income tax thresholds were not indexed, but periodically adjusted along with the marginal rates. There have been significant changes within the components of the Australian income tax system since 2001. Table 2.1 summarizes the major changes. As seen from Table 2.1, there have been periods of substantial changes to the tax system and periods where there were very

[4]In Australia, the income year is the full financial year beginning on 1 July and ending on 30 June of the following year. For brevity, we refer to each income year by the year in which the income year ends. For example, we refer to the income year 2003-04 as 2004 throughout the paper.

Table 2.1: Statutory income thresholds for the personal income tax and low income tax offset

	Income tax thresholds				Low Income Tax Offset (LITO)		
	Threshold 1	Threshold 2	Threshold 3	Threshold 4	Maximum offset	Threshold 1	Threshold 2
2001-2003	6,000	21,600	50,000	60,000	150	20,700	24,450
2004	:	:	52,000	62,500	235	21,600	27,475
2005	:	:	58,000	70,000	:	:	:
2006	:	:	63,000	95,000	:	:	:
2007	:	25,000	75,000	150,000	600	25,000	40,000
2008	:	30,000	:	:	750	30,000	48,750
2009	:	34,000	80,000	180,000	1,200	:	60,000
2010	:	35,000	:	:	1,350	:	63,750
2011	:	37,000	:	:	1,500	:	67,500
2012	:	:	:	:	:	:	67,500
2013-2016	18,200	:	:	:	445	37,000	66,667

Note: Year refers to the year in which the income year ends. For instance, 2008 refers to the income year from 1st July 2007 to 30th June 2008. Marginal tax rate is a specific tax rate applied to each income bracket given by specific income thresholds. Marginal tax rates usually increase from low to high income brackets. In Australia, there are five income brackets. The corresponding marginal tax rates are 0%, 17%, 30%, 42% and 47% in 2001 and 0%, 19%, 32.5%, 37% and 47% in 2016. Further details to changes in income thresholds and marginal rates for income taxes, low income tax offsets (LITO) and senior Australian and pensioner tax offsets (SAPTO) are reported in the Appendix. The income thresholds are in nominal values. Cells with : denote values that are the same as previous year values.

minor changes. In this regard, 2006 - 2013 can be marked as a period of active tax policy with frequent changes, while 2001 - 2006 and 2013 - 2016 were periods of inactive tax policy with relatively little changes.

The top threshold in 2004 was at $\$62,500$ compared to $\$180,000$ in 2016. This threshold was raised each year from 2005 to 2007, with the steepest rise in 2007 from $\$95,000$ to $\$150,000$. Although the marginal tax rates were relatively constant, the change in the income thresholds indirectly reduced the marginal tax rates for the top income earners. Comparatively, middle income earners faced relatively little change in their tax burdens.

Increases in the top threshold were also coupled with reductions in the tax burden of the lowest income earners through changes to the LITO. From 2006 to 2012, the government gradually increased the LITO thresholds. There was also a steep increase in the maximum offset from $235 in 2006 to $\$1,500$ in 2012. This served to reduce the effective tax rate at the bottom thresholds. In 2013, the statutory tax-free threshold was tripled from $\$6,000$ to $\$18,000$ and the LITO was adjusted to reflect this change, with a reduction of the maximum offset amount to $445. Low income earners have been largely relieved of income tax.

2.3 Data and descriptive statistics

2.3.1 Data

We employ two data sets in our analysis: (1) Restricted (unconfidentialised) data from the Household, Income and Labour Dynamics in Australia Survey (HILDA) and (2) confidentialised unit records of individual income tax returns from the Australian Tax Office (ATO). The analysis is primarily based on HILDA data. The HILDA survey collects detailed information on respondent's annual income that allows for an estimation of total personal and household incomes. Public transfers, income tax and after tax net income are estimated. In addition, the rich set of information included in the survey allows for more accurate estimations of tax payments. Further, the sample is not dependent on individuals lodging tax returns; therefore, it is more representative of the Australian population compared to the ATO sample. In addition, HILDA is relatively stable in its survey methods and income measures and there is a strong emphasis on preserving longitudinal consistency (Wilkins, 2015).

Our unit of measurement is an adult individual who legally pays taxes in Australia. The notion of income in our analysis encompasses all income flows accruing to the sampling unit: labor income, capital/asset income and private transfers. We define this as pre-government (before tax and transfer) income. We then add taxes to have post-tax and pre-transfer income. We finally add public transfers and consider post-government (after tax and transfer) income.[5] The income tax schedule and income tax bases are in nominal values. Unless explicitly mentioned, all income, tax liabilities and transfers are expressed in nominal terms.

We restrict our sample of the Restricted HILDA data to those individuals with non-negative income and tax liability. We drop any observations where the average tax rate exceeds the top marginal tax rate for a given year. Around 5% of the HILDA data were excluded. Our final sample consists of $299,662$ units in total. We report the results estimated from the Restricted version of HILDA $2001-2016$ in the main analysis. We extend our analysis to use the General (confidentialised) version of the HILDA data $2001-2018$ in Appendix. For comparison, we

[5]We report the results for pre-tax and post-transfer income, and post-tax and post-transfer income in Section 5. Herault and Azpitarte (2015) use a similar measurement of income, but call it post-fiscal (after tax and transfer) income. In addition, we also consider household as a measurement unit that pays taxes to and receives transfers from the government in Section 5.

Table 2.2: Summary statistics from HILDA 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Pre-gov. income			Tax			Relative share	Tax rate	
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share	Marginal	Average
Quintile 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quintile 2	2,505.81	2.20	2.20	1.03	0.00	0.00	0.00	0.68	0.03
Quintile 3	13,134.00	11.52	13.72	478.12	2.05	2.05	0.18	8.18	3.46
Quintile 4	30,063.78	26.38	40.10	4,544.80	19.49	21.54	0.74	27.25	15.22
Quintile 5	68,261.52	59.90	100.00	18,298.51	78.46	100.00	1.31	39.69	24.63
Top 1%	212,245.25	9.31	100.00	79,851.83	17.12	100.00	1.84	47.00	36.25

Note: The table reports the descriptive statistics of income and tax liabilities from HILDA data in 2001. Column (1) lists the mean nominal pre-government (before tax and transfer) income for each quantile. Column (2) presents the share of total pre-government income earned by the quantile. Column (3) shows the cumulative shares. Columns (4) to (6) repeats the same statistics by quantile for tax payment/liability. Column (7) reports the share of tax liability for each quantile relative to their share of income, namely, Relative Share of Tax (RST). Columns (8) and (9) presents the marginal and average tax rates averaged by quantile.

report the results estimated from the ATO sample 2004 – 2016 in Appendix.

2.3.2 Descriptive statistics

We begin by briefly documenting trends in pre-government income and tax liabilities across the income distribution from 2001 to 2016 using the HILDA data.[6]

Income and tax liabilities. Tables 2.2 presents the descriptive statistics of the distribution of pre-government income and tax liabilities in 2001. It highlights the substantial degree of concentration of both pre-government income as well as tax liabilities at the top half of income distribution. The bottom 40% earned only 2.2% of total pre-government income. With a mean pre-government income less than the tax free threshold, these low income individuals were not liable for any tax payments. Meanwhile, the richest 20% of individuals earned around 60% of total pre-government income and were liable for 79% of total tax payments. The top 1% stands out from the rest of the income distribution with 9.3 of total income and 17% of total tax payment in 2001.

The share of tax payments is higher for higher income groups. Column 7 in Tables shows the share of taxes relative to the share of income earned by each quintile. In 2001, the share of total tax paid by the top 1% was 1.8 times their share of total income. The share of total taxes relative to the share of income increases with increasing incomes indicating a progressive tax

[6]We provide a detailed description of the distribution of pre-government income and tax liability from both HILDA and ATO data in our technical appendix.

Table 2.3: Summary statistics from HILDA 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Pre-gov. income			Tax			Relative share	Tax rate	
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share	Marginal	Average
Quintile 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quintile 2	7,789.98	3.42	3.42	0.05	0.00	0.00	0.00	0.06	0.00
Quintile 3	27,992.61	12.29	15.71	892.02	2.12	2.12	0.17	11.01	2.79
Quintile 4	56,207.10	24.68	40.39	8,127.42	19.33	21.45	0.78	30.70	14.47
Quintile 5	135,740.01	59.61	100.00	33,034.04	78.55	100.00	1.32	37.62	23.61
Top 1%	512,936.88	11.26	100.00	133,765.17	15.90	100.00	1.41	47.00	27.65

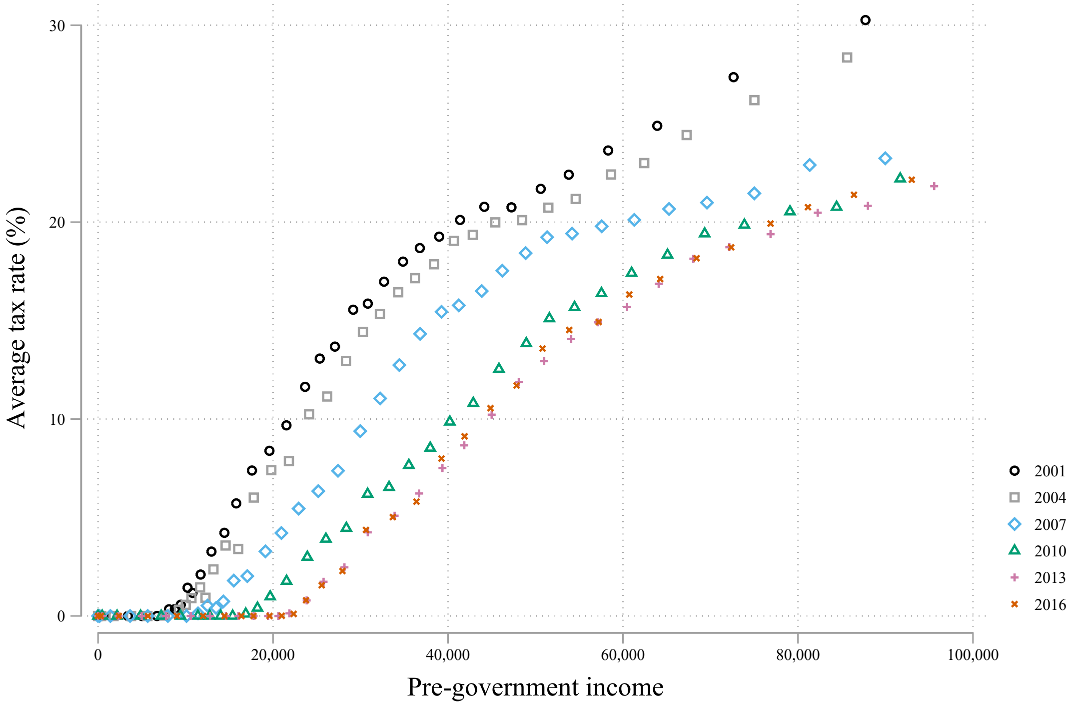
Note: The table reports the descriptive statistics of income and tax liabilities from HILDA data in 2016. Column (1) lists the mean nominal pre-government (before tax and transfer) income for each quantile. Column (2) presents the share of total pre-government income earned by the quantile and column (3) shows the cumulative shares. Columns (4) to (6) repeats the same statistics by quantile for tax payment/liability. Column (7) reports the share of tax liability for each quantile relative to their share of income, namely, Relative Share of Tax (RST) given by $\mathrm{RST}_i = \frac{\text{Percent of total tax liability by quintile } i}{\text{Percent of total income earned by quintile } i}$. Columns (8) and (9) presents the marginal and average tax rates averaged by quantile.

system. This is also reflected in the marginal tax rates (column 8) and average tax rates (column 9). Both marginal and average tax rates increase as income increases. The top marginal tax rate was 47% while marginal tax rates around the median averaged at 17% in 2001. As the average tax rates below the marginal tax rates, the tax system has a progressive structure.

Table 2.3 reports the summary statistics for 2016. The income shares by quintile are quite similar to 2001, except for the highest income group. The income share earned by the top 1% increases from 9% to 11%. Conversely, their share of tax liability decreased from 17% to 16%. As a result, there is a decline in relative share tax (RST) at the top from 1.8 to 1.4. This reduction in tax liability is also observed by the fall in average tax rate from 36% in 2001 to 28% in 2016. Comparing 2016 with 2001 reveals that the relative tax liabilities at the bottom had declined significantly with very small changes at the top. There also has been a decline in average tax rates for the bottom 4 deciles.

Average taxes. Figure 2.1 reports the average tax rates (taxes as a fraction of income) by income over time. There has been a significant reduction in the average tax rate. Compared to all other years, 2001 shows higher average tax rates at all income levels. For example, the average tax rate decreases from around 19% to 8% at the income level of $40,000. The figure displays a rightward shift from 2001 to 2016. The effective tax free threshold has increased by a large extent. This is due to changes in the statutory thresholds and those for various offsets.

Figure 2.1: Average tax rates by income

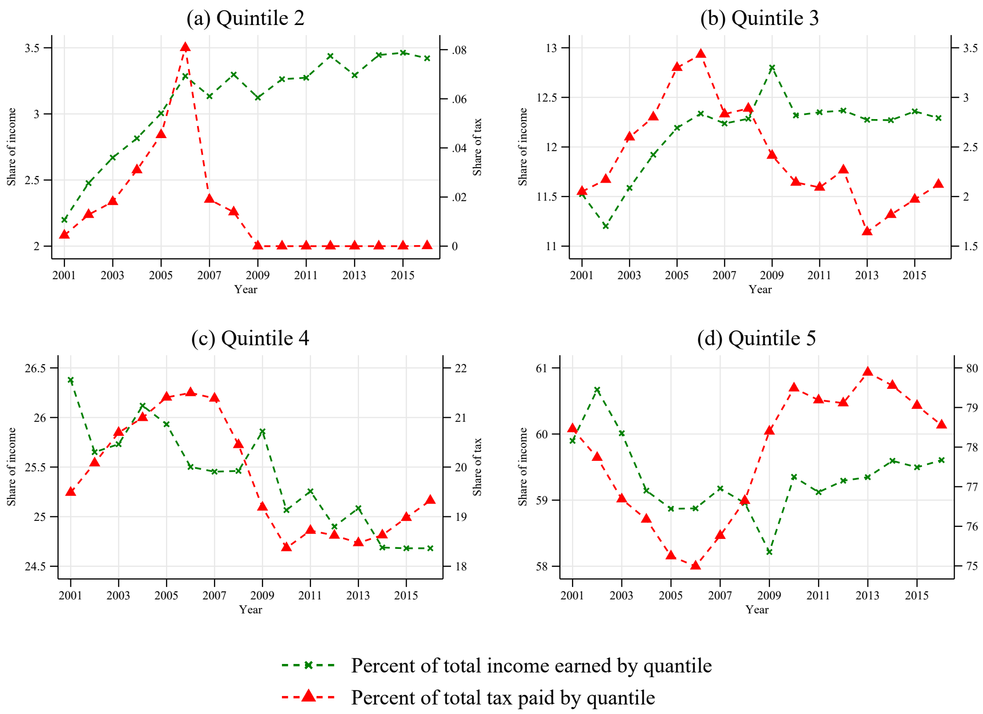


Note: Average taxes rates are taxes as fraction of income. This figure displays the average tax rates by levels of pre-government income in Australia from 2001 to 2016.

An increase in the tax free threshold tends to reduce tax burdens at the bottom and make the system more progressive. However, at the same time, the tax code has also become flatter with relatively lower tax rates at the top in 2016 compared to earlier years indicating a reduction in progressivity.

Relative income and tax shares. Figure 2.2 reports trends in the percent of total income and the percent of total tax liability by quintile from 2001. The bottom quintile has been omitted as income and tax shares remained at 0% at the bottom throughout the period. The share of income earned by the middle quintiles decreased while their share of tax liability increased from 2001 to 2002. Meanwhile, the share of income earned at the top increased while their tax share decreased. Between 2001 and 2006, both the tax share and income share of quintile 2 increased. During the same period, the top quintile experienced both a decline in their share of income and their share of tax liability. For most years, quintiles 3 and 4 follow trends in quintiles 2. After 2007, there were practically no changes in tax share for quintile 2. However,

Figure 2.2: Trends in income and tax shares by quintile



Note: This figure shows pre-government income shares and tax shares by income quintile from 2001 to 2016 using HILDA data. The green line is the share of the total income while the red line is the share of total tax liability. Quintile 1 is omitted because income and tax shares remained at 0%.

between 2007 and 2010, tax shares at the top quintile was on an upward trend while quintiles 3 and 4 experienced a sharp fall in their tax shares. Since 2013 the tax share of the top quintile has been decreased while quintiles 3 and 4 experienced an increase in their tax shares.

While descriptive statistics provide important snapshots of progressivity across the income distribution, they do not provide us with a simple indicator of how the overall progressivity of the tax system evolves over the period. It is difficult decipher trends in progressivity by comparing tables such as Tables 2.2 and 2.3 for each and every year. This motivates the need for constructing metrics to measure the overall level of tax progressivity that would pick up subtle changes in the income tax system over time.

2.4 Measuring tax progressivity

In this section, we formulate two metrics that enable us to quantitatively describe how progressive the Australian tax system is, and examine the evolution of tax progressivity over time. In general, tax progressivity is defined as the extent to which tax liability increases with income. There are various metrics for measuring tax progressivity, which can be summarized into two main perspectives: (i) how tax liability increases with income (tax progression); and (ii) how tax liability is distributed across the income distribution (tax distribution).

2.4.1 Tax progression metric

Musgrave and Thin (1948) define a progressive tax system as one where tax liability progresses when moving up the income scale. This can be expressed in terms of the progression of average and marginal tax rates, total tax liability or residual income. All these expressions are consistent with each other and can be intuitively interpreted through the lens of elasticity of tax liability with respect to income. Thus, our tax progression measure is based on this elasticity concept.

In order to illustrate this measure, consider an individual whose income and tax liability are level y and T, respectively. The elasticity of tax liability with respect to income is given by $\varepsilon = \frac{\partial T}{\partial y}\frac{y}{T}$. Let $m(y) = \frac{\partial T}{\partial y}$ and $t(y) = \frac{T}{y}$ be marginal tax rate and average tax rate, respectively. The elasticity of tax liability can be expressed in terms of a ratio of marginal tax rate to average tax rate as $\varepsilon = \frac{m(y)}{t(y)}$. If the elasticity is larger than unity, $\varepsilon > 1$, additional tax liability on an additional unit of income (marginal rate) exceeds average tax liability at that income level (average rate), i.e., $m(y) - t(y) > 0$. In such cases, the tax system is progressive.

The tax progression measure can be calculated by assuming a parametric tax function to summarize the complicated structure of the income tax code in easy-to-interpret parameters. We use a parametric tax function which is commonly used in the public finance literature (e.g., see Jakobsson (1976), Persson (1983), Benabou (2002) and more recently Heathcote, Storesletten and Violante (2017*b*)). Specifically, the parametric tax function has a form of

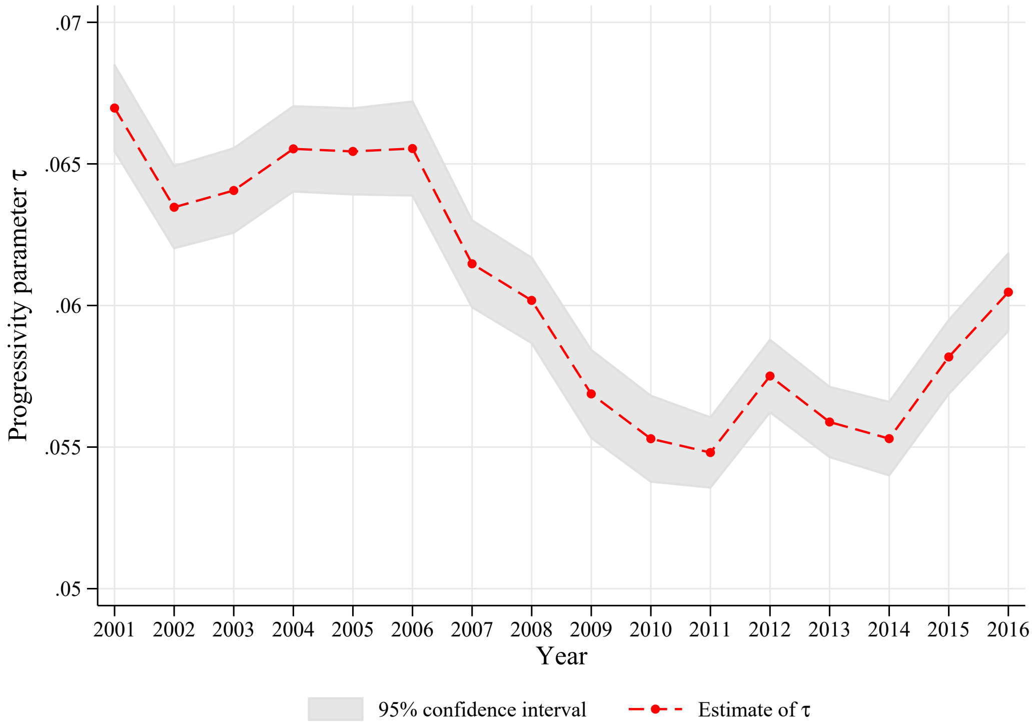
$$T = y - \lambda y^{(1-\tau)},$$

where λ is a scale parameter that controls the level of the average tax and τ is a curvature parameter that controls the curvature of the function. In effect, the curvature parameter τ is a closed-form expression of tax elasticity given by $\frac{m(y)-t(y)}{1-t(y)} = \tau$. When $\tau = 0$, the elasticity of tax liability is zero and marginal and average tax rates are identical, which is a proportional income tax. When $\tau > 0$, the elasticity of tax liability is greater than unity and the marginal tax rate is higher than the average tax rate. The higher the value of τ, the more progressive is the income tax schedule.

Importantly, this parametric tax function approach is empirically appealing as it is straightforward to estimate the two parameters τ and λ from micro data, using the logarithmic transformation of the tax function specification. We estimate the parameters of the parametric tax function for Australia, using data from HILDA and ATO. In general, these two parameters are estimated with a high degree of precision. Around 99 percent of the variation in the data is explained by the tax function and with very low robust standard errors on both the curvature parameter τ and scaling parameter λ. The estimated values of τ are in a range between 0.055 and 0.067. In general, the parametric tax function quite well represents the Australian income tax code and its changes over time.[7]

[7] We report the estimates of the parametric tax function in Table 9 in the accompanying technical appendix. Our results show that this tax function quite well represents the Australian income tax system. Similarly, Heathcote, Storesletten and Violante (2017*b*) finds this parametric tax function fits the US income and tax data very well. Holter, Krueger and Stepanchuk (2019) estimate a similar parametric tax function for several OECD countries.

Figure 2.3: Levels of tax progressivity measured by the parameter τ



Note: This figure shows the estimates of τ using HILDA 2001-2016. Technically, $\tau = \frac{m(y)-t(y)}{1-t(y)}$ is an index of tax progressivity.

Figure 2.3 displays the estimates of τ and along with the 95% confidence interval using HILDA from 2001 - 2016. Our result indicates that τ declined for the most of the period. The sharpest decline is from 2006 to 2011 after the top income threshold was increased from \$95,000 in 2006 to \$150,000 in 2007 and \$180,000 in 2009. This was a tax cut for high income individuals, which resulted in only the top 1 percent of the income distribution paying the top marginal tax rate. The taxes as a fraction of income, i.e. average tax rates, have declined significantly during the period. Smaller estimated values of the parameter τ imply that the adjusted average gap between the average and marginal tax rates has been narrowed down due to the tax cuts for relatively high income individuals.

There is an increase in the estimated value of τ for the period of 2015-16. However, the levels of tax progressivity measured by the parameter τ are generally lower than that in 2001. Accordingly, one could conclude that progressivity of the Australian personal income tax system has declined since the introduction of a New Tax System (Goods and Services Tax) Act

1999.

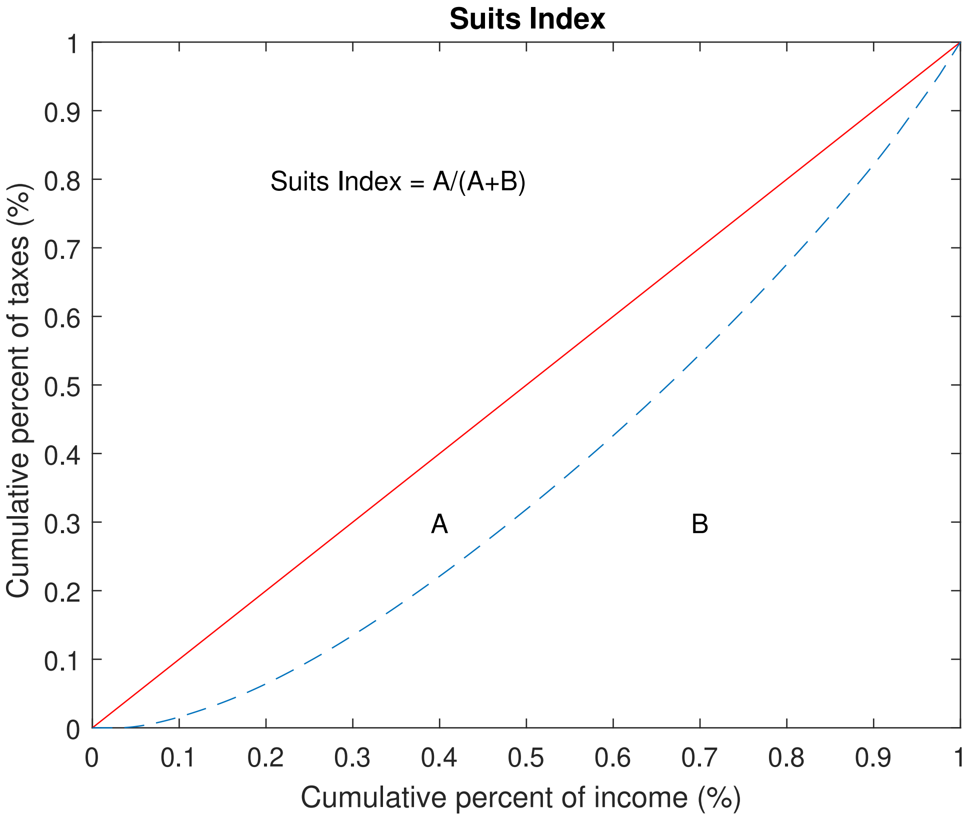
Reflecting overseas trends, we are the first to measure trends in tax progressivity in Australia using the tax progression approach with a parametric tax function. However, it is important to note that the tax progression approach basically measures the gap between marginal and average tax rates at certain points on the income distribution. In essence, it is a "local" metric and the parametric estimate of the parameter τ can only provide an approximation of this local metric. As documented before, the marginal and average tax rates vary considerably across income groups in Australia. It is necessary to have a more general metric that systematically accounts for variation of tax rates and tax liabilities across the income distribution.

2.4.2 Tax distribution metric

In this section we consider a metric for measuring tax progressivity that takes into account tax shares relative to their income shares (e.g. see Pfahler (1987)). In the literature, there are two commonly-used measures: Kakwani (1977) index and Suits (1977) index. Both indices compare the distribution of tax liabilities ordered by income with the income distribution. Progressivity depends on the extent to which the tax system deviates from proportionality. In essence, these two indices measure how equally tax liabilities are distributed across the whole income distribution. A more (less) progressive tax system is one where the tax liabilities are distributed more (less) unequally toward the upper end of the income distribution.

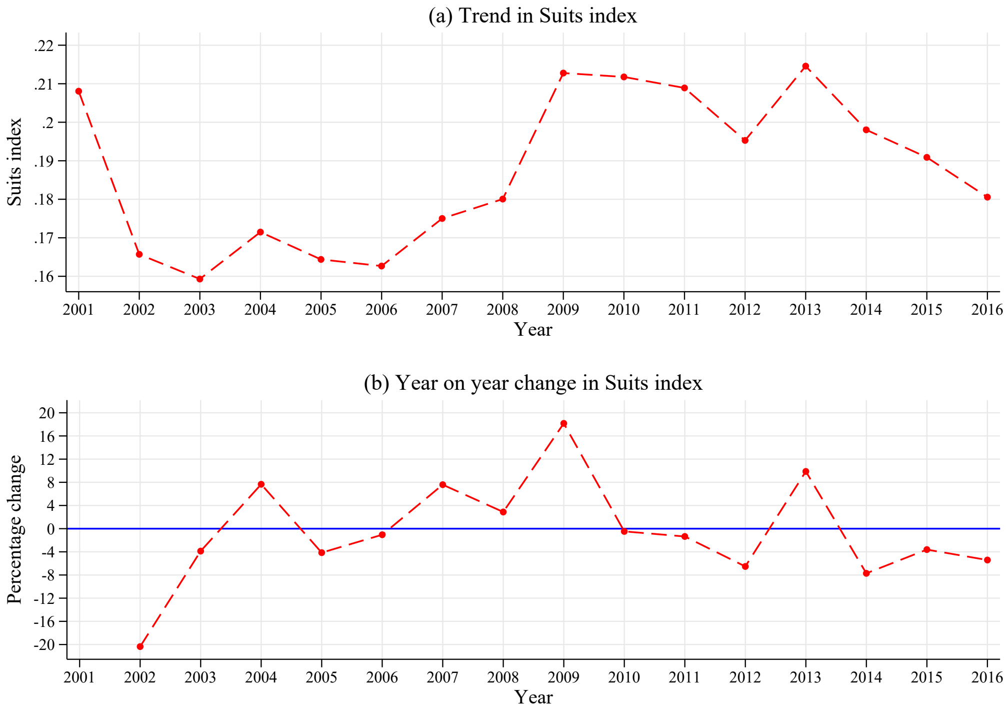
Figure 2.4 illustrates how the Suits index is calculated. The curve plots the cumulative proportion of tax liabilities ordered by pre-government income against the cumulative proportion of pre-government income. The 45 degree line indicates proportionality where tax shares equal income shares. A curve below the line indicates a progressive system where tax shares increase with rising income shares and vice-versa. The Suits index is the area between the 45-degree line and the relative concentration curve. The index ranges from -1 for the most regressive tax possible to +1 for the most progressive tax possible, and takes the value zero for a proportional tax.

Figure 2.4: The relative concentration curve of tax and Suits index



Note: The relative concentration curve plots the cumulative proportion of tax liabilities ordered by income against the cumulative proportion of (pre-government) income. The 45 degree line indicates proportionality where tax shares equal income shares. The Suits index for tax is the area between the 45-degree line and the relative concentration curve. The index ranges from -1 for the most regressive tax possible to +1 for the most progressive tax possible, and takes the value zero for a proportional tax.

Figure 2.5: Levels of tax progressivity measured by the Suits index



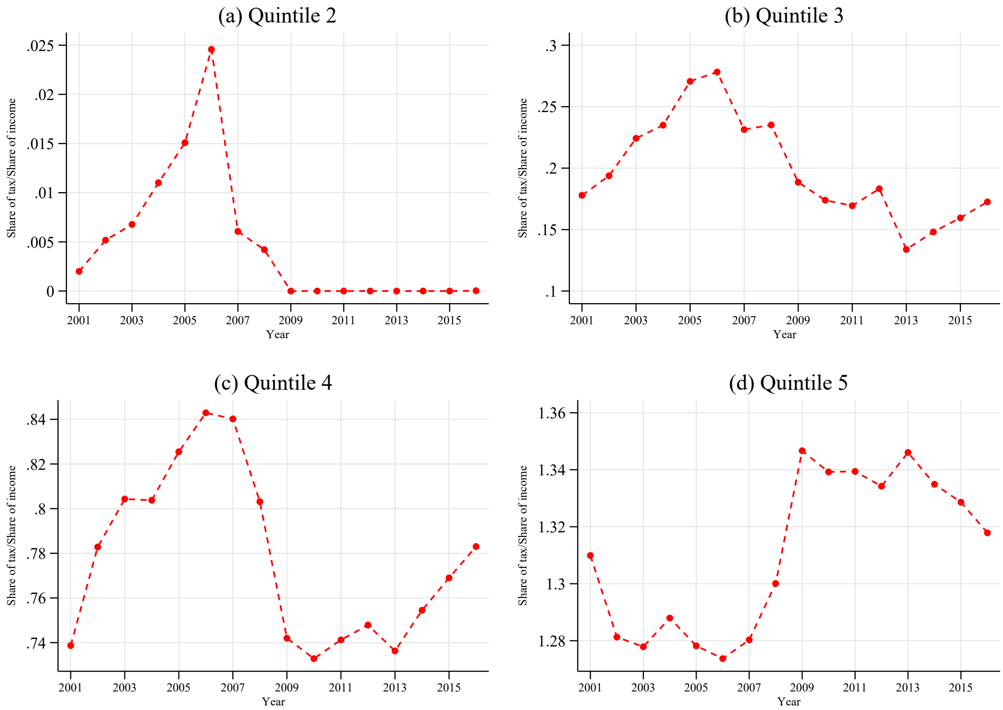
Note: This figure reports tax progressivity measured by the Suits index. Panel (a) displays the estimates of Suits index, using HILDA data from 2001 to 2016. Panel (b) displays the percentage changes.

Figure 2.5 reports the estimates of Suits index using HILDA from 2001 to 2016.[8] Our estimates confirm that the Australian income tax system is indeed progressive. As seen in Panel (a) of Figure 2.5, the Suits index is around 0.21 in 2001. Interestingly, the trend in tax progressivity are quite different from the one obtained from the tax progression metric. The level of tax progressivity changes year to year and tends to move in a cycle of greater and lesser tax progressivity (tax progressivity cycle). More precisely, there is a general downward trend from 2001 to 2006 with a reduction between 2002 and 2006 by around 20% (see Panel (b) of Figure 2.5). From 2006 – 2010 there is a significant increase in tax progressivity. The most significant increase in progressivity is seen from 2008 to 2009. The level of tax progressivity is relatively stable between 2010 and 2013. However, there is a sharp decline since 2013.

Our findings are connected to the body of Australian research on tax progressivity. Smith (2001) has a similar methodological approach using the Kakwani and Suits indices. She finds a peak in tax progressivity in the early 1950s and a strong decline till the late 1970s and then

[8]We present trends for the Suits index in the main paper and report estimates of the Kakwani index in Appendix.

Figure 2.6: Trends in tax shares relative to income share



Note: This figure shows tax shares relative to pre-government income shares (RST) by income quintile from using HILDA 2001-20016. Quintile 1 is omitted because its income and tax shares remained at 0%. The share of tax relative to share of income (RST) by income quintile is given by $\text{RST}_i = \frac{\text{Percent of total tax liability by quintile } i}{\text{Percent of total income earned by quintile } i}$.

a relatively steady trend until 1997. She also finds that only a slight temporary increase in progressivity was associated with tax reforms in the 1970s and 1980s. Smith (2001) only use taxation statistics and does not extend beyond 1997. Herault and Azpitarte (2015) use data from the Australian Survey of Income and Housing Costs (SIHC) from 1994 to 2009. They find progressivity of the Australian tax system has declined from a peak value in 1997 and then increased in 2007 and 2009. By employing a different dataset (HILDA) we confirm their progressivity trends for $2001 - 2009$, and by extending the period till 2016 we find a cycle of lesser and greater tax progressivity since 2001.

The Suits index is a useful indicator for summarizing overall tax progressivity. However, it does not identify which parts of the distribution are responsible for any changes over time. To complement the analysis, we report how much of tax and income shares by each income quintile have changed over time.

Figure 2.6 displays the trends in tax share relative to income share by quintiles. Between 2001 and 2007, quintiles 2 - 4 experienced an increase in their tax shares relative to their income shares, while the top quintile experienced a decrease. This is indicative of a decline in the progressivity of the tax system. This trend is reversed between 2007 and 2013 where the top quintile experienced a rise while the rest experience a fall in their relative tax shares, indicating an increase in progressivity. Note that, since the top quintile contributes around 78 percent of total tax payments the changes in their relative tax share strongly influences the overall trend in tax progressivity measured by the Suits index.

Hence, our two measures of tax progressivity reveal quite different trends in Australia since 2001. The tax progression measure indicates a declining trend in tax progressivity, while the tax distribution measure indicates a tax progressivity cycle. In particular, the two measures show opposite trends in tax progressivity from 2014. This difference is mainly due to the difference in methodological approach. That is, the tax progression-based approach estimates the adjusted elasticity of tax liabilities; meanwhile, the tax distribution-based approach calculates a progressivity index based on the relative share of tax liability to income across the income distribution. Arguably, the former is a local measure, while the latter is a more comprehensive measure as it takes into account the relative changes in tax liabilities across the income distribution. More importantly, the tax distribution metric is flexible, which allows us to conduct decomposition analysis so as to isolate the quantitative importance of the underlying forces behind trends in tax progressivity.

2.4.3 Determinants of tax progressivity

In this section, we examine factors that drive trends in tax progressivity using the tax distribution metric. By definition, the estimate of the Suits index depends on the evolution of tax liabilities relative to the evolution of the income distribution. The former is mainly driven by the design of the Australian income tax system and tax reforms, while the latter is mainly driven by income growth and how the economic gains are shared by Australians.[9]

[9] The evolution of income distribution is driven by many factors, including productivity, business cycles, female labour force participation, population ageing, etc, which might have different effects on progressive levels of the tax system. In this analysis, we do not attempt to isolate which factors are the most important ones. Instead, we aim to better understand how and to what extent changes in the income distribution as a whole influences tax progressivity in Australia.

2.4.3.1 Tax indexing

In Australia, income tax brackets/thresholds are not indexed to adjust automatically with rising incomes due to economic growth and inflation. In order to maintain the real burden of taxes relatively unchanged, the government could regularly adjust income tax brackets through discretionary changes, namely an "active" tax policy. In practice, however, the Australian government often leaves the tax brackets unchanged from one year to another ("inactive" tax policy). As a result, the evolution of income distribution pushes more taxpayers into higher tax brackets and increases effective and marginal tax rates, resulting in higher tax liabilities. Further, while some individuals move into higher marginal tax rate brackets, almost all move onto higher average tax rates. This phenomenon arising from the lack of indexation is known as "fiscal drag" or "bracket creep"

Bracket creep and progressivity. We now study how and to what extent bracket creep affects trends in tax progressivity in Australia. To do so we consider the period from 2013 to 2016 where there were no discretionary adjustments to the income brackets and marginal tax rates, namely an inactive tax policy period.

Table 2.4 reports the percentage of tax payers in each statutory tax bracket and the percentage of taxpayers who were eligible for maximum LITO, some LITO or no LITO. We find that the inactive tax policy disproportionately affects the percentage of taxpayers in different tax brackets, especially the ones on the lower end of the income distribution. There is a significant reduction in the number of individuals who are eligible for no income tax or LITO.

Specifically, the inactive tax policy effectively increases the number of taxpayers from the low and middle income groups. As seen in Figure 2.5 this policy subsequently leads to a declining trend in the Suits index from 2013 to 2016 (the green line). This implies that a bracket creep policy leads to a less progressive income tax system. This finding is rather surprising and contradicts a common view in the tax debate that bracket creep induces a more progressive tax system.

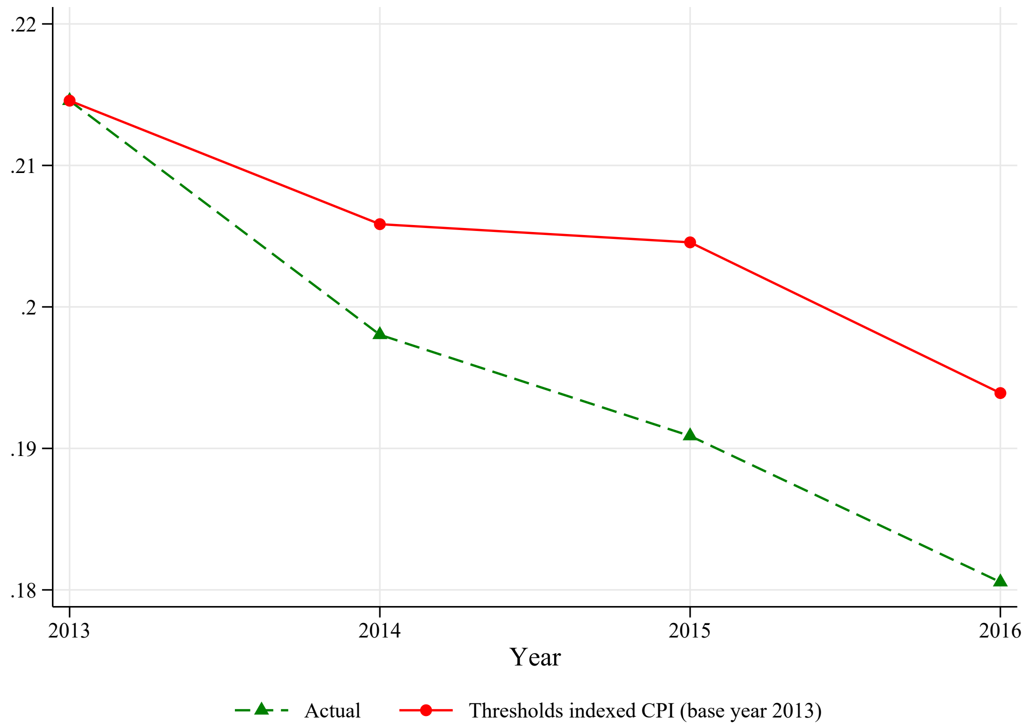
Indexation to the CPI. In order to explore the effects of bracket creep on tax progressivity, we consider a counterfactual policy experiment where income thresholds of the income tax

Table 2.4: Movements of tax payers across income tax brackets

Brackets	2013	2016	Change
0 - 18,200	51.31	48.05	-3.27
18,201 - 37,000	10.10	10.20	0.10
37,001 - 80,000	23.09	23.68	0.58
80,001 - 180,000	13.21	15.07	1.87
Above 180,000	2.29	3.00	0.71
LITO: below 37,000	61.41	58.25	-3.16
LITO: 37,001 - 66,667	17.54	17.40	-0.14
LITO: above eligibility	21.05	24.35	3.30

Note: This table reports movements of tax payers between 2013 and 2016. There were no discretionary changes in income tax brackets and marginal tax rates during this period, which is referred as an "inactive" tax policy period. While holding the tax schedule unchanged the evolution of income distribution pushes taxpayers into higher tax brackets.

Figure 2.7: Bracket creep, CPI indexation and tax progressivity



Note: The red line is the Suits index for a hypothetical tax system in which income thresholds are indexed to inflation using the consumer price index (CPI). The green line is the Suits index for the actual tax system with no indexation. The income distribution is the actual one from our HILDA sample from 2013 to 2016.

system were assumed to adjust annually by the consumer price index (CPI) since 2013. We simulate data for this hypothetical tax system and estimate the Suits progressivity index (the red line) in Figure 2.7. For comparison, we also report the results for the actual tax system (the green line).

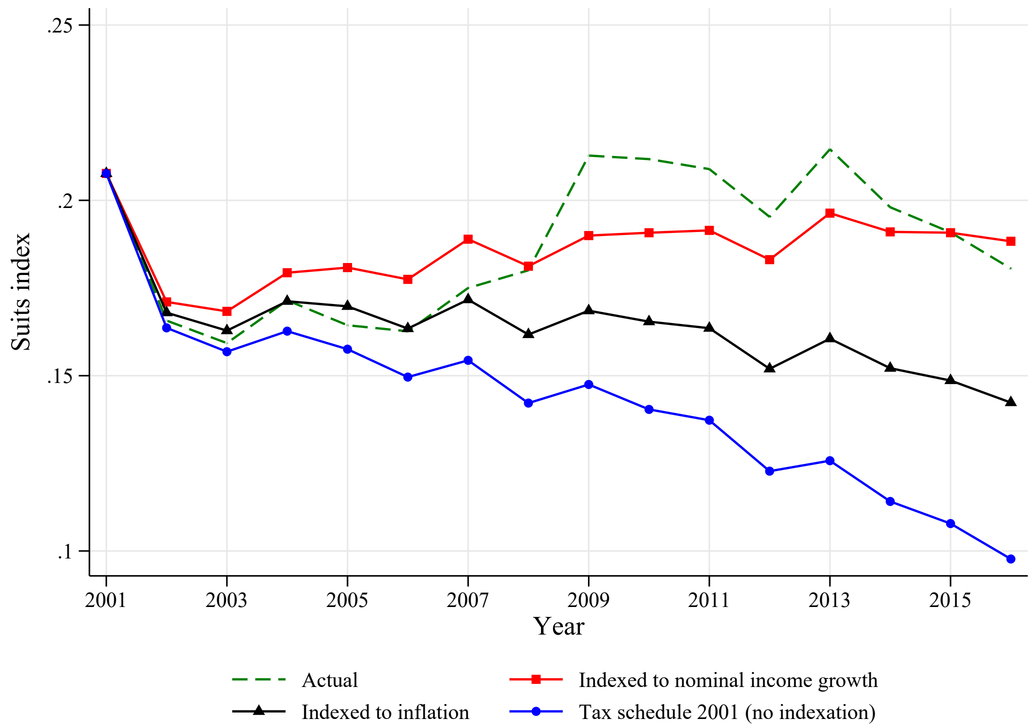
As shown in Figure 2.7 there is a similar downward trend in the Suits index with the counterfactual tax policy (the red line). However, levels of tax progressivity decline at a lower rate when the tax brackets are indexed to the CPI. Yet, this indexation system mitigates the decrease in the progressivity level of the Australian income tax system. However, it fails to anchor tax progressivity at the 2013 level. The main reason is that there are two drivers behind the shifts in income tax bases over time: inflation (nominal change in incomes) and economic/productivity growth (real change in incomes). The former is eliminated after indexing the tax brackets to the CPI, but the latter is still in play.

Indexation to nominal income growth. We now examine whether we could implement a more effective indexation system that would be able to maintain progressivity of the tax system. We consider an indexation system in which all tax brackets are indexed to nominal income growth. In particular, we assume all tax brackets are indexed to the CPI and average real income growth rate.

Figure 2.8. reports trends in the Suits index from 2001 to 2016. The dashed green line is the Suits index for the actual income tax system with no indexation. The blue line with square markers is the Suits index for a hypothetical tax system with no adjustments to income tax brackets since 2001. The red line with square markers is the Suits index for a hypothetical tax system where all income thresholds are indexed to the CPI. The black line with circle markers plots the Suits index for a hypothetical tax system where all income thresholds are indexed to nominal income growth in terms of the average CPI and growth rate.

As seen Figure 2.8, the level of tax progressivity follows a downward trend if the tax schedule is left unchanged since 2001. This result is consistent with the previous finding that the bracket creep policy reduces progressivity of the income tax system. With an inactive tax policy that left the income tax schedule unchanged the evolution of nominal pre-government income

Figure 2.8: Indexation and tax progressivity



Note: The blue line (circle markers) is the Suits index for the 2001 income tax system with no adjustments to income tax brackets since 2001. The red line (square markers) is the Suits index for a hypothetical tax system where income tax thresholds are indexed to the CPI. The black line (triangle markers) plots trends for the tax system where thresholds are indexed to average growth in nominal pre-government income. The dashed green line is the one for the actual tax system with no indexation. The income distribution is the actual one from our HILDA sample from 2001 to 2016.

distribution caused by inflation and higher productivity shifts tax burdens towards lower income groups. When the income tax schedule is indexed to the CPI (the red line with square markers), progressivity trend becomes more stable around the 2002 level until 2007 as the differences in progressivity levels are very small. The declining trend is mitigated after anchoring the nominal component of income growth. However, the progressivity level quickly deteriorated, especially after 2010. This result indicates that indexation to the CPI is not an effective tool to maintain a stable level of tax progressivity in periods when nominal income growth is subdued.

When the income brackets are indexed to both nominal and real components (black line with circle markers), levels of tax progressivity are lifted up to around the 2008 level, which is higher than the actual level in 2002, but closer to the actual levels since 2009. Notably, there is still a marked divergence in the actual trends in tax progressivity (dashed green line) and the counterfactual trends with indexation to nominal income growth (the red line). These differences imply that active discretionary tax adjustments and real income growth are the main drivers of actual progressivity levels of the income tax system after 2007.

It is important to note that levels of tax progressivity are sensitive to which tax brackets are indexed. The reason is that income growth rates are not similar across income groups. A more effective policy option would be indexation of the tax brackets to income growth rates of a nearest income quintile. A thorough investigation of alternative scenarios of indexation is important; however, it goes beyond the scope of this analysis.

2.4.3.2 Tax components

The Australian income tax system consists of four core components: a standard income tax schedule (Standard Tax), low income tax offsets (LITO), senior Australian and pensioner tax offsets (SAPTO) and Medicare levy and surcharge (Medicare Tax). Since 2001 there have been a series of tax reforms that have affected different components of the income tax system. In this section, we examine how the reforms of each component of the tax system affect the tax liabilities and the overall level of tax progressivity over time. We do so by considering the tax liabilities for four hypothetical income tax systems: (i) The standard tax schedule exclusive of all other three components ("Standard Tax"); (ii) a combination of Standard Tax and LITO,

(iii) a combination of Standard Tax and SAPTO and (iv) a combination of Standard Tax and Medicare Tax.

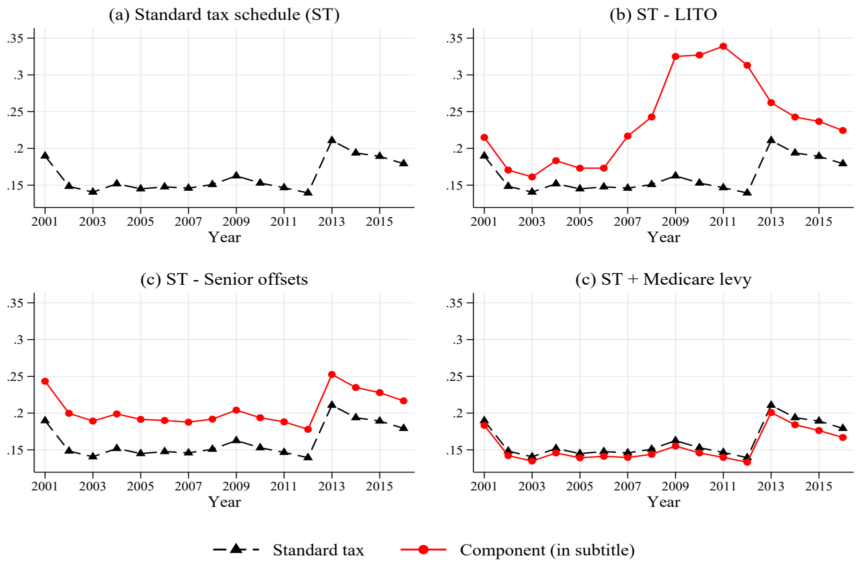
We calculate the Suits index for each counterfactual experiment and report the results in Figure 2.9. Panel (a) of Figure 2.9 plots trends in the counterfactual Suits index, assuming the Standard Tax at work. It is interesting to see that the Suits index is relatively stable from 2002 to 2012. This implies that the discretionary changes to the standard tax schedule only had a relatively small effect on the progressivity level. This result is rather surprising as there was a steady increase in the top threshold from $62,500 in 2004 to $150,000 in 2007. The most significant change in the progressivity level of the Standard Tax from 2012 to 2013 is an increase in the tax free threshold from $6,000 to $18,200.

The Suits index declines for any year when there were no changes in the Standard Tax from the previous year. As seen in Figure 2.9, there are two declining episodes in the tax progressivity trend between 2001 and 2003 and between 2013 and 2016. As discussed earlier, during these two sub-periods the tax policy are practically inactive with very little or no discretionary changes from one year to another.

Panel (b) of Figure 2.9 plots trends in tax progressivity for the counterfactual tax system that includes the Standard Tax and LITO. For all years, LITO reduces the tax liabilities of the low income individuals so that it has a positive effect on the overall level of tax progressivity. As seen in Panel (b), when LITO is subtracted from the standard tax schedule the Suits index increases. Interestingly, the changes to LITO, including a large increase in maximum offset amount and LITO thresholds, drive the upward trend in tax progressivity from 2006 to 2011. The maximum offset was reduced from $1,500 to $445 in 2013. However, the income test threshold for LITO was raised. The Suits index for LITO increased sharply between 2006 and 2011.

Subtracting all senior tax offsets (SAPTO) from standard tax schedule also reduces the tax liabilities of older individuals, which subsequently leads to higher levels of tax progressivity. Panel (c) of Figure 2.9 depicts an upward shift in trends in tax progressivity. In contrast, adding the Medicare Levy to the Standard Tax leads to a small reduction in the Suits index as depicted in panel (d). In general, the patterns in the Suits index trends in Panels (c) and (d), are similar to

Figure 2.9: Suits index for four hypothetical income tax systems



Note: There are four hypothetical income tax systems in consideration: (i) The standard tax schedule exclusive of all other three components ("Standard Tax"); (ii) a combination of Standard Tax and LITO, (iii) a combination of Standard Tax and SAPTO and (iv) a combination of Standard Tax and Medicare Levy. The income distribution is the actual ones from our sample of HILDA data. The tax liabilities are calculated from the hypothetical income tax system using the actual income distribution.

the one for the standard tax in Panel (a). However, the pattern for trends in the Suits index for the standard tax and that for LITO significantly different starting from 2006. This highlights the important role of LITO in determining the overall progressivity of the tax system since 2006.

2.5 Extensions and robustness checks

2.5.1 Government transfers and overall progressivity

In the previous section we have focused on progressivity of taxes only, but ignored government/social transfers. We now include government transfers and examine progressivity of the transfer system and then the tax and transfer system as a whole. In Australia, social transfer programs, including pension and family benefits, are means-tested, depending on household income and assets. We use data from our HILDA sample to analyse government transfers to households and their individual members.

Progressivity of the transfer system. We define transfers to be progressive if it decreases with income. We first plot the relative concentration curve to describe how progressive the Australian transfer system is. Figure 2.10 displays the relative concentration curves for government transfers, using data for 2004, 2009 and 2016, and the 45 degree line of proportionality where transfer shares equal income shares. The concave curves above the proportionality line indicate that social transfers are concentrated at the lower end of the income distribution, so that low income individuals receive a larger share of transfers. Specifically, the concentration curves for government transfer indicate that more than 60% and 90% of government transfers are allocated to the bottom 20% and 50% of income, respectively. In contrast, less than 2% of transfers are allocated to the top 20% of the income distribution. The transfer system is indeed very progressive in Australia. Compared to 2001, the transfer system is more progressive in 2016, while it is less progressive in 2009.[10]

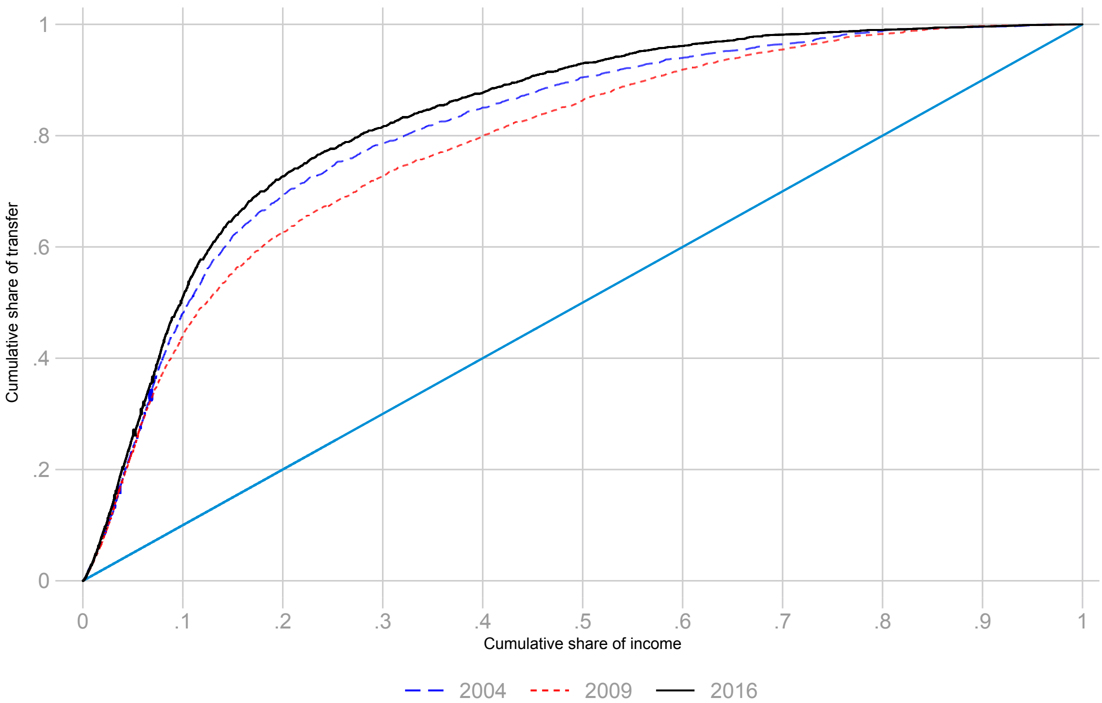
The Suits progressivity index for government transfers can be calculated based on the area between the line of proportionality and the relative concentration curve. Technically, since transfers are negative taxes a progressive transfer system results in a negative value for the Suits index. In order to compare between the Suits index for taxes only and the Suits index for transfers only in a consistent manner we transform the Suits index for transfers such that it is in terms of its absolute value. Our Suits index for progressive transfers is positive after transformation. The Suit index is $+1$ for the most progressive transfers possible and takes the value zero for a proportional transfer. The closer the Suits index is to 0, the lower the progressivity of transfers.

Panel (a) of Figure 2.11 reports the Suits index for social transfers. The Suits index confirms that the Australian transfer system is indeed very progressive with its value close to 0.9 in 2001. The progressivity level of the transfer system has been stable over the period, except for a drop in 2009. It is observed that the transfer system is slightly relatively more progressive in 2016.

Progressivity of the tax and transfer system. We now analyse the overall progressivity of combined taxes and transfers. Panel (b) of Figure 2.11 reports the trends in the overall progressivity of the tax and transfers system since 2001. The Suits index for combined taxes

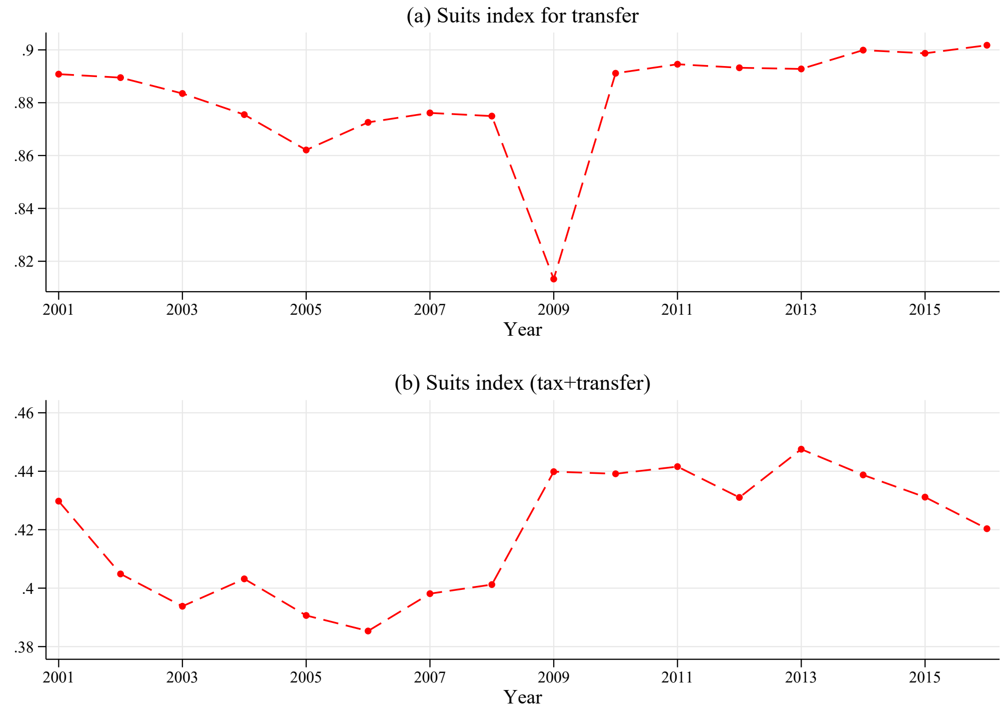
[10] We provide more descriptive statistics of government transfers and post-transfer income in Table 10 in the accompanying technical appendix.

Figure 2.10: Relative concentration curve for government transfers



Note: The relative concentration curve for government transfers plots the cumulative proportion of transfers ordered by income against the cumulative proportion of income. The 45 degree line indicates proportionality where transfer shares equal income shares. The Suits index is the area between the 45-degree line and the relative concentration curve for transfers. Technically, a progressive transfer system results in a negative Suits index. However, in order to compare between the Suits index for taxes and the Suits index for transfers in a consistent manner we transform the Suits index such that it is in terms of its absolute value. By doing so, an increase in the transformed Suits index for transfers implies an increase in progressivity.

Figure 2.11: The Suits index for transfer only and tax and transfer together



Note: The figure displays the Suits index for transfer only and the Suits index for tax and transfer together. The Suits index for transfers is transformed to have positive value, which is $+1$ for the most progressive transfers possible and takes the value zero for a proportional transfer. The Suits index for both tax and transfer is a weighted average of the individual Suits indices where the weights are equal to the system's total revenue.

and transfers is a weighted average of the individual Suits indices where the weights are equal to the system's total revenue. From our sample, the tax system generates around $60-64\%$ of total revenue and the transfer system generates a negative $35-40\%$ of total revenue during the period. Thus the progressivity of the tax system dominates the overall progressivity of the tax and transfer system. However, adding transfers significantly increases the Suits progressivity index by around 0.2 points, compared to the Suits index for tax only.

2.5.2 Household heterogeneity, equivalence scale and progressivity

In Australia, all taxpayers are required to file their tax returns individually.[11] The income tax schedule is generally applied to all tax-paying residents. However, offsets, levies and concessions often depend on the demographic characteristics of the household. For example, the num-

[11]Differently, taxpayers have options to file their taxes individually or jointly in the US and many other OECD countries.

ber of adults and children, and their age and relationship affect tax liabilities of each individual member. The medicare levy and medicare levy surcharge amounts differ based on whether one is in a relationship and in terms of the number of dependent children. Similarly, family benefits and tax offsets depend on the household composition and size.

We now study to the extent to which the family-related tax policies would change progressivity of the income tax system. We take into account household characteristics that allow adult individual members of a household to reduce their tax payments. In addition, we deviate from individual as the tax-paying unit and assume that the household is the tax-paying unit. In order to control for household size we use the OECD modified equivalence scale from Organisation for Economic Co-operation and Development (2013). This scale basically assigns a value of 1 to the first adult, of 0.5 to each additional adult and of 0.3 to each child below 15 years of age. We compute equivalised household incomes and tax liabilities based on this scale and re-calculate the Suits progressivity index for tax, using the household level data.[12]

Figure A.7a reports trends in the Suits index from the household sample. For comparison, we also report the Suits index previously estimated from the individual sample. Our results indicate that the Suits index for tax generated from the household sample is relatively lower than the one from the individual sample; however, both of them have a very similar pattern of the tax progressivity cycle. In contrast, the overall tax-transfer progressivity is less sensitive to whether we use individual data or household level data. We conclude that accounting for household demographics scales down the level of tax progressivity, while maintaining the overall trend. Thus, the progressivity cycle is robust to the change in unit of measurement. Similarly, tax progressivity is fairly robust to the two equivalence scales that are examined. In fact, using unequivalised data yields very similar results to using equivalised household data when it comes to tax.

[12]The summary statistics of the HILDA household level data are available in Table 11 in the accompanying technical appendix.

Figure 2.12: Trends in tax progressivity with different income equivalence scales

Note: The figure reports differences in Suits indices for the tax system in panel (a) and the overall tax-transfer system in panel (b) using the individual sample and household sample with various equivalisation assumptions. The OECD modified equivalence scale (red line, triangle marker assigns a value of 1 for the first adult, 0.5 to each additional adult and 0.3 to each child below 15. The square root scale (green line, square marker takes the square root of total individuals in each household.

2.5.3 Progressivity and redistribution

In this section we extend our analysis to examine implications of the progressive tax and transfer system for income inequality in Australia. For the sake of consistency with related literature, we adjust for the number of adult and children in each household using the modified OECD scale.[13]

Measuring income inequality and redistribution. There are several different indicators of inequality that are typically used in the literature. The most commonly-used measure of inequality is the Gini coefficient, which is derived from the Lorenz curve. The Gini coefficient has value between 0 to 1, where 0 represents perfect equality and 1 represents complete inequality. In this section, we simply use the Gini coefficients for pre-government income and post-government (after-tax and -transfer) income to assess the extent of redistribution that the progressive tax and transfer system induces.

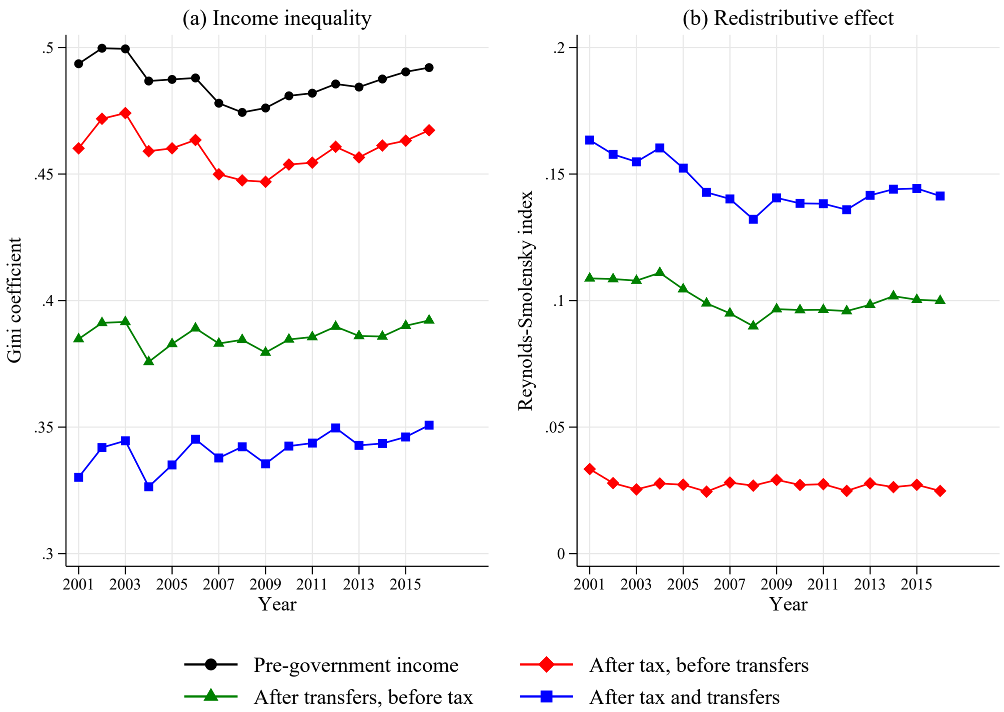
Panel (a) of Figure 2.13 plots the trend in the Gini coefficient for pre-government (before tax and transfer) and post-government income (after tax or after transfer or after tax and transfer).[14] Trends in pre-government income inequality has been relatively stable during the period. Inclusion of progressive taxes leads to a reduction in post-tax income inequality as the Gini coefficient for after-tax income is lower than that for pre-government income. However, there is a larger reduction in the Gini coefficient for after-transfer income. This implies the transfer system plays a more important role in the redistribution of income from rich to poor individuals. The progressive tax and transfer system significantly reduce income inequality in Australia. Reynolds and Smolensky (1977) measures the difference between Gini coefficients for pre-government income and post-government income to formulate a redistribution index that measures the redistributive effect of the tax and transfer system.

Panel (b) of Figure 2.13 displays the Reynolds-Smolenksy redistribution index for tax and transfers. As observed in Panel (b), the Reynolds-Smolenksy index indicates that the redistributive effect of progressive taxes is smaller than that of progressive transfers. The overall

[13]We find that in contrast to the Suits index, the Gini coefficient and the Reynolds-Smolensky index is highly sensitive to the equivalence scale used for the data.

[14]Our estimates of the Gini coefficient are slightly higher than estimates using HILDA data cited in similar literature. This is because we include irregular income as well as regular income. In addition, we drop observations with inconsistent values for tax liability. We report our Gini estimates in Section 6.3 in the technical appendix.

Figure 2.13: Income inequality and the redistributive role of the tax and transfer system



Note: Panel (a) displays trends in income inequality measured by the Gini coefficients for pre-government and post-government income. Pre-government income is a sum of incomes from labor and capital market activities and private transfers. Post-government income consists of post-tax, post-transfer, and post-tax and transfer income. Panel (b) reports the redistributive effects measured by the Reynolds-Smolenksy index.

redistributive effect of the tax and transfer system is relatively smaller from 2001 to 2008. Similarly, the redistributive effect of the transfer system is declined during the period. This was followed by a steady increase till 2015. In contrast, the redistributive effect of the tax system remained fairly steady from 2001 to 2016.

Herault and Azpitarte (2015) examine trends in the redistributive impact and progressivity of the tax and transfer system between 1994 and 2009 using the Australian Survey of Income and Housing Costs (SIHC). They find that after reaching a peak value in the late 1990s, the redistributive effect of the tax and transfer system declined sharply. Having used a different dataset, we confirm that the redistributive effect follows a declining trend in early 2000s, but this trend slightly reversed after 2008.

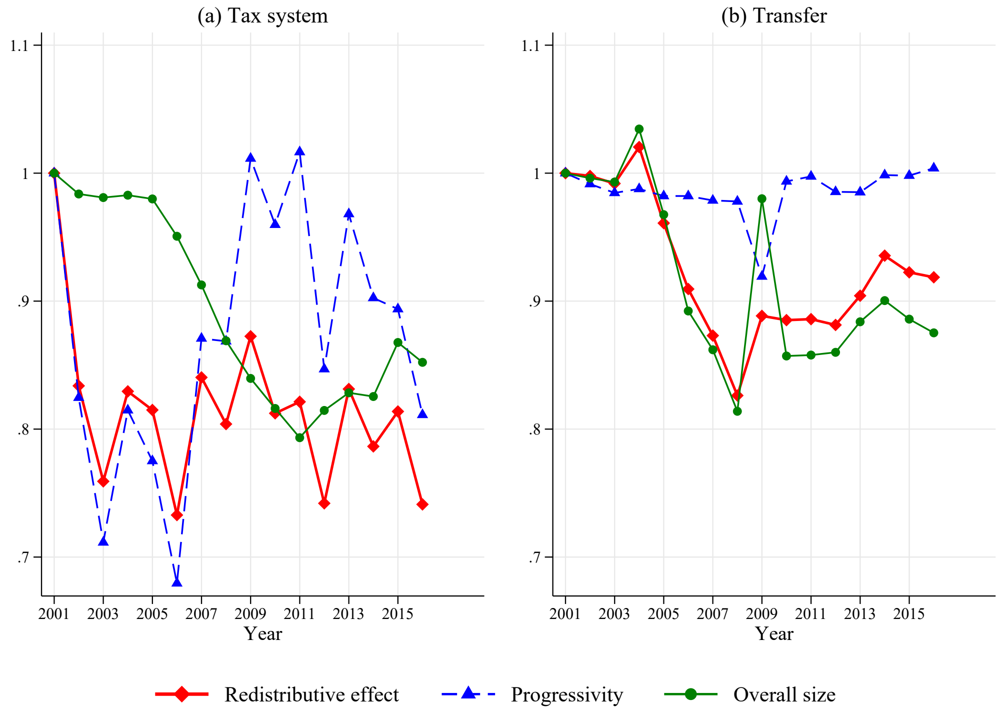
Progressivity and size of the tax and transfer system. It is important to note that progressivity is but one component of the redistributive effect. As per Lambert (1985), the redistributive effect is explained by the progressivity of the tax system and the transfer system and their respective sizes as measured by average tax and transfer rates. Aronson, Johnson and Lambert (1994) shows that in the presence of horizontal inequality, the redistributive effect must also be corrected for the presence of re-ranking. The effect of re-ranking caused by the net fiscal system can be measured by the difference between post-government Gini coefficient and the concentration coefficient of post-government income using the pre-government rankings. This is known as the Atkinson-Plotnick re-ranking index (Atkinson, 1980). Individual level data from HILDA shows a fairly small re-ranking effect for the tax-transfer system with an average Atkinson-Plotnick index of around 0.02 with a between year standard deviation of 0.002. Hence, we rule out any large effect on redistribution from re-ranking and focus on the size and progressivity of tax and transfers.

We explore how each of these factors contributes to trends in redistribution by examining co-movements. As such, we compare co-movements in progressivity, size and redistributive effect of the Australian tax and transfer systems separately. Our focus is less on the level and more on the year on year movement in the trend. Hence, for ease of exposition, we normalize the relevant metrics for each year by their 2001 values. This is illustrated in Figure 2.14.

Panel (a) of Figure 2.14 plots these co-movements for the tax system. Trends in progressivity and the redistributive effect of the tax system moved together while the trend in size of the tax system generally moved in the opposite direction. In this regard, between 2001 and 2003, there was a steep decline in both progressivity and the redistributive effect while tax size remained relatively constant. Between 2006 and 2009 progressivity and redistributive effect sharply increased while there was a sharp downward trend in tax size.

Panel (b) of Figure 2.14 plots the normalized trends for the transfer system. In contrast to the tax system, trends in the redistributive effect of transfers was less driven by trends in transfer progressivity, which remained relatively stable for most of the period. Rather, changes to the overall size of transfers had a large impact on the redistributive effect. For instance, a significant decline in the average size of transfers from 2004 to 2008 lead to a sharp decline in the redistributive effect. The progressivity of the transfer system was relatively stable for most of the period except between 2008 and 2010. There was a significant decline in the progressivity

Figure 2.14: The role of tax and transfer progressivity and their size in the redistributive effect



Note: The figure reports the role of progressivity and size of the tax and transfer system in overall redistribution.

of the transfer system from 2008 to 2009. This was countered by a large increase in the average size of transfers which in turn increased the redistributive effect.

In summary, our exploratory analysis shows that tax progressivity plays a crucial role in the redistributive effect of the overall tax-transfer system. Between 2001 and 2016, trends in tax progressivity heavily affected trends in the redistributive effect of income tax. However, any effect from the tax system on overall redistribution is small in comparison with the effect from the transfer system. During the period, the redistributive effect of the transfer system was governed less by its respective progressivity, and more by the size of transfers.

This finding provides an insight to the debate on tax progressivity and its impact on income inequality. The key point is that the progressive tax system alone has limited role; meanwhile, the size and structure of the transfer system had played a central role in redistribution in Australia during the period.

2.6 Conclusion

This paper makes two contributions. First, we characterize the distributions of income and tax liabilities in Australia since introducing the Goods and Services Tax Act, using household survey data from HILDA and administrative data from the ATO individual tax sample. We calculate the effective average and marginal tax rates that individuals face and discuss how the income distribution and taxes have changed. Second, we provide a comprehensive analysis of the Australian personal income tax system's progressivity since 2001.

We formulate two metrics for measuring tax progressivity. The first one measures tax progressivity in terms of tax liability progression at a given income level, i.e., tax elasticity with respect to income (Tax progression measure). The second one relies on the distribution of tax liabilities relative to the income distribution (Tax distribution measure). Our estimates of these two measures show trends in tax progressivity are quite different. The tax progression measure indicates a declining direction in tax progressivity. Meanwhile, the tax distribution measure indicates a cycle of tax progressivity. This difference is mainly due to the difference in methodological approach. The tax progression measure intuitively estimates tax liabilities' elasticity, while the tax distribution measure calculates the relative share of tax liability to income.

We conduct a number of counterfactual analyses to identify factors behind changes in tax progressivity levels using the tax distribution measure. We find that the lack of a proper indexation system has a negative effect on the tax progressivity trend in Australia. Bracket creep pushes more taxpayers into higher tax brackets as the income distribution evolves. Discretionary adjustments to income brackets are necessary to maintain tax liabilities relative to income distribution changes due to inflation and economic growth. Without active tax policy changes from one year to another, the tax system's progressivity declines. Indexing tax brackets to the CPI partially mitigates the decline in tax progressivity; however, it fails to account for real income growth. We identify two sub-periods of inactive tax policy, between 2001 and 2003 and between 2013 and 2016, that result in a significant decline in tax progressivity. Also, we find that the increase in the Low Income Tax Offset's generosity contributed most to the increase in tax progressivity from 2006 to 2009.

We extend our main analysis of tax progressivity with an exploratory examination of the overall tax-transfer system. This helps in contextualizing tax progressivity within the broader net fiscal system. In this regard, the key finding is that the transfer system's role outweighs the role of the tax system in the overall redistributive effect. Thus, tax progressivity had a limited role in mitigating income inequality. In contrast, changes to the average size of transfers were most affected by redistribution. For most of the period, the transfer system's progressivity remained relatively stable. Nevertheless, despite its limited effect in overall redistribution, tax progressivity played a crucial role in the tax system's redistributive effect. In that, trends in the tax system's redistributive effect closely follow trends in tax progressivity.

Finally, we highlight the quantitative importance of accounting for household heterogeneity when measuring tax progressivity using household survey data. The Suits index's magnitude is sensitive to whether we use individual data or equivalised household data. Taxes and transfers depend on age, family structure, and many other factors. Also, since the Suits index is independent of the tax system's size, it can be used for international comparison of tax progressivity across countries. We leave these issues for future research.

Chapter 3

Tax progressivity in Australia: A dynamic general equilibrium analysis

3.1 Introduction

There are concerns about the increasing gap of inequality in Australia. One way to mitigate and address these concerns is through the Australian tax system. Historically, Australia has a significantly progressive income tax code. However, the recent passing of the Treasury Laws Amendment (Tax Relief) Bill 2019 has led to a significant flattening of Australia's income tax code. In particular, this has renewed debate on the importance of maintaining a progressive income tax system. This paper aims to study the redistribution and social insurance role of the Australian personal income tax system by measuring the optimal degree of tax progressivity in conjunction with the means-tested pension system design.

According to the insights from Varian (1980) and Eaton and Rosen (1980), the government could use a progressive tax system to provide social insurance and to transfer resources from the lucky to unlucky ones who have low labor productivity/income incomplete market economy. A progressive income tax system where the average tax rate increases with income plays a redistributive and social insurance role. It provides partial insurance against idiosyncratic shocks and unfavorable initial conditions by relieving more impoverished individuals from a high tax burden. It also reduces the variance of income and consumption over the lifecycle and ensures a more equal distribution of income, wealth, and consumption. However, such progressive income taxes have adverse effects on labor supply and savings as increasing marginal tax rates discourage people from saving and working. This paper aims to evaluate these trade-offs in the Australian income tax system.

We employ a dynamic general equilibrium, small open economy model with overlapping generations of heterogeneous households born with different innate earnings ability (skill types) and faced idiosyncratic shocks to labor productivity. Our model builds on Tran and Woodland (2014) that includes details of the Australian means-tested pension system in a model with idiosyncratic labor income risk and endogenous retirement. To model the progressive income tax system, we use a parametric tax function with two parameters - one that determines the scale of income tax, and another that determines progressivity. Tran and Zakariyya (2021) find that this parametric tax function closely approximates the Australian income tax code and matches the income tax distribution. We calibrate our benchmark model to match the Australian macroeconomy's key features and household life-cycle behavior patterns. We closely match the distributions of market income, post-government income (after tax and transfers), and the distribution of income tax liability as measured by the Suits (1977) index.

Our main aim is to determine the welfare-maximizing (optimal) level of income tax progressivity, taking into account the means-tested pension system. We take a stand on the social welfare function and use the utilitarian approach. The sum of ex-ante expected lifetime utilities of all individuals born into the stationary equilibrium defines social welfare. We assume that a utilitarian planner places equal weight on households within the economy. We measure the optimal degree of progressivity as the progressivity parameter that maximizes social welfare.

We find the highest social welfare level is attained under a proportional income tax code at a flat rate of 14% with no tax-free threshold. This implies that the adverse incentive effects of high marginal tax rates dominate the redistribution/insurance effects in our general equilibrium model economy. There are significant gains in welfare for all skill types when switching to the optimal income tax code. However, these gains are distributed unevenly across skill types. The highest increase in welfare is experienced by high skill types, followed by medium skill types, and the lowest increase for low skill types. We check our optimal proportional tax code's robustness by examining welfare gains and changes in macroeconomic aggregates by holding wage constant at the benchmark rate. We find that even under partial equilibrium assumptions, shifting to a proportional income tax results in higher savings, labor supply, and welfare.

Next, we examine to what extent the design of the means-tested pension system affects the optimal level of tax progressivity. The pension system is a central pillar of the Australian transfer system and has the following distinct features. Pension benefits for retirees are unrelated to contribution history during working age and subjected to income and asset tests. The pension system is a part of the overall government budget and financed by general government revenue rather than a specific payroll tax. The means-tested pension system is progressive, with the taper rates acting as an implicit non-linear income tax to target low-income individual retirees. According to Tran and Woodland (2014), the government could use its pension system to provide social insurance against income and mortality risks. However, it would face trade-offs between insurance and incentive effects similar to the progressive income tax system. Our quantitative analysis confirms that the progressivity and level of income tax are intertwined with the means-tested pension system's design. Specifically, the means-tested pension system's generosity and coverage directly influence the progressivity level of the income tax code.

On the other hand, the income tax system's progressive level strongly influences the pension system's optimal progressivity. Conditional to the existing maximum benefit and means-test thresholds, social welfare is highest when the income test taper rate is at 10% under the optimal income tax code. This is much lower than the current taper rate of 50%. The welfare effects of lower taper rates are more pronounced at higher tax progressivity levels. With a proportional income tax, the welfare gains from reducing the taper rate are relatively insignificant compared to economies with progressive taxation. A subtle but essential result from this second experiment is that, albeit with lower taper rates, means-tested pension results in higher social welfare than universal Pay As You Go (PAYG) pensions. This result also stands at all levels of income tax progressivity. This partly implies that, conditional on the existence of a public pension system, the presence of means-testing strengthens the pension system's social insurance role.

Thus, our main finding is that a proportional tax characterizes the optimal income tax code in our dynamic general equilibrium model economy. This proposition is reasonably robust to the alternative designs of the pension system.

To further investigate the robustness of the optimal income tax, we conduct sensitivity checks by changing some of our modeling assumptions. We first investigate our results' sensitivity to labor supply elasticity and risk aversion. We solve alternative versions of our model for alternative values of the risk aversion parameter and Frisch elasticity of labor supply. Our results confirm that optimal progressivity is robust to changes in labor supply elasticity and risk aversion for our Cobb-Douglas specification of household preferences. In contrast, the optimal taper rate increases with the risk aversion coefficient. This is in line with previous literature that indicates that the gains from means-testing public pensions are more significant in frameworks with higher risk aversion.

Unlike previous studies, including Heathcote, Storesletten and Violante (2017*a*), we explicitly model all major government transfer programs. We examine whether the optimal progressive income tax code is sensitive to this modeling assumption. For this purpose, we switch off all public transfers in our model, including pension and all public transfers, before the age of 65 and search for the welfare-maximizing level of progressivity. We find welfare gains from reducing progressivity from the benchmark level. However, the optimal tax code is no longer a proportional income tax. This result implies that the optimal progressive income tax code is contingent on public transfer programs providing social insurance.

Another concern is the flexibility in the choice of labor hours (divisible labor) in our general equilibrium framework. We assume that workers are free to choose from a flexible schedule of work hours to respond to changes in the tax schedule and the wage rate. We investigate the sensitivity of the optimal tax code to a more rigid choice of work hours by assuming that workers can only choose between not working, working part-time, and working full-time. We calibrate average work hours for part-time and full-time to match Australian data. We find that there are still welfare gains from reducing tax progressivity under this assumption. However, the optimal tax system is no longer proportional.

Related literature. Our paper links to three main branches within the tradition of dynamic general equilibrium literature on public finance - (1) the literature on optimal income tax progressivity, (2) optimal pension systems, and (3) optimal progressivity and optimal social security.

In regards to optimal progressivity, we follow the approach of searching for optimal progressivity within a given parametric class of tax scheme. This implies the use of a parametric tax function that closely approximates a given income tax code (where the slope of the function determines progressivity); and searching for the value of the progressivity parameter that maximizes the utilitarian social welfare function. This approach has a long standing tradition in the public finance literature going back to Ramsey (1927), Ventura (1999), Benabou (2002), Conesa and Krueger (2006) , Krueger and Ludwig (2016), Heathcote and Tsujiyama (2016) and Heathcote, Storesletten and Violante (2017*a*). This is in contrast to the the Mirrlees (1971) approach to optimal taxation that imposes no constraints on the form of the tax schedule. Heathcote and Tsujiyama (2016) shows that for a wide range of welfare functions, the best policy derived from utilizing a parametric class of tax function delivers the vast majority of potential gains from the fully optimal nonparametric Mirrlees tax schedule.

A standard prediction from this branch of literature that employs dynamic general equilibrium models with idiosyncratic risk and incomplete markets is that, reductions in progressivity have positive effects on welfare and aggregate activity and adverse impact on distribution. Also, common among these models is that, social security in general and the pension system are often simplified and not fully considered. The literature often employs benchmark models of the U.S. where coverage is universal, and effects from the extensive margin are not relevant.

The second branch of literature closely related to this paper is that of general equilibrium life cycle models that examine optimal pension systems. This branch includes papers such as Imrohoroglu, Imrohoroglu and Jones (1995), Sefton and van de Ven (2008) and Kudrna and Woodland (2011) that examine the effects via the intensive margin arising from means-tested versus PAYG pensions. A majority of these models show positive welfare outcomes in means-tested pension systems compared to PAYG systems. Tran and Woodland (2014) extend these papers by examining the extensive margin effects. They show that the interactions between taper rates and the maximum pension benefit via the extensive margin results in opposing effects on incentives and welfare effects to changes in taper rates vary significantly over the levels of maximum pension benefits. Similar to other papers within this branch, their analysis takes the tax system as given.

Closest to our paper in approach are those that examine the interplay between optimal tax progressivity and optimal social security. They analyse whether the generosity of specific social insurance schemes justify a more or less progressive tax system. McKay and Reis (2016) study the optimal generosity of unemployment benefits and progressivity of income taxes in a model with macroeconomic aggregate shocks and individual unemployment risk. They solve for the ex-ante socially optimal replacement rate of unemployment benefits and progressivity of personal income taxes in the presence of uninsured income risks, precautionary savings motives, labor market frictions and nominal rigidities. Their results imply that, more generous unemployment benefits justify a more progressive income tax system. Tran and Jung (2018) examine optimal progressivity together with the design of the health insurance system in a model where individuals are exposed both to idiosyncratic and health risks over the lifecycle. They find that the design of the health insurance system strongly affects optimal progressivity, whereby in the presence of health risk the optimal tax system is more progressive compared to those that abstract from health risk such as Conesa and Krueger (2006) and Heathcote, Storesletten and Violante (2017*a*). When health risk is reduced or removed, the optimal tax system becomes less progressive and closer to the optimal tax system reported in previous literature. The central message of these papers is that optimal progressivity depends on the type of risk being mitigated social insurance, and the adequacy of relevant social insurance mechanisms.

This paper contributes to the literature studying tax progressivity in Australia. Tran and Zakariyya (2021) document stylized facts and estimate the progressivity trends of the Australian personal income tax system. This paper builds a dynamic general equilibrium model that can match these facts and studies the optimal design of a progressive income tax system in conjunction with the means-tested pension system. This paper also contributes to the growing body of research on the impacts of fiscal policy reforms in Australia analysed using general equilibrium OLG models that incorporate the behaviour of households and firms (e.g., see Kudrna and Woodland (2011), Tran and Woodland (2014) and Kudrna and Tran (2018)). Different from these previous studies, we focus on the personal income tax system.

The paper is structured as follows. Section 4.2 presents the dynamic general equilibrium, overlapping generations model. Section 3.3 details functional specifications and calibration. Section 3.4 devotes to quantifying the optimal progressive income tax code. Section 3.5 examines the role of means-tested age pension in determining the optimal level of income tax progressivity. Section 3.6 details some robustness check on our findings. Section 4.10 offers some concluding remarks.

3.2 Model

We study a small open economy model with individual heterogeneity and endogenous labor supply and retirement. Individual heterogeneity is driven by differences in labor productivity over the life cycle and the distribution of assets at the start of the life cycle. In addition, labor productivity is subject to idiosyncratic risk. There is a perfectly competitive representative firm and a government with full commitment technology.

3.2.1 Demographics

The economy is populated by agents whose ages are denoted by $j \in [1,...,J]$. In each period, a continuum of individuals of age 1 are born and live to a maximum of J periods. They face a probability ψ_j of surviving up to age j conditional on being alive at age $j-1$. Population grows at a constant rate n. The demographic structure is stationary such that the fraction of population of age j agents μ_j at any point in time can be recursively defined as $\mu_j = \frac{\mu_{j-1}\psi_j}{(1+n)}$. The fraction of agents who do not survive to age j is $\tilde{\mu}_j = \frac{\mu_{j-1}\left(1-\psi_j\right)}{(1+n)}$.

3.2.2 Preferences

All agents have identical lifetime preferences over consumption $c_j \geq 0$ and leisure $l_j \in (0,1]$. Preferences are time seperable with a constant subjective discount factor β. Agents also derive utility from bequething their assets upon death given by the function $\phi(b)$ which governs the amount of bequest (explained in more detail in Section 3.3). The role of the bequest motive in our model is to match individual's life cycle behavior. However for simplicity we abstract from any inter-generational links between parents and children. The utility function of the agent is

$$U_0 = E\left\{\sum_{j=1}^{J}\left[\beta^{j-1}\psi_j u\left(c_j, l_j\right) + \left(1-\psi_j\right)\phi\left(b\right)\right]\right\} \tag{3.1}$$

3.2.3 Endowments

Agents are born with a specific skill type ρ that determines their labor productivity over the life cycle. Skill types in each cohort differ by their exogenously given labor productivity, social welfare benefits before the age of 65 and the number of children. Accordingly, we consider three skill types $\rho \in \{low, medium, high\}$. In each period of life, agents are endowed with 1 unit of labor time that has labor productivity denoted by e_j which has a deterministic and stochastic component. In that, $e_j = e(\rho, j)$ is skill and age dependent and follows a Markov switching process with $\pi_j\left(e_{j+1}|e_j\right)$ denoting the conditional probability that a person with labor productivity e_j at age j will have labor producitivity e_{j+1} at age $j+1$.

3.2.4 Technology

There is a constant returns to scale production function that transforms capital K and effective labor services (human capital) H into output Y. This is given by $Y = AF\left(K, H\right)$ where A represents total factor productivity which grows at a constant rate, g. Capital depreciates at rate δ. The firm chooses capital and labor inputs to maximize its profit given rental rate q and market wage rate w according to $\max_{K,H}\left\{AF\left(K,H\right) - qK - wH\right\}$.

3.2.5 Fiscal policy

We model three specific features of the Australian fiscal system: (1) progressive income tax system, (3) a constant consumption tax rate given by $\tau^c\left(0,1\right)$and (4) means-tested pension system.

Progressive income tax. The government levies tax on market income (labor and asset income) using a progressive income tax schedule. We summarize the various marginal tax rates and income tax brackets using a parametric tax function commonly used in the literature.

Let y_j be the market income of the agent at age j. The income tax function is

$$T\left(y_j\right) = y_j - \lambda y_j^{1-\tau} \tag{3.2}$$

where λ gives the average level of taxation and $\tau \in [0,1]$ measures the degree of progressivity.

Means-tested pension. The old-age pension system is not universal and targets households who have low private incomes through the use of income and assets means tests. Agents are eligible for the old-age pension upon reaching the age threshold j^P . The amount of pension benefit $\mathscr{P}\left(a_j, y_j\right)$ is given by

$$\mathscr{P}\left(a_j, y_j\right) = \begin{cases} \min\left\{\mathscr{P}^a\left(a_j\right), \mathscr{P}^y\left(y_j\right)\right\} & \text{if } j \geq j^P \\ 0 & \text{otherwise} \end{cases} \tag{3.3}$$

such that

$$\mathscr{P}^a\left(a_j\right) = \begin{cases} p^{\max} & \text{if } a_j \leq \bar{a}_1 \\ p^{\max} - \omega_a\left(a_j - \bar{a}_1\right) & \text{if } \bar{a}_1 < a_j < \bar{a}_2 \\ 0 & \text{if } a_j \geq \bar{a}_2 \end{cases} \tag{3.4}$$

where $\bar{a}_1$ and $\bar{a}_2 = \bar{a}_1 + p^{\max}/\omega_a$ are the asset thresholds and ω_a is the asset taper rate.

and

$$\mathscr{P}^y\left(y\right) = \begin{cases} p^{\max} & \text{if } y_j \leq \bar{y}_1 \\ p^{\max} - \omega_y\left(y_j - \bar{y}_1\right) & \text{if } \bar{y}_1 < y_j < \bar{y}_2 \\ 0 & \text{if } y_j \geq \bar{y}_2 \end{cases} \tag{3.5}$$

where $\bar{y}_1$ and $\bar{y}_2 = \bar{y}_1 + p^{\max}/\omega_y$ are the income thresholds and ω_y is the income test taper rate.

Other public transfers. The government also runs a social welfare program that pays social welfare benefits st_j to households aged $j < 65$. These benefits are skill dependent (targeted to lower income households) and are determined exogenously. Further details are provided in the calibration section.

Government budget constraint. The government consumes an amount G in every period in addition to spending on the age-pension. These are financed from two sources: tax revenues and the issue of new debt $\Delta D_{t+1} = D_{t+1} - D_t$. As such, the government incurs interest payments rD_t on current public debt. In steady state, $D_{t+1} = D_t$ and the government budget constraint is satisfied such that

$$\sum_j T(y_j)\,\mu(\chi_j) + \sum_j T(c_j)\,\mu(\chi_j) = \sum_j \mathscr{P}(\chi_j)\,\mu(\chi_j) + \sum_j st_j\mu(\chi_j) + G + rD \tag{3.6}$$

where $\mu(\chi_j)$ is the measure of agents in state $\chi_j = (e_j, a_j)$, $\sum_j T(c_j)$ is the total tax revenue from consumption tax and $\sum_j T(y_j)$ is the total tax revenue from income tax.

Bequest distribution. The role of the bequest motive in our model is to match individual's life cycle behavior. However for simplicity, we abstract from any intergenerational links between parents and children. The government has an additional role in distributing bequests (both accidental and intentional) from dead agents to those alive. Bequests are distributed equally across all agents that are alive.

3.2.6 Market structure

Markets are incomplete and households cannot insure against indiosycnratic labor income and mortality risks by trading state contingent assets. They can hold one-period riskless assets to imperfectly self-insure against these risks. We assume agents are not allowed to borrow against future income, implying asset holdings are non-negative such that $a_j \geq 0$ for all j.

The economy is assumed to be a small open economy. The free flow of financial capital ensures that domestic interest rate is equal to the world interest rate r which is assumed to be constant. Hence, the rental price of capital is given by $q = r + \delta$. The total capital that goes into the production comprises of foreign assets A^F as well as the domestic assets that result from household savings.

3.2.7 Household problem

We express the decision problem of an agent in recursive language. Let $\chi_j = \left(e_j, a_j\right)$ denote the agent's state variables at age j. At the beginning of each period, the agent realises his state and chooses his optimal consumption c_j, leisure time l_j and end of period asset holdings a_{j+1}. When the agent chooses to allocate all time to leisure ($l_j = 1$), the agent exits the labor market and retires for the period.

Agents have three sources of income, labor earnings, asset income and transfers. Labor earnings are determined by supply of effective labor service $\left(1-l_j\right) e_j$ at wage rate w. Asset income is earned on the savings and households hold the cash balance from savings income $(1+r)\, a_j$. In addition, eligible agents may receive the old-age pension $\mathscr{P}\left(a_j, y_j\right)$ depending on the age threshold and the means-tests. Agents also receive bequests b_j as a lump-sum transfer from the government.

The household problem can be written recursively as

$$V^j\left(\chi_j\right) = \max_{c_j, l_j, a_{j+1}} \left\{u\left(c_j, l_j\right) + \beta\left(\psi_j E\left[V^{j+1}\left(\chi_{j+1}\right)|e_j\right] + \left(1-\psi_j\right)\phi\left(b\right)\right)\right\} \tag{3.7}$$

subject to

$$a_{j+1} = \frac{1}{1+g}\left[a_j + e_j\left(1-l_j\right)w + ra_j + b_j + st_j + \mathscr{P}\left(a_j, y_j\right) - T\left(y_j\right) - \left(1+\tau^c\right)c_j\right]$$

$$a_j \geq 0, 0 < l_j \leq 1 \tag{3.8}$$

where $E\left[V^{j+1}\left(\chi_{j+1}\right)|e_j\right]$ is the expected value function and $\left(1-\psi_j\right)\phi\left(b\right)$ is the utility from bequething conditional on the probability of not being alive in the next period. Individual quantitity variables except for labor hours are normalized by the steady state per capita growth rate g.

3.2.8 Equilibrium

Given the government policy settings for the tax system and the pension system, the population growth rate, world interest rate, a steady state competitive equilibrium is such that:

(a) a collection of individual household decisions $\{c_j(\chi_j), l_j(\chi_j), a_{j+1}(\chi_j)\}_{j=1}^{J}$ solve the household problem;

(b) the firm chooses labor and capital inputs to solve the profit maximization problem;

(c) the total lump-sum bequest transfer is equal to the total amount of assets left by all the deceased agents;

(d) the current account is balanced and foreign assets A^F freely adjust so that $r = r^w$, where r^w is the world interest rate;

(e) the domestic markest for capital and labor clear;

(f) the government budget constraint defined in Eq.(6) is satisfied.

3.3 Calibration

This section describes calibration and parametrization of the model. We calibrate our model to closely approximate key Australian macroeconomic and fiscal indicators[1] for the period of 2000-16.

[1]This is except for the pension system, we take taper rates and income and asset thresholds for 2016. However, we adjust the maximum benefit in order to match the pension participation rate and pension to GDP ratio for the period.

Table 3.1: Key parameter values and calibration targets/source

Parameter	Value	Details
Preferences		
Discount factor	$\beta = 0.994$	Match S/Y
Inverse of intertemporal elasticity of substitution	$\sigma = 2$	
Share parameter for leisure	$\gamma = 0.245$	Match labor supply profile
Weight of children in utility	$\eta = 0.6$	Nishiyama and Smetters (2007)
Weight of bequest motive	$\phi_1 = -9.5$	De Nardi (2010)
Extent to which bequest is a luxury good	$\phi_2 = -11.5$	De Nardi (2010)
Technology		
Annual growth rate	$g = 0.033$	
Total factor productivity	$A = 1$	
Share parameter of capital	$\alpha = 0.4$	
Annual depreciation rate	$\delta = 0.055$	

3.3.1 Demographics

One model period corresponds to 5 years. Agents enter the model at age 20 ($j = 1$) and live up to a maximum of age 90 ($J = 14$). We take ψ_j as the average survival probability for males and females from 2003-2016 Life Tables of the Australian Bureau of Statistics (ABS). The average annual growth rate of new born agents in the model is 1.56% which is average annual population growth rate in Australia during the period.

3.3.2 Preferences

Instantaneous utility obtained from consumption and leisure has a constant relative risk averasion (CRRA) from and is defined as

$$u\left(c_j, l_j\right) = \frac{\left[\left(1 + d_{j,\rho}\right)^{\eta\gamma} c_j^{\gamma} l_j^{1-\gamma}\right]^{1-\sigma}}{1-\sigma} \tag{3.9}$$

where γ is the weight on utility from consumption relative to that of leisure, σ is coefficient of relative risk aversion, $d_{j,\rho}$ is the number of dependent children at age j for skill type ρ, and η is the adult equivalency scale that converts consumption by children into adult equivalent amounts as per Nishiyama and Smetters (2007).

We set the relative risk aversion coefficient to $\sigma = 2$. We follow Nishiyama and Smetters

(2007) and set $\eta = 0.6$. We calibrate γ to match average work hours. The subjective discount factor β is calibrated to match gross household savings to GDP ratio which has averaged around 0.2 according to ABS data. The number of children $d_{j,\rho}$ is calculated from the Household, Income and Labour Dynamics in Australia (HILDA) data, using the average number of dependents in the households between 0 - 19 years in each skill type by age group.

We incorporate utility from bequeathing as per De Nardi, French and Jones (2010) to match consumption and savings in old-age. This is specified by

$$\phi(b) = \phi_1 \left(1 + \frac{a_{j+1}}{\phi_2}\right)^{1-\sigma} \tag{3.10}$$

where the term ϕ_1 reflects the concern about leaving bequests, while ϕ_2 measures the extent to which bequests are a luxury good. The values of the parameters that most closely match savings after the age of 80 are $\phi_1 = -9.5$ and $\phi_2 = 11.5$.

3.3.3 Labor productivity

Deterministic productivity. We use a balanced panel of the HILDA survey waves 1-17 to determine skill types. We divide the sample into three skill types - low, medium and high. The low skill type includes those who have not finished high school. The medium skill type includes those who have finished high school but do not have a graduate qualification. The high skill type includes all those who have graduate or higher qualifications. We follow Tran and Woodland (2014) in estimating earnings ability profiles for these skill types. The earnings ability profiles for low skill and high skill types are shifted up and down using shift parameters to approximately replicate the market income distribution in Australia.

Stochastic productivity. Each individual is subject to stochastic earnings shocks within his/her own skill type. To express this, we first divide each skill type into three quantiles. We express the level of schock by taking the average wage by quantile and skill type for the year 2008. We normalize the average wage by the median wage of each skill type. The mobility of individuals across different quantiles within the skill type is captured by Markov transition matrices. To estimate transition matrices, we count the number of individuals in a quantile in a given period move to another quantile in the next period. To do so, we use data from waves

1 - 17 of HILDA. Since our model period is 5 years, we construct panel datasets with 5 year lags. Hence we estimate the transition matrices for each wave and average over them in order to make the matrices more persistent. We assume that the transition matrix from age 55-59 to the age 60-64 characterizes the dynamics of earnings ability from age 65 onwards.

3.3.4 Technology

The production function is given by $Y = AK^{\alpha}H^{1-\alpha}$ where α is the capital share of output. We set $\alpha = 0.4$. The depreciation rate for capital is determined by the steady state condition and is $\delta = 0.055$. The average annual GDP per capita growth rate in Australia is 3.3 percent. Hence we set $g = 0.033$. The total factor productivity A is a scaling parameter.

3.3.5 Fiscal policy

To calibrate fiscal policy in the benchmark model, we set parameters for the age pension, other social welfare transfers and taxation to match key fiscal targets. Table 3.2 reports on the key fiscal targets used in the calibration of the benchmark model.

Table 3.2: Calibration of fiscal policy in steady state

Variable	Target	Value
Age pension	Total share in GDP (%)	2.42
	Pension participation rate (%)	60
Social welfare transfers to those below 65 years	Total share in GDP (%)	4.95
Personal income tax	Progressivity parameter τ^y	0.08
	Suits index	0.2
	Total share in GDP (%)	10.47
Consumption tax	Total share in GDP (%)	3.49
General government expenditure	Total share in GDP (%)	12
Public debt	Total share in GDP (%)	10

Taxes. We set consumption tax rate at the statutory rate of 10%. As explained in Section 2, the income tax system in our model is approximated by the parametric tax function. We estimate the value of the progressivity parameter τ^y from the tax data as per Tran and Zakariyya (2021). We estimate the following log form of the parametric tax function using ordinary least squares regression for each year.

$$\ln \hat{y}_i = \ln \lambda + (1 - \tau^y) \ln y_i + u_i \tag{3.11}$$

where $\hat{y}_i$ is post-tax income y_i is pre-tax income and the error term u_i follows a normal distribution. Table 3.3 reports on the estimated parametric tax function for selected years using ATO tax return data. Estimates for all years yield a fairly precise estimate of τ^y around 0.085 with a robust standard error of 0.001 and an adjusted R^2 of 0.99.

Table 3.3: ATO select years

	2008	2012	2016
τ	0.086	0.082	0.081
	(0.001)	(0.001)	(0.001)
λ	2.129	2.073	2.048
	(0.007)	(0.005)	(0.006)
Adjusted R^2	0.99	0.99	0.99

Means–tested pension. We index maximum pension by the average labor income at net pension replacement rate in Australia which has averaged around 40% during the benchmark period. We apply means-test taper rates and thresholds for 2016. The income test taper rate in our benchmark is $\omega^y = 0.5$ which reflects the reduction in pension by \$0.5 for every \$1 above the low income threshold. The asset test taper rate is $\omega^a = 0.0015$ for every \$1000 above the low asset threshold.

The actual test in Australia includes seperate asset tests for renters and homeoweners as well as seperate tests for couples and singles. In our model, there is no difference between residential assets and non-residential assets. Hence, we are unable to directly use the statutory income and asset thresholds. Instead, we calibrate these to match pension participation rates over the life cycle and the share of age pension in GDP.

Social welfare. We lump government benefits such as family benefits, disability support pension and unemployment benefits in to a single social transfer variable $st_{\rho,e,j<65}$ for those below the age of 65. Using HILDA data for the calibration period, we calculate the share of social welfare by skill type and age.

General government expenditure and debt. We define government expenditure as all government expenditure other than public transfers and age-pension that is not accounted for in the model. Government expenditure is set at 12% of GDP to reflect the average of such expenses over the benchmark period. Similarly, public debt is set at 10% which is close to the average net public debt share of GDP.

3.3.6 Market structure

Under our small open economy assumption, we take world prices for internationally traded goods and the world interest rate on bonds as given. We normalize the world price to 1 and assume the world (and domestic) interest rate is $r = 4\%$. The net foreign ownership of Australia's capital stock averaged around 20% over the period of 2000-17.

3.3.7 Benchmark model performance

In this section, we discuss how our benchmark model solution matches with data. Table 3.4 compares macroeconomic aggregates generated from our benchmark model with Australian data. Much central to our analysis of progressivity and redistribution, the model is able to match the Gini coefficient of pre and post government income inequality, and the Suits Index.

Table 3.4: Comparison of model generated values for key variables with Australian data

Variable	Model	Data
Household savings [a]	23.32	22.18
Income tax revenue [a]	16.86	10.47
Consumption tax revenue [a]	5.87	4.86
Total tax revenue [a]	22.73	24
Social welfare transfers [a]	4.74	4.95
Age pension [a]	2.18	2.42
Market income (labor and capital income) inequality [b]	0.57	0.57
Post-government (after tax and transfer) income inequality [b]	0.45	0.41
Income tax progressivity parameter τ^y	0.085	0.085
Average level of taxation λ	2.55	2.61
Suits index of income tax progressivity	0.2	0.2

[a] In % share of GDP. [b] Gini coefficient.

Figure 3.1 plots the taxable income distribution and the Lorenz curve generated by the model with that generated from HILDA data for 2016. Figure 3.2 plots the same for post-government income while Figure 3.3 plots the relative concentration curve of cumulative proportion of income tax against the cumulative proportion of taxable income. Our model also closely approximates the actual income tax function in Australia with a tax free threshold of $23,000. This comes close to the actual effective tax free threshold when all tax offsets are taken into account. Between 2012 and 2016, the effective tax-free threshold after the low income tax offset was around $20,542. The tax free threshold after accounting for other offsets such as the Senior Australian Tax Offset and the Beneficiaries Tax Offset would be slightly higher.

Figure 3.1: Distribution of taxable (market) income

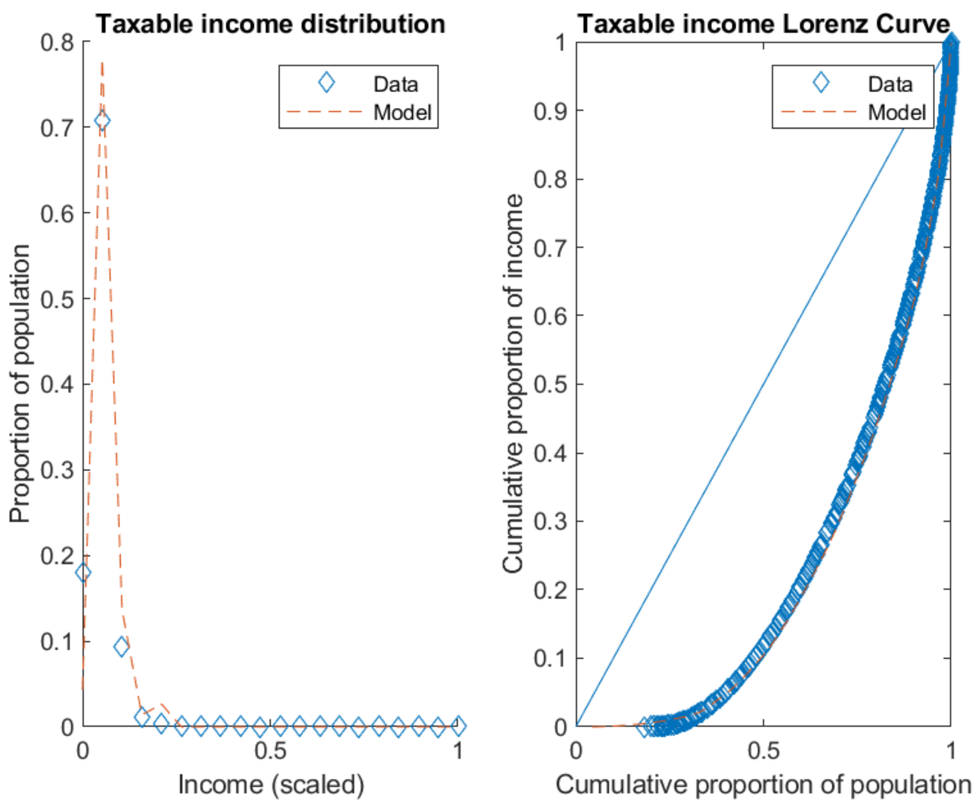


Figure 3.2: Distribution of post-government income

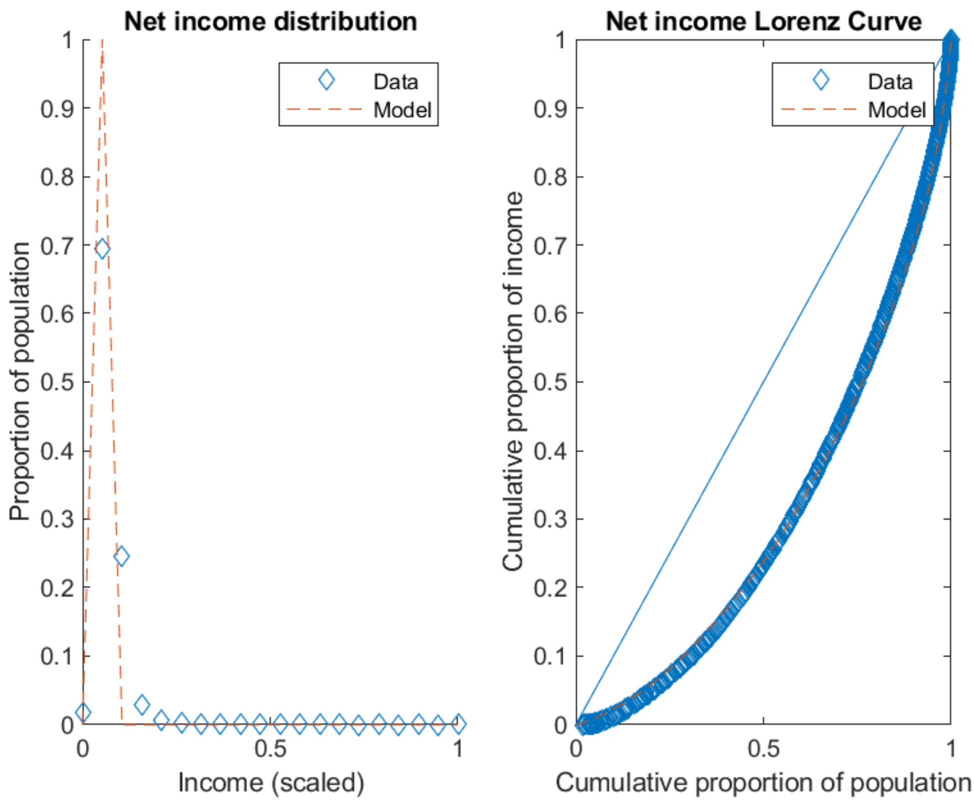
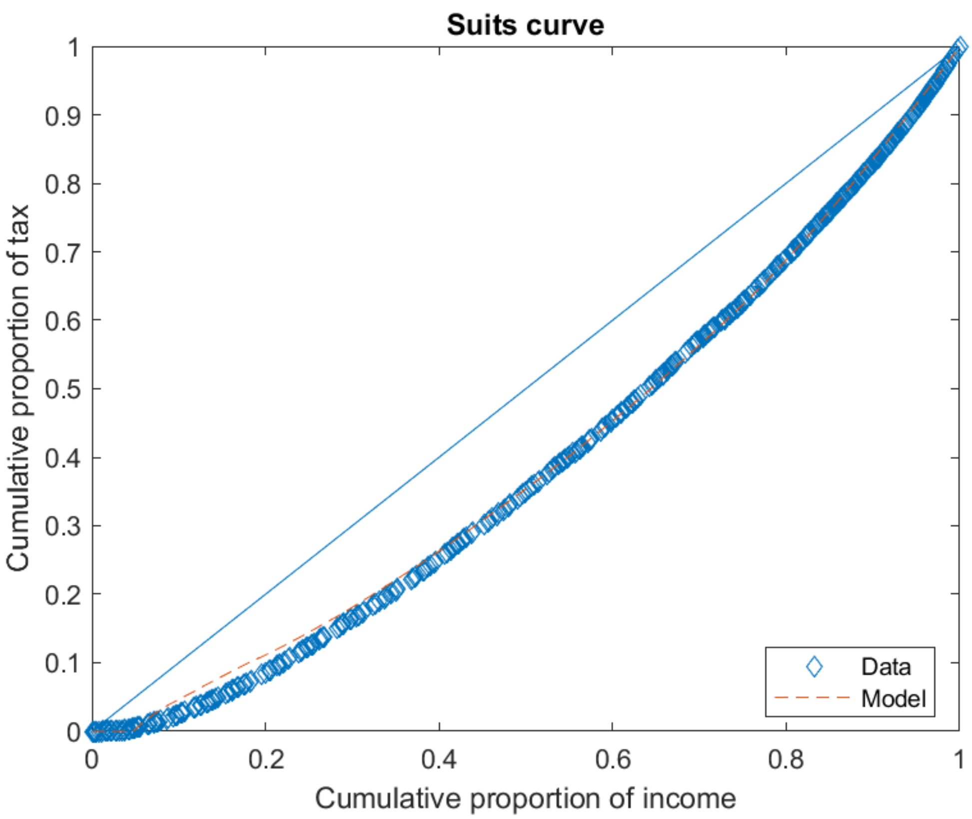


Figure 3.3: Distribution of post-government income



While government expenditure shares of GDP closely approximate values from data, income tax revenue and consumption tax revenue shares of GDP are above actual averages for the benchmark period. One possible reason is that our model does not include all sources of tax revenue for the government. In the case of consumption tax, our model taxes consumption at a constant rate across the economy without any exemption. In reality, a significant proportion of consumption is exempt from taxation. It is important to note that total tax revenue share of GDP in our benchmark model is 22.73% which is close to the average total tax revenue share of GDP of 24%.

Our benchmark model is able to generate life cycle profiles for assets, labor hours and labor income that is close to the shape of profiles seen in actual data. Pension participation rates in our model are however higher than those extracted from HILDA data. One possible reason is that our model does not include the mandatory privately-managed pension system. In Australia, private pension program, known as the Superannuation Guarantee, mandates the contribution of a percentage of gross wages of each employee superannuation fund. The stock of superannuation assets earn investment income that is realised in their old-age. Incorporating this feature would potentially improve the match between model and data, but would add a significant layer of computational complexity to our stochastic model.

3.3.8 Social welfare

We define the optimal tax code within the chosen parametric class as the one that yields the highest social welfare. We define the social welfare function as the ex-ante lifetime utility of an individual born into the stationary equilibrium given a specified tax code T parametrized by (λ, τ^y).

$$SWF = \int V\left(\chi_{j=1}|T\right) d\Lambda\left(\chi_{j=1}\right) \tag{3.12}$$

Our goal is to search for the optimal level of progressivity under different specifications of the pension system. We do so by constructing a grid in the space (τ^y, ω^y); which is the progressivity parameter of the income tax function τ^y and the pension income-test taper rate

ω^{y}[2]. The range of τ^y is restricted between 0 and 1, excluding the possibility of a regressive income tax. We keep the level of government expenditure G, pension parameters, social welfare ST and the consumption tax rate τ^c constant at their benchmark values. The government budget is balanced by adjusting the income tax scale parameter λ. We compute the associated expected utility of a newborn for every grid point and find the welfare-maximizing (τ^y, ω^y)-combination. We compare the steady state macroeconomic aggregates of the welfare maximizing combination with the benchmark model.

We compute welfare gains in terms of the certainty equivalent consumption variation (CEV) - the uniform percentage increase in consumption needed to make a household indifferent between being born in the benchmark and being born into the proportional tax system. A positive CEV reflects a welfare gain due to tax reform compared to the benchmark. Throughout the paper we compute welfare gains in our experiments in terms of CEV relative to the benchmark. We compare macroeconomic aggregates in terms percentage deviation from benchmark values.

3.4 The optimal income tax code

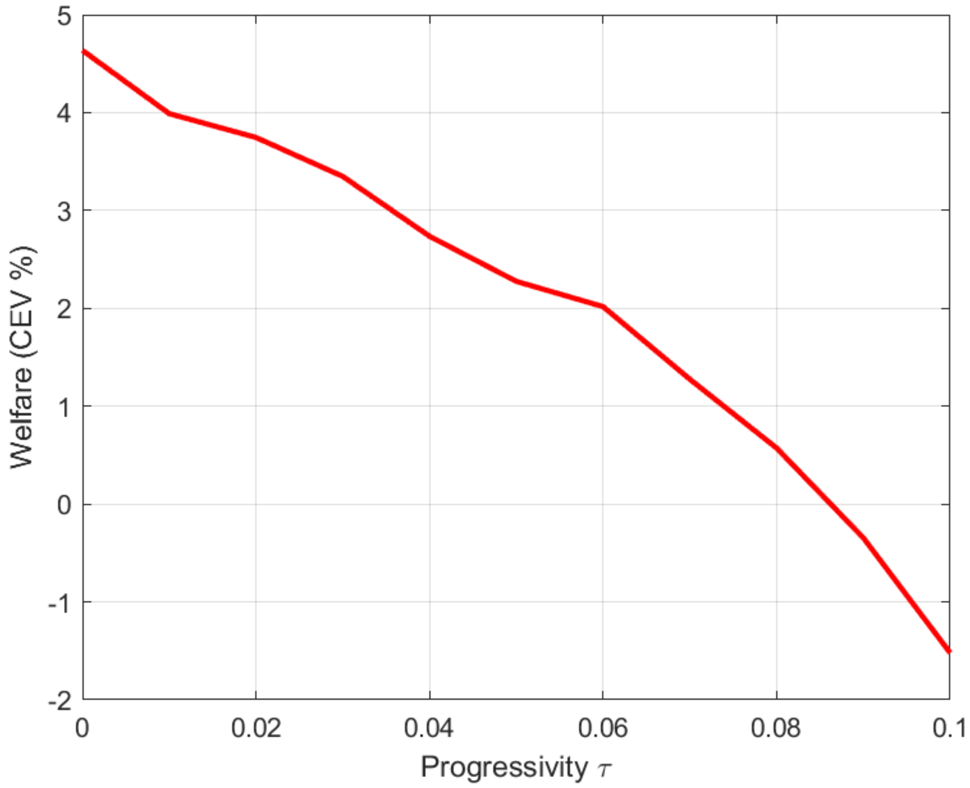
In our first experiment, we examine the incentive and insurance effects of varying the progressivity level conditional on the current pension system. To do so, we hold all other fiscal variables except for the income tax code at benchmark levels and vary the progressivity parameter τ^y between 0 and 1. As explained earlier, in all our experiments we balance the government budget by adjusting the scale of the income tax via the parameter λ.

Figure 3.4 plots social welfare for different values of progressivity holding the pension system fixed in real terms. A reduction in the value of the progressivity parameter τ^y from the benchmark value of 0.085 results in an increase in welfare. We find that welfare is highest with a proportional income tax system with $\tau^y = 0$.

Our model yields an optimal income tax code with $\tau^y = 0$ and $\lambda = 0.85$. This translates to a tax code with an average tax rate of 14.71%. Our results come close to the optimal proportional tax rate of 17.2% for the U.S. proposed by Conesa and Krueger (2006) except there is no fixed

[2]We focus on the income-test taper rate alone as it is the binding test in our model. The majority of OLG models of the Australian economy only consider the income test as it affects most of those who receive a partial pension.

Figure 3.4: Welfare at different values of progressivity τ^y



deduction or tax-free threshold. Figure 3.5 plots the average and marginal tax rates over income for the benchmark and the proportional tax.

Our optimal tax code implies those earning a taxable income below $140,000 faces a higher tax burden compared to the benchmark. In fact, the lower the taxable income, the larger the increase in tax burden. The natural question is then, why do we observe welfare gains despite these perceived inequities in the shifiting of the tax burden?

3.4.1 Welfare gains and macroeconomic aggregates

In order to undestand welfare gains, we first compare aggregate variables between the proportional tax system and our benchmark model. Table 3.5 compares welfare gains and the percentage changes in the main macroeconomic variables compared to the benchmark.

Figure 3.5: Tax rates: benchmark vs. proportional

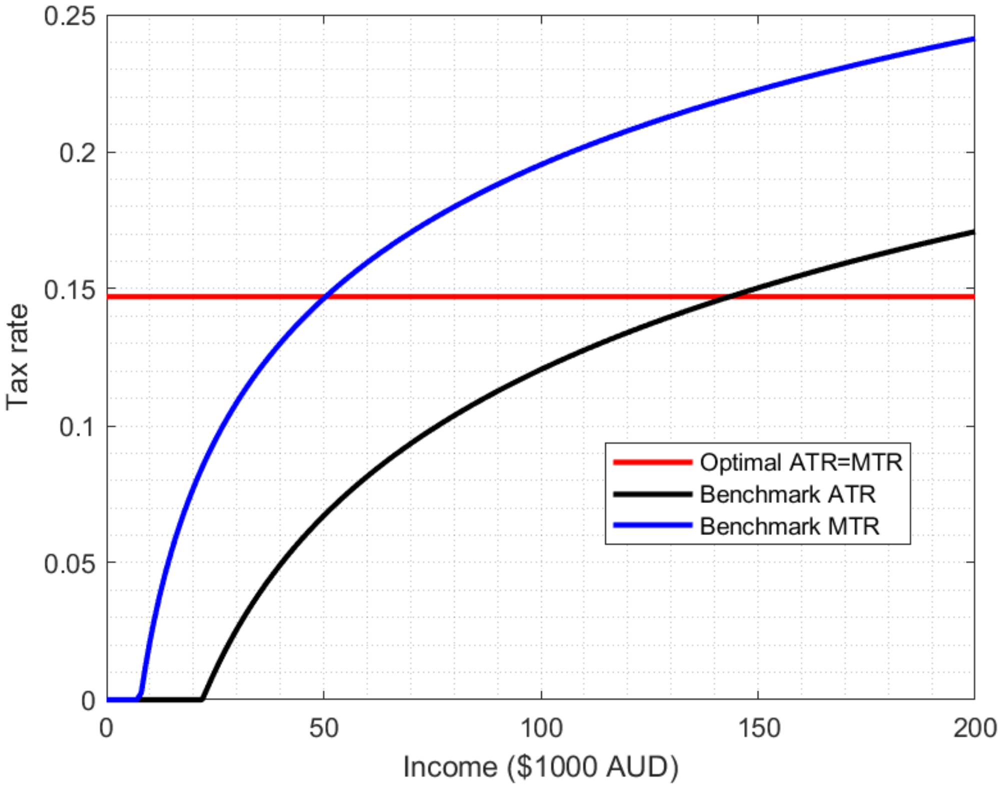


Table 3.5: Aggregate macroeconomic and welfare effects when switching from benchmark to optimal tax system

		By skill type		
	Aggregate	**Low**	**Medium**	**High**
Percent of households in skill type		30	50	20
Welfare (CEV)	4.64	4.19	4.36	6.27
GDP	39.97			
Savings	94.35	59.82	75.50	149.68
Consumption	44.22	38.07	38.76	52.82
Labor supply (hours worked)	11.12	9.27	11.45	12.80
Labor force participation rate	-2.18	-2.85	-4.55	3.70
Wage rate	24.53			
Average tax rate (averaged by group)	-9.37	5.31	-1.83	-34.66
Percent of taxpayers	13.45	24.74	12.39	2.50
Total income tax	-13.36	-3.47	-5.70	-22.29
Income tax as % of Y	-38.10			
Consumption tax revenue	44.22			
Consumption tax as % of Y	3.04			
Percent of pensioners	-4.48	0.00	0.00	-25.34
Total pension	-8.64	-1.29	-3.30	-41.46
Pension expenditure as % of Y	-34.73			
Labor income	39.97	37.03	39.41	41.71
Capital income	81.24	54.59	63.52	128.27
Net income	67.16	49.48	56.25	91.05

All aggregate variables except welfare expressed as percentage deviation from benchmark value.

The optimal tax code results in higher savings and labor supply, resulting in a GDP per capita that is 40% higher than the benchmark. Aggregate labor supply increases quite evenly across all skill types. This is reflective of the fact that changes in both the average tax rate as well as the wage rate reduces disincentives to work. In this regard, the wage rate increases by 25% while on average, the average tax rate decreases by 10% (on average). Proportional tax system also results in an increased incentive to save. Savings in the optimal sytem is 94% higher than the benchmark. This is partly explained by the positive income effect from increased labor income (+40%) and reduced tax burdens. In addition, reduced marginal and average tax rates at the top of the income distribution results in a positive substitution effect. This is seen from the significantly higher savings among medium and high skill types compared to the benchmark. Although aggregate labor hours are higher in the optimal, labor force participation rates are around 3% lower.

3.4.2 Decomposition of aggregate effects

As seen from Table 3.5, the wages in the optimal are 25% higher than the benchmark, while tax rates on average are 9% lower. In a small open economy, higher wages translate to higher savings, and in turn, higher labor and capital income, consumption and welfare. Thus, it is useful to examine the extent to which welfare and aggregate variables change due to higher wages in general equilibrium, and the extent to which they change due to the change in tax code itself.

To conduct this decomposition exercise, we conduct a partial equilibrium analysis where we keep wages constant at benchmark levels and impose the optimal proportional tax rate of 14.71% on our model. Again, we calculate welfare effects in terms of consumption equivalent variation and other aggregate variables as percentage deviations from benchmark values. Since the only difference from the benchmark is the optimal tax code, the CEV and percentage changes between the benchmark and counterfactual gives the effect of changes in the tax code ('Tax effect').

Table 3.6: Welfare and aggregate output effects - optimal versus counterfactual

	(1) Optimal (Overall effect)	**(2) Fixed** w, λ (Tax effect)	**(3) Difference** (Wage effect)
Wage rate	0.40	0.32	
Average tax rate (%)	14.71	14.71	
Welfare (CEV)	4.64	1.46	3.17
- Low skilled	4.19	1.09	3.10
- Medium skilled	4.36	1.25	3.11
- High skilled	6.27	2.78	3.49
GDP (%$\triangle$from benchmark)	39.97	22.49	17.48

Table 3.6 summarizes the results of this decomposition exercise. Column (1) repeats the aggregate effects of switching to the optimal tax code from the benchmark as listed in Table 3.5. Column (2) gives the tax effect as described in the preceding paragraphs. Column (3) lists the difference in values in columns (1) and (2) - subtracting the tax effect from the overall effect, giving the effect of increase in wages from benchmark to optimal ('Wage effect'). We further disaggregate these effects by skill types and examine each variable seperately as follows.

Effect on labor supply. Table 3.7 shows the effect on labor supply from the optimal tax code. Changing from the benchmark to the optimal results in opposite aggregate effects on labor along the extensive and intensive margins. The extensive margin of labor supply, captured by the labor force participation rate is lower by 2.18%, while the intensive margin of labor supply captured by aggregate hours worked are are higher in the optimal by 11.12% compared to the benchmark. Labor hours are higher for all skill types. In contrast, low and medium skill types experience lower labor force participation rates while high skill types experience higher participation rates.

Table 3.7: Effect on labor supply

	Aggregate	**Low**	**Medium**	**High**
Wage rate	24.53			
Average tax rate	-9.37	5.31	-1.83	-34.66
Labor hours				
- Overall effect	11.12	9.27	11.45	12.80
- Tax effect	7.86	7.21	8.19	8.01
- Wage effect	3.26	2.06	3.26	4.79
Labor force participation rate				
- Overall effect	-2.18	-2.85	-4.55	3.70
- Tax effect	-4.32	-3.21	-4.79	-4.57
- Wage effect	2.14	0.36	0.24	8.27
Labor income				
- Overall effect	39.97	37.03	39.41	41.71
- Tax effect	9.39	8.00	9.14	10.20
- Wage effect	30.58	32.29	34.65	56.98

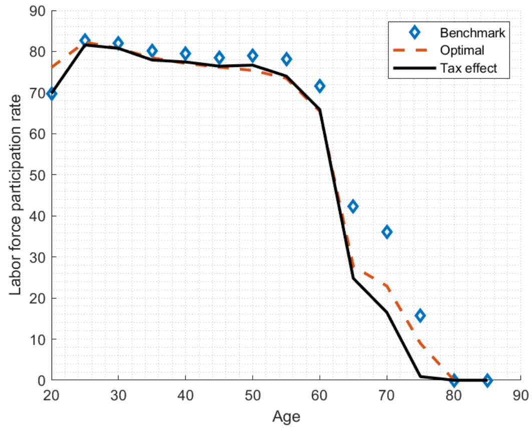
Our decomposition shows that the reduction in participation rates is primarily due to the tax effect. When we impose the optimal tax code at benchmark wages, all skill types experience lower participation rates on average. This is a result of higher marginal tax rates at the bottom compared to the benchmark. In addition, the optimal tax code does not include a tax-free threshold. This has significant impacts on the extensive margin.

When it comes to the decision of whether to work or not, those individuals with low levels of labor productivity have less incentive to work despite higher wages due to the higher marginal tax rate of 14.72% on their labor income. The existence of the public transfer and pension systems add to this disincentive. The interplay between pensions and higher average tax rates are evident when we examine labor force participation rates over the lifecycle by skill type (Figure 3.6). The solid black lines show LFPR over the lifecycle in the optimal economy while the dashed line plots the effect of the tax code on LFP.

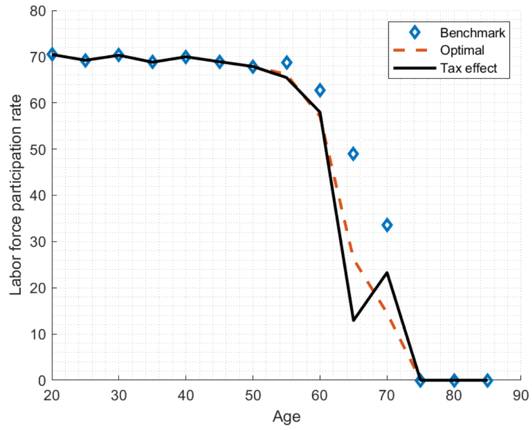
Figure 3.6(a) shows a significant reduction in LFPR past the age-pension eligible age of 65 years in the optimal compared to the benchmark. This is significantly high for low and medium skill types. Beyond the age of 65, eligibility for the age-pension serves as a disincentive for those with low levels of productivity to work. In comparison, high skill types exhibit a higher LFPR at age 20 and past retirement age. This owes to the fact that they experience lower tax rates as well as higher wages compared to the benchmark. In addition, high skill types are less

Figure 3.6: Labor force participation rates over the lifecycle

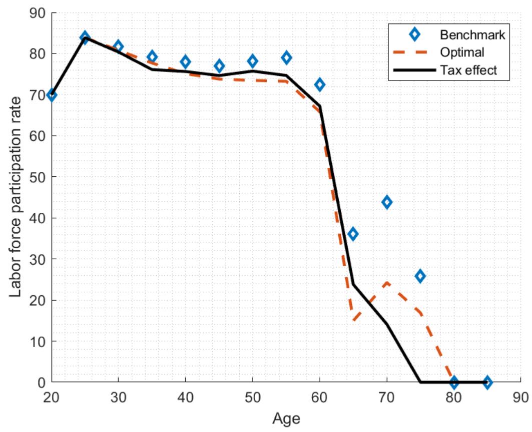
(a) Aggregate



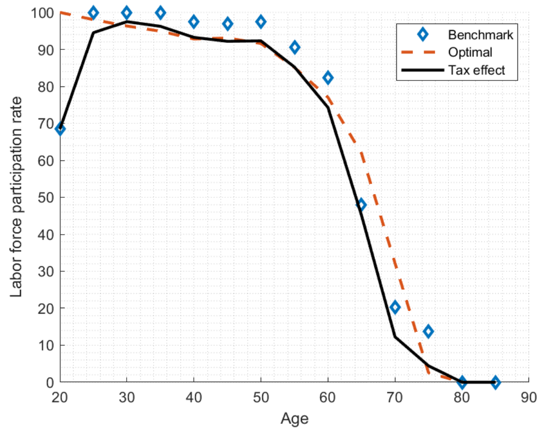
(b) Low skill



(c) Medium skill



(d) High skill



likely to be eligible for pensions in a means-tested system. The fact that labor force particiaption rates are higher in the optimal general equilibrium case compared to the our partial equilibrium case where wages are held constant, shows that the increase in wages in general equilibrium serves to mitigate any negative effects on the extensive margin of labor due the change in tax code.

Overall, positive effects of the optimal tax code on the intensive margin outweigh the negative on the extensive margin. Since marginal tax rates are constant at 14.71% in the optimal tax system, workers do not face any negative tax incentives from increasing their hours worked. This is evident from Table 3.7 by the fact that despite an increase in the average tax rate by 5.31% for low skill types, they experience 7.21% higher labor hours compared to the benchmark even when wages are held constant.

Effect on savings. Higher labor income in the optimal compared to the benchmark translates in to higher savings. Table 3.8 shows compares savings in the optimal economy compared to the benchmark in terms of percentage deviations. Even when wages are held constant at benchmark levels, the change in tax code results in 46.74% higher savings. It is especially higher for high skill types at 82.86% as their average tax rate is lower by 34.66%. The effect of the constant marginal tax rate is again evident from the effect of savings on low skill types. Despite a higher average tax rate, low skill types on average save more compared to the benchmark. In a small open economy, interest rates are not responsive to increases in household savings. The proportional tax system thus eliminates any disincentive to save more.

Table 3.8: Effect on savings

	Aggregate	**Low**	**Medium**	**High**
Wage rate	24.53			
Average tax rate	-9.37	5.31	-1.83	-34.66
Savings				
- Overall effect	94.35	59.82	75.50	149.68
- Tax effect	46.74	24.41	34.26	82.96
- Wage effect	47.60	35.41	41.25	66.72

Distributional effects. Table 3.9 summarizes the effects of the optimal income tax code on inequality. Column (1) lists the gini coefficients for income, tax, consumption and wealth inequality in the benchmark. Column (2) lists the gini coefficients for the optimal economy.

Column (3) provide the gini coefficients from our partial equilibrium economy with wage are fixed at benchmark rate and the optimal tax code.

Table 3.9: Gini coefficients: benchmark, optimal, and optimal tax code at benchmark wage rates

	Benchmark	Optimal	Fixed wage
Labor income	0.60	0.58	0.59
Capital income	0.52	0.54	0.52
Taxable income	0.57	0.54	0.54
Net income	0.39	0.44	0.43
Suits index	0.20	0.00	0.00
Consumption	0.30	0.37	0.37
Wealth	0.56	0.63	0.59

The trade-off between efficiency and equity implied by a switch to a proportional tax code is evident from the higher net income inequality with a gini coefficient of 0.44 compared to the benchmark of 0.39. This is a result of an increase in tax burdens at the bottom and a decrease in tax burdens at the top relative to the benchmark. Similarly, consumption and wealth inequality is higher in the optimal compared to the benchmark.

The negative effects on inequality is partially mitigated by increases in labor and savings across the income distribution. This is evident in the small reductions in labor income income inequality. The Gini coefficients for capital income inequality and wealth inequality are slightly higher in the optimal. As explained earlier in relation to Table 3.8, savings for high skill types relative to other skill types increase by a disproportional percentage (149.78% compared to 59.82% for low skill types 75.50% for the medium skill types).

3.5 Means-tested pension and optimal tax progressivity

The optimal tax code proposed in Section 3.4, is a flat tax with no tax-free threshold. Such a tax does not have any social insurance role. At this juncture, it is important to note that this optimal tax is contingent on the existence of the current public transfer system. Within the public transfer system, the age-pension plays a significant social insurance role in the economy. In this section, we examine the interplay between optimal tax progressivity and social insurance from the perspective of the means-tested age pension system in Australia.

There are many interesting facets of the means-tested pension system. To keep our analysis relevant to the context of optimal progressivity, we steer our explainations along the lines of one guiding question - “does the coverage and generosity of the age-pension affect optimal progressivity?”. Before we proceed, for simplicity and ease of exposition, we restrict our focus in this section only on the income test. In all our experiments, the income test is the binding test whereas the asset test is non-binding.

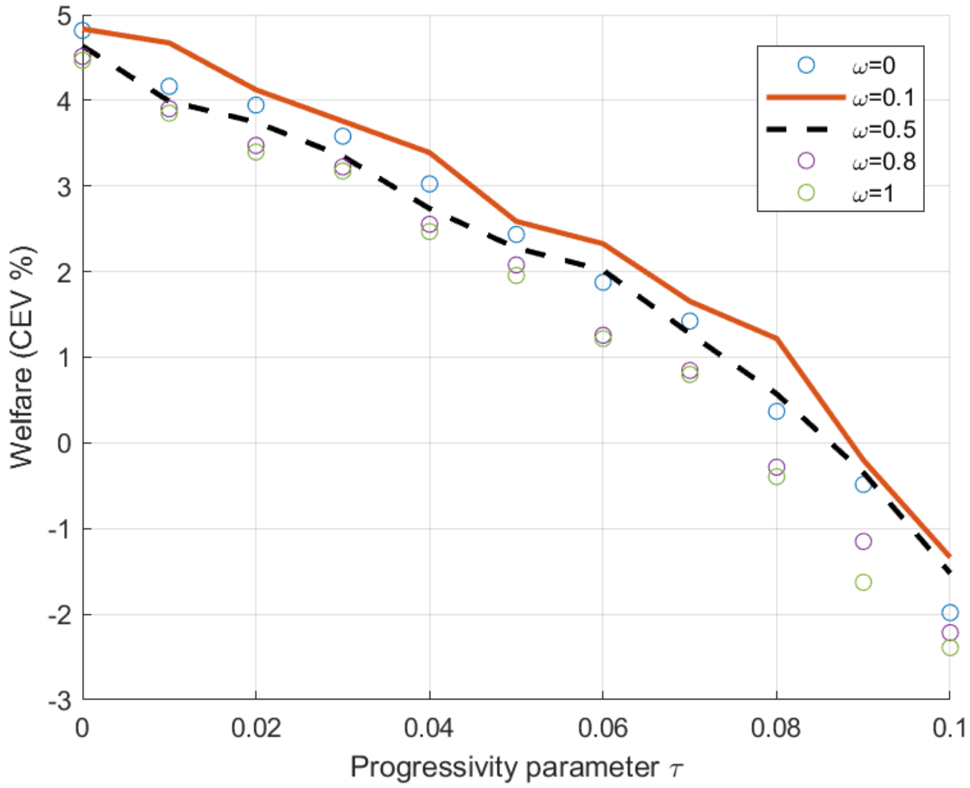
In a means-tested pension system, only those below certain thresholds are eligible for the maximum benefit $p^{\max}$. Above this threshold $\bar{y}_1$, the benefit is reduced at a taper rate (in our case $\omega \in [0,1]$) till the benefit equals 0. The means-testing instruments $(p^{\max}, \bar{y}_1, \omega)$ results in two seperate channels of effects: (*i*) the number of individuals eligible for pension (coverage/extensive margin) and (*ii*) the level of pension benefits (generosity/intensive margin). To understand these two channels, recall that our income-test is given by

$$p = \max\left[0, p^{\max} - \omega\left(y - \bar{y}_1\right)\right] \tag{3.13}$$

Coverage is determined by the threshold $\bar{y}$ and ω. In this section, we focus on coverage through the taper rate ω while holding $\bar{y}$ constant. It is possible to focus on coverage only through the taper rate. That is because the ω directly determines the extensive margin - the upper threshold level above which a person does not receive any pension. Let $\bar{y}_2$ denote this threshold. At higher taper rates, $\bar{y}_2$ will be closer to $\bar{y}_1$ as the pension amount will reach 0 at a faster rate ω. In fact when $\omega = 1$, $\bar{y}_1 = \bar{y}_2$ and those above this threshold do not receive any pension. This is known as a strict means-test. In contrast, when ω is lower, $\bar{y}_2$ will be further from $\bar{y}_1$. This means that more individuals would be eligible for at least a partial pension. When $\omega = 0$, the extensive margin disappears and the means-tested system collapses to a universal PAYG pension.

Generosity (intensive margin) is jointly determined by the maximum benefit $p^{\max}$ and the taper rate ω. It is quite obvious that a higher $p^{\max}$ increases the pension benefit for all those who are eligible. The role of the taper rate is slightly more complex. For those above $\bar{y}_1$, the taper rate serves as an implicit tax that reduces their pension benefit. A higher ω implies a lower benefit and vice-versa. Thus, the taper rate works through both the extensive and intensive

Figure 3.7: Welfare at different values of progressivity τ^y and income test taper rates ω^y



margin. The taper rate has two opposing effects on welfare. On one hand, when taper rates are higher the pension system is more targeted towards lower income individuals. This enhances the social insurance role of the pension system and strengthens intra- and inter-generational risk sharing. On the other hand higher taper rates have a negative effect on social welfare through its role as an implicit tax that distorts savings and labor incentives in old-age.

3.5.1 Taper rate and progressivity

Holding $p^{\max}$ and $\bar{y}_1$ at benchmark levels, we simulate the effect on welfare and macroeconomic aggregates for different taper rates and progressivity levels. We search over different values of two policy parameters - progressivity level τ^y and the taper rate ω^y for the combination that gives the highest social welfare. We find that social welfare is highest under a proportional tax system with no tax free threshold and where the pension system is means-tested with a taper rate $\omega^y = 0.1$.

Figure 3.7 plots social welfare against progressivity parameter values τ^y at different taper rates for the age pension income test ω^y. At any given taper rate, social welfare increases with decreasing progressivity and is highest when $\tau^y = 0$. This implies that any social insurance effects of progressive taxation are outweighed by incentive effects. In regards to taper rates, at any given level of progressivity, social welfare increases with decreasing taper rates. Again, this is indicative of the social insurance effect of means-tested pensions being outweighed by negative incentive effects on labor supply and savings.

An important subtle observation from Figure 3.7 is that the gap between social welfare at different taper rates becomes larger as the tax system becomes more progressive. As mentioned earlier, the taper rate works through both the intensive and extensive margins. In regards to the intensive margin, individuals desire lower taper rates in more progressive tax systems as a mitigation for higher marginal tax rates that they face as their income increases. There is also greater desire for higher coverage (extensive margin). Higher marginal tax rates imply lower after-tax incomes even higher up the income distribution. In such a context, obtaining at least a partial pension becomes more desirable. The need for lower taper rates and greater coverage declines as the tax system becomes less progressive. In a proportional tax system, differences in social welfare at different taper rates are substantially small.

Table 3.10 summarizes key aggregates for the different models. Aggregate variables are given in terms of percent deviation from benchmark value and social welfare is expressed in terms of CEV. For brevity, we focus on four taper rates, $\omega^y = 0$ (universal pensions), $\omega^y = 0.1$ (optimal pension), $\omega^y = 0.5$ (benchmark pension) and $\omega^y = 1$ (strict means-test). In terms of CEV, relative to the benchmark a proportional tax system with taper rate $\omega^y = 0.1$ yields 4.83% while $\omega^y = 0$ yields 4.82% which is a negligible difference. Similarly, differences in the percentage change in GDP, savings, consumption and labor supply relative to benchmark between the $\omega^y = 0.1$ economy and $\omega^y = 0$ economy are fairly small.

Table 3.10: Comparison: benchmark and proportional tax at different taper rates

	Benchmark	Proportional			
Taper rate ω^y	0.5	0	0.1	0.5	1
Progressivity τ^y	0.085	0	0	0	0
Tax-free threshold ($AUD)	23,000	0	0	0	0
Average tax rate (%)	Progressive	14.97	14.75	14.71	14.77
Welfare (CEV)		4.82	4.83	4.64	4.47
GDP		41.54	41.53	39.97	38.97
Savings		97.49	98.19	94.35	90.99
Consumption		45.81	45.74	44.22	43.33
Labor supply (hours worked)		12.70	12.14	11.12	11.22
Labor force participation rate		-0.45	-0.80	-2.18	-2.36
Wage rate		24.90	25.22	24.53	23.67
Average tax rate (mean)		-7.23	-8.67	-9.37	-9.22
Total pension		5.74	-0.50	-8.64	-11.36

The effect of taper rates via the extensive margin is most evident when comparing the labor force participation rates (LFPR) between the economies with different taper rates. The percentage decrease in LFPR from benchmark rate is highest when $\omega^y = 1$. Tighter coverage acts as a disincentive for individuals to work so as to reduce their earnings such that they are eligible for the pension benefit. In regards to savings, lower taper rate is a lower implicit tax on capital income. Thus, through the intensive margin, lower taper rates would result in higher savings. On the other hand, lower taper rates mean greater coverage. Through the extensive margin this acts as a disincentive to save for retirement. The fact there is a considerable increase in savings as the taper rate is reduced from 1 to 0.1 implies that the positive effects through the intensive margin outweigh negative effects through the extensive margin.

Why is welfare not higher when means-tests are completely eliminated in a universal PAYG pension ($\omega^y = 0$)? Table 3.10 shows that the average tax rate is slightly higher with universal pension compared to means-tested pensions. Relative to the system with the optimal taper rate of $\omega^y = 0.1$, pension expenditure is higher in the universal pension system. Compared to the benchmark, when $\omega^y = 0$, total pension expenditure is 5.74% higher than the benchmark while means-tested pensions result in a percentage decrease relative to the benchmark. Other things constant, higher pension expenditure implies higher average tax rates. This is perhaps a main reason why the universal pension system is less preferable compared to a means-tested system with relatively low taper rates. In addition, the taper rate is itself an implicit tax on labor and interest earnings in old-age. An increase in the taper rate from 0.1 to 1 serves as a disincentive to save. In addition, it discourages individuals from working longer. This is evident in the reduction in savings and labor force participation rates as the taper rate is increased.

3.5.2 Maximum benefit and progressivity

Section 5.2 establishes that under our steady state assumptions, the economy is in a region where the social insurance effects of both progressive taxation and means-tested age pensions are outweighed by negative effects on incentives. In this context, it is worthwhile to ask whether the existence and the level of the pension system has any effects on social welfare. We examine this question by indexing the maximum benefit in an alternative economy to that in the benchmark as $p^{\max}(\varphi) = \varphi p^{\max,\text{benchmark}}$ where $\varphi \geq 0$ is a parameter. When $\varphi = 0$, the government closes the pension program, when $\varphi = 1$, the pension program is the same as the benchmark economy and when $\varphi > 1$ the maximum benefit is higher than the benchmark. We hold the taper rate constant at benchmark level and vary the maximum benefit and the progressivity parameter τ^y.

Table 3.11: Welfare (CEV%) at different progressivity levels and pension benefits

	$p^{\max}(\varphi) = \varphi p^{\max,\text{benchmark}}$				
Progressivity τ^y	0.00	0.50	1.00	1.50	2
0	8.33	6.87	4.64	1.05	0.02
0.02	8.13	6.63	3.75	0.00	0.04
0.04	8.05	6.27	2.74	0.02	0.06
0.06	7.73	6.05	2.02	0.03	0.09
0.08	7.39	5.27	0.57	0.04	0.15
0.1	7.11	4.68	0.02	0.08	0.60

Table 3.12: Optimal tax code and aggregate effects with different maximum pension benefits

	$p^{\max}(\varphi) = \varphi p^{\max,\text{benchmark}}$				
φ	0.00	0.50	1.00	1.50	2
Optimal τ^y	0	0	0	0	0
Average tax rate (%)	5.90	8.54	14.71	24.57	33.55
Welfare (CEV%)	8.33	6.87	4.64	1.05	1.94
GDP	101.77	74.28	39.97	8.22	-7.51
Savings	318.39	207.38	94.35	12.40	-20.73
Labor	26.80	19.98	11.12	5.02	3.05

At all benefit levels, we find that a propotional tax code yields the highest welfare in terms of CEV relative to the benchmark. Table 3.11 lists these welfare gains for different progressivity levels and maximum pension benefit levels. Table 3.12 lists the average tax rate, welfare (CEV% relative to benchmark) and macroeconomic aggregates (in percentage deviation from benchmark values) under the optimal tax code in the economies with different levels of maximum benefit. Similar to Tran and Woodland (2014), we find that decreasing the pension benefit results in social welfare gains such that social welfare is maximum when the public pension system ceases. In addition, a decreased generosity in pension benefits results in increased savings, labor supply and output.

The negative relationship between macroeconomic aggregates and pension benefits is linked to two factors. First, a generous pension program results in adverse effects on incentives to save and work. Second, higher pension benefits results in higher pension expenditures on the government. In our experiments, this increased expenditure is financed by increasing the scale of the income tax. This is seen in the increase in average tax rates as the pension benefit is raised. As explained in section 4, higher tax rates negatively affect savings and labor supply. Thus, in general equilibrium, the adverse effects on incentives to save and work outweigh any social insurance effects from the pension system.

3.5.3 The jointly optimal progressive income tax and age pension

Contingent on the existence of a public pension system, we now turn our attention to characterise the jointly optimal income tax code and pension system in terms of the optimal pension benefit and taper rate. We search over parameter values τ^y (progressivity), φ (maximum benefit relative to benchmark) and ω^y (income test taper rate) by using the income tax scale parameter λ to balance the budget. For ease of exposition and tractability, we focus on two different levels of pension benefits: low $\varphi = 0.5$ and high $\varphi = 1.5$. In each alternative economy, the government keeps the maximum benefit unchanged and varies the taper rate and the progressivity parameter between 0 and 1.

Welfare effects. For all taper rates and levels of maximum pension benefit, we find that welfare is maximized with a proportional tax system. This result is indicative of the fact that contigent on the existence of a public pension system, the negative incentive effects of progressive taxation outweigh any social insurance effects. Table 3.13 lists CEV% relative to our steady state benchmark economy for each of these economies with different levels of pension benefits at different taper rates. The taper rate that attains the maximum welfare gain under each economy is formatted in boldface. Of the combinations examined in the experiment, maximum welfare is attained in a proportional tax system with a pension system with an income test taper rate of 0.1 and maximum pension benefit that is 50% lower than the benchmark. Quite consistently, at all benefit levels, welfare is higher at lower taper rates. This indicates that the incentive effects of lower taper rates through the intensive margin outweigh any social insurance effects via the extensive margin.

Table 3.13: Welfare effects of adjusting taper rates under a proportional tax in economies different levels of pension beneft

	CEV% (relative to benchmark)		
Taper rate	$\varphi = 0.5$	$\varphi = 1$	$\varphi = 1.5$
0	6.89	4.82	**2.04**
0.1	**6.97**	**4.83**	**2.04**
0.2	6.96	4.81	2.03
0.3	6.94	4.75	1.99
0.4	6.91	4.70	1.29
0.5	6.87	4.64	1.05
0.6	6.84	4.55	0.96
0.7	6.85	4.56	0.68
0.8	6.88	4.51	0.57
0.9	6.90	4.48	0.46
1	6.90	4.47	0.22

Macroeconomic aggregates. Table 3.14 gives the percentage deviation in aggregate savings and labor supply from the benchmark economy for the different economies at different taper rates. In the economy where pension benefit is 50% of benchmark levels, the highest level of savings and labor supply is under a strict means-tested pension system with $\omega^y = 1$. The taper rate that delivers the best welfare outcome is not the one that results in the highest savings and labor supply when the pension benefit is low. This is partly due to the fact that means-testing strengthens the social insurance role of the pension system. Thus, it is better to preserve means-tests and target the pension system towards lower incomes under a proportional tax system rather than provide universal coverage. However, as evident from Table 3.13, the gains from means-testing are marginally small in a proportional tax system with relatively low maximum benefits.

Table 3.14: Aggregate savings and labor supply effects of adjusting taper rates under a proportional tax in economies different levels of pension benefit. Values are given in terms of % deviation from benchmark.

	Savings			Labor supply		
Taper rate	$\varphi = 0.5$	$\varphi = 1$	$\varphi = 1.5$	$\varphi = 0.5$	$\varphi = 1$	$\varphi = 1.5$
0	198.38	97.49	**26.09**	20.44	**12.70**	**6.91**
0.1	204.22	**98.19**	**26.09**	20.35	12.14	6.62
0.2	206.33	97.96	25.91	20.14	11.73	6.42
0.3	207.85	96.73	25.28	20.02	11.42	6.27
0.4	207.86	95.85	15.48	20.04	11.24	5.41
0.5	207.38	94.35	12.40	19.98	11.12	5.02
0.6	207.51	92.71	11.22	20.07	11.57	5.02
0.7	208.88	92.77	7.77	20.30	11.44	4.88
0.8	210.60	91.97	6.51	20.41	11.40	4.84
0.9	212.34	91.24	5.30	20.55	11.30	4.76
1	**212.97**	90.99	2.49	**20.58**	11.22	4.02

For the economy where pension benefits are at benchmark levels, savings is highest at $\omega^y = 0.1$ and labor supply is highest under universal coverage ($\omega^y = 0$). For the economy where maximum benefit is 150% of benchmark levels, both labor supply and savings are highest under universal coverage. This reinforces the fact that, when the maximum benefit is high, the effect of the taper rate through the intensive margin is greater than social insurance effects through the extensive margin. As evident from Table 3.13, as the pension system becomes more generous, the negative incentive effects are more pronounced as taper rates are increased.

3.5.4 The role of the age-pension in the context of a proportional tax

In summary, in all specifications of the pension system, the optimal tax code is characterised by a proportional income tax. Contingent on the existence of a public pension system, we find that adverse incentive effects dominate insurance effects at higher taper rates. This does not however completely rule out the social insurance role of the pension system. At all levels of progressivity, at the benchmark level of maximum benefit, we find that a means-tested pension system with a taper rate of 0.1 attains higher welfare than a universal pension system. However, adverse incentive effects of means-tested pensions become more pronounced with increasing generosity of the pension system.

Thus, when the maximum benefit is more generous, a universal pension system results in the higher or equivalent welfare. In the line of other related literature that utilize general equilibrium models to analyse social security, we find that welfare is maximized in an economy with no pension system. In addition, our optimal tax code with a proportional tax rate and no tax-free threshold rules out any social insurance role for the income tax system. At this point, we stress that we obtain these results conditional on the existence of a progressive transfer system before the age of 65 years. In Section 6, we test the robustness of the optimality of our porportional tax in an economy with no public transfers.

3.6 Sensitivity analysis and extensions

In this section, we consider the sensitivity of our steady state general equilibrium results to alternative modelling assumptions. We first consider how sensitive our optimal tax code is to the existence of the public transfer system. Second, we examine whether optimal progressivity depends on assuming divisible labor hours. Finally, we examine the sensitivity of our results on optimal progressivity and pension taper rate to different values of risk aversion and labor supply elasticity. Our sensitivity analysis also opens avenues for future research and extensions. Where relevant, at the end of each section we highlight potential ways in which the analysis can be extended.

3.6.1 Risk aversion, labor supply elasticity and optimal tax progressivity

In this section, we examine the sensitivity of our results to labor supply elasticity. It is reasonable to expect greater responses to changes in progressivity if labor supply is more elastic. In our benchmark economy, household preferences are specified in terms of $u(c,l) = \frac{\left[c^{\gamma} l^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}$. Under this specification, the Frisch elasticity is given by $\frac{l}{1-l}\frac{1-\gamma(1-\sigma)}{\sigma}$ which varies over the lifecycle relative to labor supply. We first consider different values of the risk aversion paramter by settting it to alternative values of $\sigma = 3$ and $\sigma = 4$. Second we examine an alternative specification of additively seperable utility function where the Frisch elasticity of labor supply is constant over the lifecycle given by

$$u(c,l) = \frac{c^{1-\sigma}}{1-\sigma} - \chi \frac{(1-l)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} \tag{3.14}$$

where we use the parameter γ to denote Frisch elasticity and χ. In each of these modifications, we recalibrate the benchmark to match data.

Table 3.15 lists the optimal progressivity parameter and optimal income test taper rate under these alternative specifications. We find that the optimal tax code is not sensitive to the specification of preferences. That is, under all values of Frisch elasticity and risk aversion examined, the optimal tax code is a proportional tax. In contrast, the optimal taper rate increases with the risk aversion coefficient. In fact, when we set $\sigma = 4$ as per Tran and Woodland (2014), we obtain the same optimal taper rate of 0.3. This also indicates that the gains from means-testing public pensions are greater in frameworks with higher risk aversion.

Table 3.15: Optimal progressivity and taper rate under alternative preferences

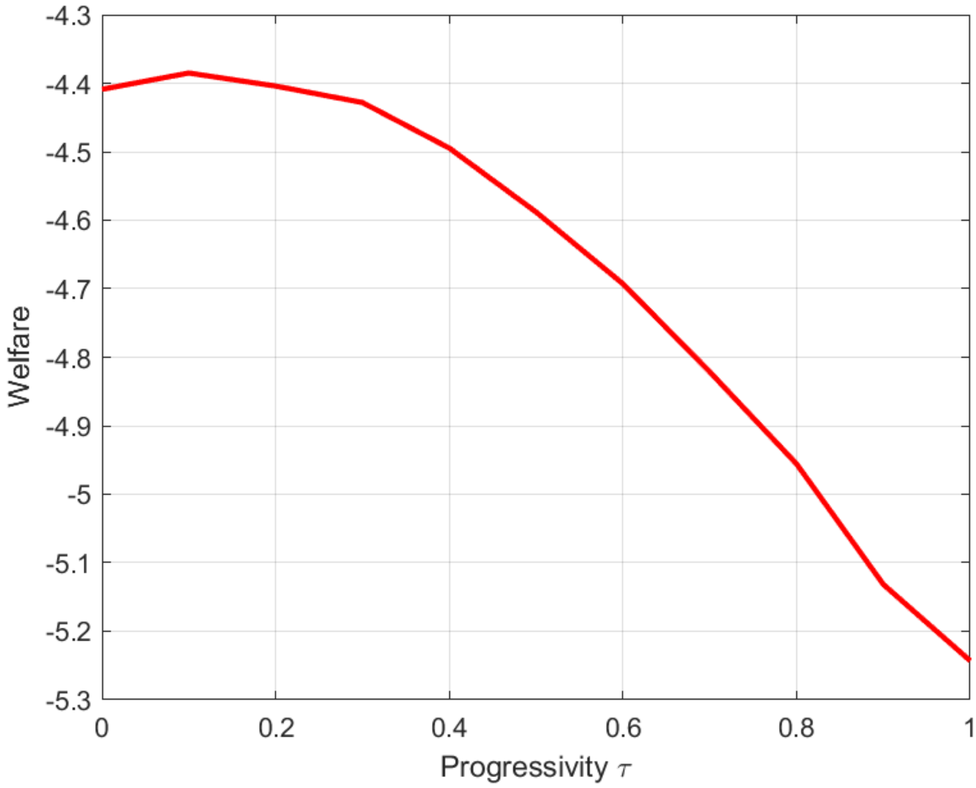
Labor supply elasticity	Optimal τ^y	Optimal ω^y	Average tax rate (%)
Varying over the lifecyle with $\sigma = 2$ (benchmark)	0	0.1	9.05
Varying over the lifecyle with $\sigma = 3$	0	0.2	15.41
Varying over the lifecyle with $\sigma = 4$	0	0.3	15.03
Constant Frisch elasticity	0	0.2	15.64

3.6.2 The role of public transfers

A flat tax without any tax free threshold rules out any social insurance role for the income tax system. At this point, we stress that we obtain our results within the context of the wider tax-transfer system in the Australian economy. Australia has a highly progressive transfer system that targets the majority of public transfers towards those at the bottom of the income distribution. In this section, we show that higher social welfare from a proportional tax code is contingent on the existence of public transfers.

To do so, we use a version of our model where we switch off all public transfers to households. Thus, the government only uses its tax system to finance exogenously given general expenditures. The household budget only depends on its own individual labor earnings and capital income. Since, this version of the model does not include public transfers we increase government expenditure as a share of GDP to 36% in order to generate total government ex-

Figure 3.8: Social welfare at different progressivity levels (no public transfers)



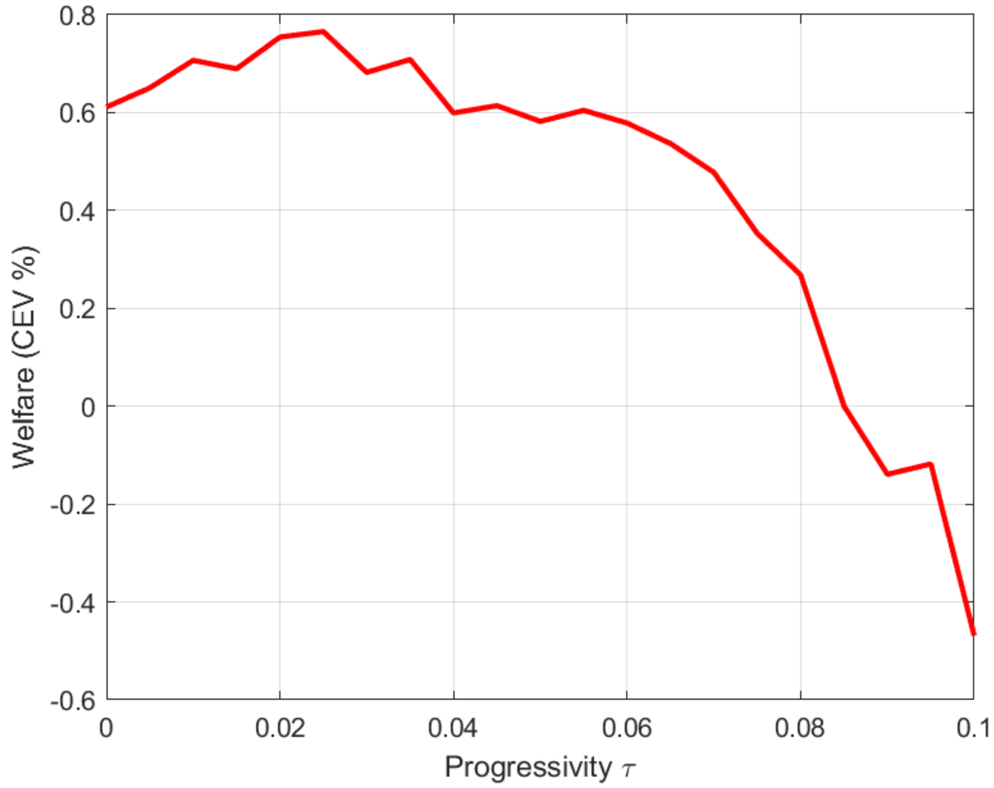
penditures that are equivalent to our benchmark levels. Under these assumptions, we obtain an optimal tax code where the value of the progressivity parameter is $\tau^y = 0.1$, and a tax free threshold $\$120,000$ which is much higher than the current benchmark economy.

Extensions. It is reasonable to believe that the structure and progressivity of the public transfer system also matters in determining the progressivity of the income tax code. However, a detailed examination of these aspects require more details in terms of the actual transfers received by households. Thus, an important extension to our analysis of optimal progressivity is to model the transfer system in greater detail. Since public transfers are dependent on demographic characteristics such as age and family structure, such an analysis requires a model with greater household heterogeneity. We deem this beyond the scope of this paper and leave it for future research.

Another possible extension is to examine the implications of public goods on income tax progressivity[3]. This would require incorporating a share of public goods in to the household

[3]We thank Dr. Solmaz Moslehi for providing insights on this issue.

Figure 3.9: Social welfare at different progressivity levels (indivisble labor)



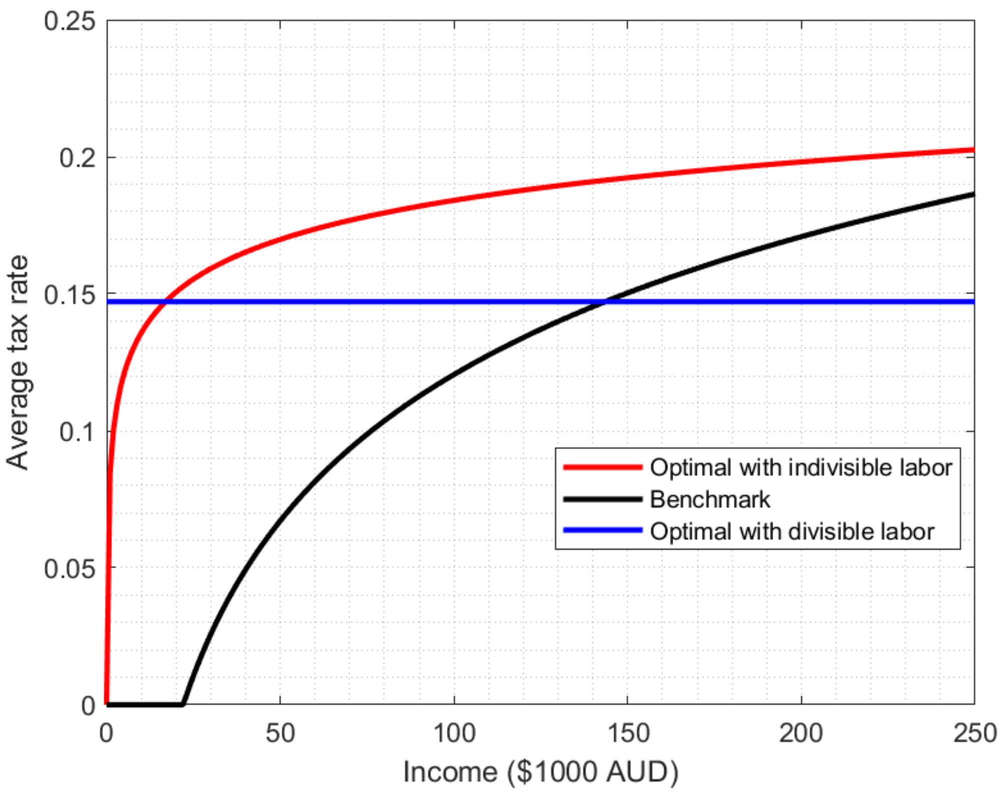
utility function such that public consumption is a partial substitute for private consumption. While this is an interesting and important extension, it requires a richer model and is beyond the scope of the current paper.

3.6.3 Indivisible labor hours

As evident from Section 4, households respond to reduction in progressivity by increasing their labor hours. Our model implicitly assumes a high degree of flexibility in the hours available for work. In this section, we consider a case where households face constraints in the hours available for work. For example, assume that households face three simple choices: not work, work part time and work full time. We take the average hours of work for part-time and full-time workers from HILDA data and calibrate them to match with our benchmark economy. As such, average hours of work for part-time workers are set at 12% of the total time endowment and full-time work is set at 44% of time endowment.

Figure 3.9 plots social welfare for different progressivity levels with indivisible labor. Under

Figure 3.10: Average tax rates (indivisble labor)



this assumption, we still find welfare gains from decreasing progressivity. However, the optimal tax code is no longer a proportional tax, but with a progressivity parameter $\tau^y = 0.025$. Figure 3.10 compares average tax rates between the benchmark and the optimal tax codes under the assumption of divisible labor hours and indivisible labor hours. Compared to the optimal tax code under divisible labor, the optimal tax code with indivisible labor results in higher average tax rates. For those earning below \$350,000, the average tax rate is higher under this assumption compared to the benchmark economy.

Extensions. The purpose of this section is to highlight the sensitivity of our results to the assumption that labor hours are highly divisible. In reality, individuals face several constraints in terms of the hours that are available for work. A detailed examination of these constraints in labor hours and how that would affect optimal progressivity is of utmost importance. In addition, since there are gender differences in the composition of part-time and full-time workers, an examination along these lines could also include an analysis of the gender differentials in regards to the impacts of tax progressivity. Such an examination would also require a model with greater household heterogeneity.

3.6.4 Imperfect capital mobility

In all our simulations using the benchmark model, we observe a substantial increase in savings when we move from a progressive tax code to a proportional one. In the benchmark, we assume that the interest rate is exogenous and independent from the level of domestic savings in our small open economy. In this subsection, we test how sensitive our results are to this assumption. To do so, we assume that the domestic interest rate is partially endogenous and given by

$$r = \bar{r} + \Omega \left(\frac{A^F}{Y} - \frac{\bar{A}^F}{\bar{Y}} \right) \tag{3.15}$$

where $\bar{r}$ is the exogenous world interest rate, A^F/Y is the ratio of net foreign assets to GDP, $\bar{A}^F/\bar{Y}$ is the ratio in the benchmark steady state and Ω governs the responsiveness of the domestic interest rate to changes in the ratio. Following Kudrna and Tran (2018), we set $\Omega = 0.02$. As per this specification similar to a closed economy, when domestic savings increases (and the share of net foreign assets declines), the domestic interest rate will increase. We find that our results are not sensitive to the relaxing of the perfect capital mobility assumption. The optimal tax code is still proportional with an average tax rate of 14% and the optimal income test taper rate remains at 0.1.

3.7 Conclusion

This paper is a first attempt to examine the Australian progressive income tax system's social insurance in a dynamic general equilibrium framework. We base on a utilitarian social welfare function and find that it is maximized in a proportional income tax system with no tax-free threshold. This optimal tax system is contingent on a public transfer system's design. The Australian public transfer system is relatively generous and progressive compared to similar OECD countries.

We also acknowledge the limitations of our analysis in terms of the specification of our model. More research is needed to understand optimal income tax progressivity in a model with greater household heterogeneity in terms of family structure and detailed public transfers. Similarly, our sensitivity analysis shows that optimal progressivity is sensitive to labor market assumptions. Labor market frictions in terms of constraints on employment and work hours could also significantly improve our understanding of optimal income tax progressivity.

Withstanding these limitations, our paper points to a general conclusion on the welfare effects of flattening the income tax code. In that, the adverse incentive effects on labor supply and savings from progressive taxation can be reduced by moving towards a less progressive income tax system. Public transfers in general and the age-pension, in particular, complements a less progressive tax system by providing social insurance for the poorer segment of the population. This conclusion carries an important policy implication. Governments interested in flattening the income tax code should give careful consideration to the design and generosity of the public transfer system to mitigate any reduction in the social insurance role of the income tax system.

Chapter 4

On the fiscal limit of income taxation in Australia

4.1 Introduction

After decades of favorable economic conditions, Australia has been experiencing significant pressures on its fiscal system since the Global Financial Crisis (GFC). The aftermath of the GFC brought about a decrease in the underlying cash balance from a surplus of 1.7% of GDP in 2007-08 to a deficit of 4.2% by 2010-11, and a corresponding increase in net debt from -3.4% to 6.4%. Since then, net debt has increased at an exponential rate reaching 24.8% of GDP in 2019-20 (Australian Government, The Treasury, 2020). Catastrophic bush-fires at the end of 2020 and the current COVID-19 pandemic has immensely amplified the fiscal burden. Recent forecasts estimate the cash deficit at 11% of GDP in 2020-21 with net debt at 36.1% which is expected to increase further to over 40% in the following three years[1].

In this context, it is important now more than ever to examine the potential and limits of Australia's tax system to generate the revenue required to ensure long-term fiscal sustainability. Compared to other developed countries, Australia relies more heavily on income tax to generate revenue (Australian Government, The Treasury, 2015). Personal income tax accounts for nearly half of total government revenue at 47.2% in 2019-20 (Australian Government, The Treasury, 2020). Thus considering the optimal design of Australia's income tax code is a crucial first step

[1] Trends in nebt debt and government deficit for Australia are included in the Appendix.

in this exercise. How much additional revenue could be gained by changing the income tax code? Would a more or less progressive code generate more revenue? How much could we increase tax rates before revenue starts to decline? Could increasing tax rates on tax revenue sources other than personal income generate more or less revenue?

This paper addresses these questions using a dynamic general equilibrium, overlapping generations (OLG) model calibrated to match key features of the Australian economy. Our model includes (1) heterogeneous households who differ by their earnings ability (skill type) and are subject to uninsurable idiosyncratic labor income risk, (2) production sector represented by a single firm and (3) government sector that finances a means-tested age pension system, other public transfers, general government purchases and debt by imposing a consumption tax, company income tax and personal income tax. Our benchmark economy is modeled as a small open economy. We consider the closed economy case and compare results of our benchmark experiments in detail in our sensitivity analysis.

Our experiments involve examining the impact of changing the progressivity and the average tax rates of the income tax code on tax revenue. We approximate the Australian income tax code using a parsimonious two parameter tax function commonly used in the public finance literature going back to Jakobsson (1976) and Persson (1983)[2]. One parameter determines the level of average tax rates (tax level) while the other controls the tax function's curvature. This approximation captures the tax code's main features such as the tax-free threshold and the average tax rates at different taxable income levels. Also, it accounts well for the distribution of income tax liabilities across the taxable income distribution.

We examine the revenue implications of changes to the income tax code with the aid of Laffer curves for different values of curvature and tax level parameters against tax revenue. We focus on two main concepts based on the Laffer curve - (1) fiscal limit and (2) fiscal space. The fiscal limit of the income tax code is at the Laffer curve peak where total tax revenue reaches a maximum. Changing the tax code beyond this limit results in a decline in tax revenue. Fiscal space gives the difference between this maximum tax revenue and the current (benchmark) revenue amount. It measures the government's capacity to raise revenue to meet its spend-

[2]This tax function has more recently been put forward in the dynamic general equilibrium literature by Benabou (2002) and Heathcote, Storesletten and Violante (2017*b*) and is commonly known as the "HSV tax function".

ing commitments without compromising fiscal sustainability. We quantify the fiscal space in terms of the percentage difference between the maximum revenue and current revenue. We also quantify fiscal space in terms of the debt to GDP ratio as a secondary measure.

Our focus is on the overall income tax code rather than the top tax rates as numerous other papers in the literature. Thus, we first examine changes to the curvature while holding the tax level fixed, and compare income tax revenue across the resulting steady states. In the parametric tax function we use, at any given tax level, a decrease in curvature results in a reduction of the tax-free threshold (thus increasing the tax base) and an increase in average tax rates at the bottom of the income distribution. We find that decreasing the tax function's curvature leads to increasing revenue. At the benchmark tax level, revenue is maximized under a flat income tax system. One main reason for this is that, except for those households with very low earnings ability, a flat tax system eliminates distortions from progressive tax rates as they increase labor hours. We find that this positive effect outweighs any negative effect from rising tax rates. In addition, the negative incentive effect on the lowest skill type is not sufficient to decrease revenue as a flat tax system results in a zero tax-free threshold. Thus, those with even very low labor hours pay income tax.

We find that the relationship between progressivity and revenue is robust to different average taxation levels. We vary values of both the tax level and curvature parameters and find that revenue is maximized with a flat income tax for any given level of taxation. This echoes findings by Holter, Krueger and Stepanchuk (2019) who find that maximal revenue in the US labor tax code can be raised with a flat tax. However, while Holter, Krueger and Stepanchuk (2019) find that maximal tax revenue is attained with a flat labor income tax rate of 60%, the Laffer curve in our benchmark small open economy peaks at a flat tax rate of 95%. This result is robust to alternative policy tools to balance the budget, and alternative assumptions on household preferences. Since social insurance from the means-tested pension system plays a significant role in our model, we also check the robustness of the results to excluding pension from our model and find that the peak of the Laffer curve goes from 95% to 90%. Thus the results are reasonably robust to this assumption.

At the fiscal limit (Laffer curve peak), total tax revenue is at 126% of the benchmark. This gives the overall fiscal space in terms of total tax revenue. It is important to note that this is significantly lower than the maximum income tax revenue of 209% at the peak of the Laffer curve for income tax. In general equilibrium, increasing personal income tax rates lead to negative spillover effects. The negative income effect due to increasing the personal income tax rate results in a significant decline in household consumption and consumption tax revenue. We also find that the economy can sustain a debt-to-GDP ratio of 174% at the fiscal limit. This is because an increase in tax revenue increases the government's ability to borrow and service more debt. However, given that we do not model the risk premium on public debt, we concede that the actual ratio may be lower in reality.

Our results also highlight the advantage of being a small open economy when it comes to increasing tax revenue. Our benchmark small open economy is modeled assuming perfect capital mobility across borders. This assumption is the main reason why the benchmark economy can sustain extremely high average tax rates. Effects to the aggregate stock of capital due to negative incentive effects on household savings as the tax rate increases is mitigated by foreign capital inflows. This maintains wages and the interest rate at benchmark levels. Our sensitivity analysis examines the other extreme on the capital mobility spectrum - the closed economy. Even in the closed economy, maximum revenue is attained with a flat tax. However, as the tax rate rises, the wage rate decreases, leading to more considerable labor supply reductions at any given tax rate compared to the open economy. As a result, similar to Holter, Krueger and Stepanchuk (2019) the Laffer curve peaks at a lower tax rate of 60%.

Our experiments provide some insights that are relevant for income tax policy. First, removing distortions of progressive income taxation incentivizes most households to increase their labor supply and earn higher incomes that imply higher tax revenues. Second, there is potential for a government concerned with increasing tax revenues to increase income tax rates in Australia. Considering the results we obtain from the two extremes of capital mobility - open economy and closed economy - the peak of the Laffer curve for income tax is between 60% and 95%. Third, out of the current taxation sources in the Australian tax system, the personal income tax code has the most potential to generate greater revenue. We find that raising personal income tax rates leads to more considerable gains in total revenue than raising the consumption tax rate. Moreover, increasing the tax rate on company profits above the benchmark rate leads to a decrease in total tax revenue.

Related literature. Our paper contributes to the growing literature on the relationship between tax rates and tax revenues in quantitative macroeconomic models. Table 4.1 summarizes recent notable papers from this strand of literature that is similar in focus and approach to ours. Trabandt and Uhlig (2011) characterize the shape of the Laffer curve for labor and capital income tax rates in a one-sector growth model with an infinitely lived representative household. However, in contrast to the other papers in Table 4.1, they do not account for the non-linear structure of taxation.

The majority of papers that explicitly deal with non-linear taxes focus on the top marginal tax rate. The motivation for these papers typically center on the propositions from static optimal tax literature for higher tax rates at the top - in particular, Diamond and Saez (2011) that calls for a revenue maximizing top tax rate of 73%. Using an OLG model with endogenous human capital investment, Badel, Huggett and Luo (2020) quantify the effects of high marginal labor income tax rates on aggregate economic activity, wage inequality, revenue and welfare. They find that the Laffer curve for the top tax rate occurs at a much lower rate (49% with endogenous human capital and 59% with exogenous human capital).

In contrast, Kindermann and Krueger (2020) finds a higher top tax rate in a similar model but with different assumption on the productivity of top earners. Both papers examine changes to tax rates using a piece-wise linear tax function[3] with different marginal tax rates at different income levels, and examine changes to the top marginal tax rate while taking the rest of the income tax code as given.

Although their focus is also on labor income tax rates at the top, Guner, Lopez-Daneri and Ventura (2016) is closer to this paper in approach. They approximate the US labor income tax code using the same two parameter tax function that we use (referred to in the literature as the "HSV tax function" after Heathcote, Storesletten and Violante (2017*b*)). They examine increasing top tax rates by increasing the curvature of the tax function and making it steeper. They find that making the US labor income tax code more progressive results in very small

[3] Badel, Huggett and Luo (2020) approximates the piece-wise tax function with a polynomial.

Table 4.1: Selection of quantitative dynamic taxation literature investigating tax rates and revenues

	Tax type	Model	Tax function/approach	Public transfers	Revenue maximizing result
Kindermann and Krueger (2020)	Labor income	- OLG. - Uninsurable labor productivity risk. - Exogenous education types.	- Piece-wise (different marginal tax rates for high and low earners). - Change marginal tax rate at the top.	- PAYG social security	Argues for higher top tax rates (92% in steady state). Driven by large, persistent but mean-reverting productivity shocks.
Badel, Huggett and Luo (2020)	Labor income	- OLG - Uninsurable labor productivity risk. - Endogenous human capital (high skilled are disproportionately high earners).	-Badel and Huggett (2017) formula. - Change tax rate.	- Lump-sum transfer to all agents.	Lower top tax rate (49% with endogenous human capital, 59% with exogenous human capital).
Holter, Krueger and Stepanchuk (2019)	Labor income	- OLG - Family structure - Uninsurable labor productivity risk. - Endogenous human capital	- HSV tax function. - Vary average level of taxation at different progressivities.	- Per capita transfers. - PAYG social security. - Unemployment benefits for women that work zero hours.	Laffer curves vary due to varying progressivity in different countries. US: Revenue increases by 63% when current tax code is replaced by a flat tax rate of 60%.
Guner, Lopez-Daneri and Ventura (2016)	Labor income	- OLG. - Uninsurable labor productivity risk. - Exogenous education types.	- HSV tax function. - Increase progressivity to shift the burden towards top earners.	- PAYG social security	- Marginal increases in tax revenue by making tax function more progressive.
Trabandt and Uhlig (2011)	Labor and capital income	- Infinitely lived representative agent. - Extensions: endogenous human capital, heterogeneous agents.	- Flat taxes.	- Household takes government consumption and lump sum transfers.	- Labor income tax: peaks between 50-70%. - Capital income tax: peaks between 48-64%.

increases in revenue.

In contrast to the other papers in Table 4.1, Holter, Krueger and Stepanchuk (2019) is closer in focus to ours as they examine the overall labor income tax code rather than the maximal top tax rate. They examine the impact on tax revenue from varying both the level of taxation and the progressivity of the tax code. They find that revenue is maximized under a flat tax code with an average tax rate of around 60%. Our experiments on the revenue maximizing progressivity of the Australian income tax code yields the proposal for a flat income tax. Moreover, under closed economy assumptions, the tax rate at the peak of our Laffer curve is 60%.

A large proportion of papers in the dynamic taxation literature including Holter, Krueger and Stepanchuk (2019) focuses mainly on the US where labor and capital incomes are taxed under two separate tax codes. A major difference in our paper is that we examine the Australian context where both labor and capital incomes are taxed under the same tax code. Thus, although our tax function is similar in form to Guner, Lopez-Daneri and Ventura (2016) and Holter, Krueger and Stepanchuk (2019), it is different in terms of the taxable income. Moreover, we impose a non-negativity constraint such that we exclude any net transfers from the tax function. Instead, we approximate the Australian public transfer system separately from the tax system. In particular, we include the means-tested age pension system. This is another distinction from dynamic general equilibrium models of the US economy that has a PAYG social security system.

By examining the income tax code in the Australian context, we contribute to the growing body of research on the impacts of fiscal policy reforms in Australia that are analyzed using general equilibrium OLG models which incorporate the behavior of households and firms (e.g., see Kudrna and Woodland (2011), Tran and Woodland (2014) and Kudrna and Tran (2018)). Our paper follows the general policy theme of Kudrna and Tran (2018) who examine the welfare effects of various fiscal consolidation plans.

Among the various consolidation plans, Kudrna and Tran (2018) consider temporary increases in income tax by adjusting the scale of the progressive income tax function to finance reductions in government deficit. However, their focus is on the transition to a balanced budget, rather than examining the design of the income tax code that would maximize government revenue. We add to their contribution by examining the fiscal limits of the Australian income tax code in greater detail by analyzing the impact of its design on government revenues in the long run.

The paper is structured as follows. In Section 4.2 we set up our dynamic general equilibrium OLG model used for our analysis, and provide details of our calibration in Section 4.3. In Section 4.4, we explain our computational experiments. Next, we present the results of our main experiments in two sections. Section 4.5 presents the main results focusing on the fiscal limit. For each of our experiments, we first illustrate how changing the respective parameter of the tax function changes the income tax code. Then we detail the resulting behavioral responses from changes to the tax code, and their impact on macroeconomic aggregates and income tax revenue. Section 4.6 details the fiscal space in terms of total tax revenue and in terms of sustainable public debt.

We put our results in perspective in Section 4.7, highlighting that the reason for the fiscal limit in our result at a very high tax rate of 95% is mainly due to the advantages of being a small open economy. We contrast our main results with that of a closed economy. Next we summarize robustness checks in Section 4.8. Prior to conclusion, we present some further considerations that are important in a real policy context in Section 4.9. Section 4.10 offers some concluding remarks.

4.2 Model

We construct a large-scale overlapping generations model in the spirit of Auerbach and Kotlikoff (1987) that includes households who are ex-ante heterogeneous with respect to education level and ex-post heterogeneous due to uninsurable idiosyncratic labor productivity risk. Our model is an extended version of the general equilibrium OLG model developed for the Australian economy by Tran and Woodland (2014). Similar to other OLG models of the Australian economy, our benchmark is modeled under small open economy assumptions, and consider implications of perfect capital mobility in our sensitivity analysis.

4.2.1 Demographics

The model economy is populated by 14 overlapping generations aged $20-90$ years. One model period corresponds to 5 years. In each period, a new generation aged 20 enters the model and faces random survival probability ψ_j with a maximum age of 89 years. We assume a stationary demographic structure such that the fraction of population of age j at any point in time is given by $\mu_j = \frac{\mu_{j-1}\psi_j}{(1+n)}$, where n is the constant rate of population growth.

Each cohort consists of 5 exogenous skill types that are based on education level $\rho \in$ {very low, low, medium, high, very high}. Those whose highest education attained is below high school are classified as very low skilled and those with high school but no further qualification are classified as low skilled. Those with a further tertiary training but without a graduate level qualification are classified as medium skilled. Graduates are defined as high skilled and those with post-graduate qualifications are defined as very high skilled. These classifications capture differences in life cycle earnings profiles in Australia.

4.2.2 Endowments and preferences

Endowments. In each period, households are endowed with 1 unit of labor time with labor productivity $e\left(j,\rho,\eta_j\right)$ where η_j is a stochastic component that follows a Markov switching process with a transition matrix $\pi_{\rho,j}\left(\eta_{j+1}|\eta_j\right)$. The wage a household faces in the market is given by $w\cdot e\left(j,\rho,\eta_j\right)$. Thus, households face two types of risk - idiosyncratic wage risk and mortality risk. As per Bewley (1986) and Huggett (1993) we assume that these cannot be explicitly insured. Rather, households self-insure against them by accumulating a stock of private assets a_j that earns interest income at a risk-free rate r.

Household income and net transfers. The household's market income thus includes labor income and capital income given by

$$y_j = w\cdot e\left(j,\rho,\eta_j\right)\cdot\left(1-l_j\right)+ra_j \tag{4.1}$$

In addition to market income, households obtain public transfers $st_j\left(\rho,\eta_j,j\right)$ that are dependent on skill type, level of stochastic shock η_j and age j. They are also entitled to a public pension $\mathscr{P}\left(a_j, y_j\right)$ that is dependent on their asset and market income. These transfers from the government are explained in detail in section 4.2.4. Households also pay consumption tax at the rate τ^c on their consumption c_j and income tax $t\left(y_j\right)$ on their market income.

Preferences. Households have preferences over stochastic streams of consumption c_j and leisure l_j. In addition to the precautionary savings motives, following De Nardi (2004) we assume households have a warm glow bequest motive determined by the function $\phi\left(b\right)$ (explained in more detail in Section 4.3). This is dependent on survival probability ensuring that all assets are not completely consumed in old age. The role of the bequest motive in our model is to match individual's life cycle behavior. However, for simplicity, we abstract from any intergenerational links between parents and children.

Let the state of the household at age j be $\chi_j = \left(j, \rho, \eta_j, a_j\right)$. Given time invariant prices, taxes and transfers, the household problem is written recursively as

$$
\begin{aligned}
& V^j\left(\chi_j\right) = \\
& \qquad \max_{c_j, l_j, a_{j+1}} \left\{ u\left(c_j, l_j\right) + \beta \left[\psi_{j+1} \sum_{\eta_{j+1}} \pi_{\rho,j}\left(\eta_{j+1} | \eta_j\right) V^{j+1}\left(\chi_{j+1}\right) + \left(1 - \psi_{j+1}\right) \phi b\left(a_{j+1}\right) \right] \right\} \\
& \qquad \text{subject to:} \\
& \qquad a_{j+1} = \frac{1}{1+g}\left[a_j + e_j\left(1 - l_j\right) w + r a_j + b_j + s t_j + \mathscr{P}\left(a_j, y_j\right) - t\left(y_j\right) - \left(1 + \tau^c\right) c_j\right] \\
& \qquad a_j \geq 0, \qquad 0 < l_j \leq 1
\end{aligned}
\tag{4.2}
$$

where individual quantity variables except for labor hours are normalized by the steady state per capita growth rate g.

4.2.3 Technology

We assume a representative, competitive firm that hires capital K and effective labor services H (human capital) to operate the constant returns to scale technology $Y = AK^{\alpha}H^{1-\alpha}$, where $A \geq 0$ parameterizes the total factor productivity which grows at a constant rate g and α is the capital share of output. Capital depreciates at a rate δ in every period. The firm choose capital and labor inputs to maximize its profit given rental rate q and the market wage rate w according to

$$\max_{K,H}\left\{\tau^{f}\left(AK^{\alpha}H^{1-\alpha}-wH\right)-qK\right\} \tag{4.3}$$

where $\tau^{f}\in[0,1]$ is the company income tax rate. The firm pays tax on a portion of its income denoted by its revenue minus wages.

4.2.4 Fiscal policy

Government revenues. The government finances its fiscal programs by collecting tax revenue via a personal income tax $t\left(y_{j}\right)$, a tax on consumption at the rate $\tau^{c}\in[0,1]$ and a company income tax at the rate $\tau^{f}\in[0,1]$ (explained in the previous sections).

The government levies a progressive income tax on market incomey_{j} that includes both labor income and capital income. We approximate the Australian personal income tax code using the following parametric tax function.

$$t\left(y_{j}\right)=\max\left(0,y_{j}-\lambda y_{j}^{1-\tau}\right) \tag{4.4}$$

The parametric tax function is commonly used in dynamic general equilibrium tax literature such as Benabou (2002), Heathcote, Storesletten and Violante (2017*a*) and Guner, Lopez-Daneri and Ventura (2016). The parameter τ determines the curvature of the tax function and thus, the degree of progressivity of the tax code. The parameter λ determines the average level of income taxation in the economy. We explain the tax function in greater detail in Section 4.3.5.

Total government revenue is given by

$$Tax=\sum_{j}t\left(y_{j}\right)\mu\left(\chi_{j}\right)+\sum_{j}t\left(c_{j}\right)\mu\left(\chi_{j}\right)+\tau^{f}\left(AK^{\alpha}H^{1-\alpha}-wH\right) \tag{4.5}$$

where $\mu\left(\chi_{j}\right)$ is the measure of agents in state χ_{j}.

Public pension. One of the key features of the Australian social security system is the means-tested pension system which targets households with low income and assets during old-age. The system is not universal and is funded via general government revenues. Households are eligible for pension upon reaching the age threshold j^P.

The amount of pension benefit $\mathscr{P}\left(a_j, y_j\right)$ is given by

$$\mathscr{P}\left(a_j, y_j\right) = \begin{cases} \min\left\{\mathscr{P}^a\left(a_j\right), \mathscr{P}^y\left(y_j\right)\right\} & \text{if } j \geq j^P \\ 0 & \text{otherwise} \end{cases} \tag{4.6}$$

such that

$$\mathscr{P}^a\left(a_j\right) = \begin{cases} p^{\max} & \text{if } a_j \leq \bar{a}_1 \\ p^{\max} - \omega_a\left(a_j - \bar{a}_1\right) & \text{if } \bar{a}_1 < a_j < \bar{a}_2 \\ 0 & \text{if } a_j \geq \bar{a}_2 \end{cases} \tag{4.7}$$

where $\bar{a}_1$ and $\bar{a}_2 = \bar{a}_1 + p^{\max}/\omega_a$ are the asset thresholds and ω_a is the asset taper rate.

and

$$\mathscr{P}^y\left(y_j\right) = \begin{cases} p^{\max} & \text{if } y_j \leq \bar{y}_1 \\ p^{\max} - \omega_y\left(y_j - \bar{y}_1\right) & \text{if } \bar{y}_1 < y_j < \bar{y}_2 \\ 0 & \text{if } y_j \geq \bar{y}_2 \end{cases} \tag{4.8}$$

where $\bar{y}_1$ and $\bar{y}_2 = \bar{y}_1 + p^{\max}/\omega_y$ are the income thresholds and ω_y is the income taper rate.

Other public transfers. In addition to the pension system, we approximate all other public transfers to households in order to closely reflect the breadth of the social welfare system in Australia. Other public transfers are given by $st_j\left(\rho, \eta_j, j\right)$ such that they are dependent on skill type, level of stochastic shock η_j and evolves over age j. This closely approximates the progressive nature of the transfer system, as well as changes in the level of transfers by the age of households.

Government budget constraint. In addition to the social welfare system explained above, the government also spends an amount G on general government purchases. Total government expenditure is financed by tax revenues and the issue of new debt which incurs interest payments rD. In steady state, the level of public debt is constant and the government budget constraint is given by

$$Tax = \sum_{j} \mathscr{P}\left(a_j, y_j\right) \mu\left(\chi_j\right) + \sum_{j} st_j\left(\rho, \eta_j, j\right) \mu\left(\chi_j\right) + G + rD \tag{4.9}$$

The government has an additional role in distributing bequests (both accidental and intentional) from dead agents to those alive. Bequests are distributed equally across all surviving households.

4.2.5 Market structure

The Australian economy fits the description of a small open economy better than a closed economy. Thus, we assume that the domestic capital market is fully integrated with the world capital market. Hence, under free inflows and outflows of capital, the domestic interest rate r is exogenously set by the world interest rate r^w. Labor is internationally immobile so that there is no migration. The wage rate w adjusts to clear the labor market in equilibrium.

Markets are incomplete such that households cannot insure against idiosyncratic wage risk and mortality risk by trading state contingent assets. In addition, they are not allowed to borrow against future income, such that asset holdings are non-negative.

4.2.6 Equilibrium

Given the government policy settings for the tax system and the pension system, the population growth rate, world interest rate, a steady state competitive equilibrium is such that:

(i) a collection of individual household decisions $\left\{c_j\left(\chi_j\right), l_j\left(\chi_j\right), a_{j+1}\left(\chi_j\right)\right\}_{j=1}^{J}$ solve the household problem given by equation (4.2);

(ii) the firm chooses effective labor and capital inputs to solve the profit maximization problem in equation (4.3);

(iii) the total lump-sum bequest transfer is equal to the total amount of assets left by all the deceased agents

$$B = \sum_{j \in j} \frac{\mu_{j-1}\left(1-\psi_j\right)}{(1+n)} \int a_j\left(\chi_j\right) d\Lambda_j\left(\chi_j\right) \tag{4.10}$$

(iv) the current account is balanced and foreign assets A_f freely adjust so that $r = r^w$, where r^w is the world interest rate;

(v) the domestic market for capital and labor clear

$$K = \sum_{j \in j} \mu_j \int a_j (\chi_j) \, d\Lambda_j (\chi_j) + B + A_f \tag{4.11}$$

$$H = \sum_{j \in j} \mu_j \int (1 - l_j) \, e_j (\chi_j) \, d\Lambda_j (\chi_j) \tag{4.12}$$

and factor prices are determined competitively such that $w = (1 - \alpha) \frac{Y}{H}$, $q = \alpha \frac{Y}{K}$ and $r = q - \delta$;

(vi) the government budget constraint defined in equation (4.9) is satisfied.

4.3 Mapping the model to data

We map the steady state equilibrium to reflect key statistics for the Australian economy for $2012 - 2016$. We chose 2012 to begin our analysis to eliminate any temporary shocks to economic activity and resultant fiscal shocks due to the Global Financial Crisis. 2016 is the last year for which complete data on all key statistics were available. We present values for parameters that were determined by standard and their respective sources or benchmark targets in Table 4.2.

4.3.1 Demographics

One model period lasts 5 years. Households become economically active at age 20, ($j = 1$). They are eligible for age-pension at age 65 ($j = 10$). Household survival probability becomes zero (die with certainty) at age 90. We set the population growth rate to $n = 1.5\%$. We use Life Tables for the period from the Australian Bureau of Statistics to determine survival probabilities ψ_j.

Table 4.2: Key parameters, targets and data sources

Parameter	Value	Source/Target
Demographics		
Population growth rate	$n = 1.5\%$	WDI
Survival probabilities	ψ_j	Australian Life Tables (ABS)
Technology and market structure		
Capital share of output	$\alpha = 0.4$	Tran and Woodland (2014)
GDP per capita growth rate	$g = 1.3\%$	WDI
Depreciation	$\delta = 0.055$	Tran and Woodland (2014)
Total factor productivity	$A = 1$	(scaling parameter)
Interest rates	$r = r^w = 1.01\%$	Investment share of GDP
Preferences		
Frisch elasticity of labor	$\gamma = 2$	Freestone (2020) estimates for Aust.
Disutility of work	$\varphi = 10$	Labor hours over life cycle
Discount factor	$\beta = 0.99$	Household savings share of GDP
Strength of bequest motive	$\phi_1 = -9.5$	Asset profiles over life cycle
Extent to which bequest is a luxury	$\phi_2 = 12$	
Adjustment for children's consumption	$\zeta = 0.6$	Nishiyama and Smetters (2007)
Fiscal policy		
Consumption tax rate	$\tau^c = 7\%$	Consumption tax share of GDP
Income tax scale	$\lambda = 0.5509$	Average tax rates by taxable income
Income tax curvature (progressivity)	$\tau^y = 0.15$	
Company profits tax rate	$\tau^f = 11\%$	Company tax share of GDP and investment/GDP ratio.
Pension income test taper rate	$\omega^y = 0.5$	Official taper rate
Pension asset test taper rate	$\omega^a = 0.0015$	
Maximum pension	p^{max}	Pension share of GDP
Pension thresholds	y_1, a_1	Pension participation rates
General government purchases	$G = Y \times 20\%$	WDI
Public debt	$D = Y \times 20\%$	
Other public transfers	$ST = Y \times 6.4\%$	OECD-SOCX

WDI: World Development Indicators, ABS: Australian Bureau of Statistics, OECD-SOCX: Social expenditure database of the OECD.

4.3.2 Technology and market structure

Production in the economy is characterized by the Cobb-Douglas function $AK^{\alpha}H^{1-\alpha}$. We follow Tran and Woodland (2014) and set the capital share of output $\alpha = 0.4$, the parameter $A = 1$ and the depreciation rate of physical capital $\delta = 0.055$. GDP per capita growth rate g

is set at 1.3% which is the average rate for Australia during the period, taken from the World Development Indicators database of the World Bank.

Under our small open economy assumption, we take the world interest rate on bonds as given and assume the world (and domestic) interest rate is $r = 4\%$.

4.3.3 Labor productivity

We estimate labor productivity using data drawn from the Household, Income and Labour Dynamics in Australia (HILDA) longitudinal survey for the years 2001-2018. The deterministic component of labor productivity is estimated separately for each skill type by regressing the log of hourly wages by age while controlling for time fixed effects. The labor productivity profiles for the lower and higher skill types are shifted up and down using shift parameters to approximately replicate the distribution of taxable income in Australia.

The stochastic shock to labor productivity for each skill type is determined by splitting hourly wage by each age into quintiles. We follow Tran and Woodland (2014) in estimating the Markov transition matrix that characterizes the dynamics of productivity over the life cycle. In that, we estimate the proportion of individuals who remain in a quintile at each age and the proportion who moves to another quintile. To make the transition matrix more persistent, we use the average of estimates between 2001 and 2018. We assume that labor productivity declines at a constant rate, reaching zero at 80 years. We also assume that the Markov transition matrix is age invariant after 65 years.

4.3.4 Preferences

We assume that the period utility function is given by

$$U(c,l) = \log(c) - \varphi \frac{(1-l)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} \tag{4.13}$$

where φ controls the intensity of preferences for labor versus consumption and $\gamma \geq 0$ governs the Frisch elasticity and inter temporal elasticity of labor supply. We calibrate φ to match average work hours and set $\gamma = 2$ based on labor supply elasticity estimates using HILDA data by Freestone (2020). In order to match consumption profiles by life cycle and skill, we weight consumption by the factor $\left(1+dp_{j,\rho}\right)^{\xi}$, where $dp_{j,\rho}$ is the number of dependent children at age j for skill type ρ and η is the demographic adjustment parameter for consumption. We estimate the average number of children of ages 0-19 in each age group and skill type using HILDA and set $\xi = 0.6$ following Nishiyama and Smetters (2007).

We incorporate utility from bequeathing as per De Nardi, French and Jones (2010) to match consumption and savings in old-age. This is specified by

$$\phi\left(b\right) = \phi_1 \left(1 + \frac{a_{j+1}}{\phi_2}\right)^{1-\sigma} \tag{4.14}$$

where the term ϕ_1 reflects the concern about leaving bequests, while ϕ_2 measures the extent to which bequests are a luxury good. The values of the parameters that most closely match savings after the age of 80 are $\phi_1 = -9.5$ and $\phi_2 = 12$.

4.3.5 Fiscal policy

We base our policy settings and their parameter values for the period between 2012-2016 to calibrate the fiscal policy in the benchmark model.

Income tax. As explained in Section 4.2.4, we approximate the Australian income tax code using a parametric tax function. Let y be taxable income, $t\left(y\right)$ be the total tax liability, $\bar{t}\left(y\right)$ and $t^{'}\left(y\right)$ respectively be the average and marginal tax rates at income level y. In Australia, both capital and labor incomes are taxed together under the same code. Hence taxable income $y = wh + ra$. We also restrict $t\left(y\right)$ to be a pure tax function such that there are no net receivers from the income tax system[4].

The parametric function has the form

$$t\left(y\right) = \max\left[0, y - \lambda y^{1-\tau}\right] \tag{4.15}$$

[4]This is a significant departure from papers exploring the Laffer curve for labor income tax in the US using this parameteric tax function.

$$\bar{t}(y) = \max\left[0, 1 - \lambda y^{-\tau}\right] \tag{4.16}$$

$$t^{'}(y) = \max\left[0, 1 - (1-\tau)\lambda y^{-\tau}\right] \tag{4.17}$$

where $\tau \in [0,1]$ is commonly known as the curvature parameter and λ is a shift parameter. $\tau \geq 0$ determines the curvature (progressivity) of the tax function at any given level of λ. When $\tau = 0$, the tax code is proportional. The higher the value of τ, the more progressive is the income tax code. A tax code with $\tau = 1$ implies one with a lump-sum tax of λ. The parameter λ controls the level of the average tax rate and thus captures the need for revenue at any given level of τ. A higher λ implies a lower level of average tax and vice-versa.

Given the non-negativity constraint on $t(y)$, we can determine the tax-free threshold y^f below which there is no income tax as

$$y^f = \lambda^{\frac{1}{\tau}} \tag{4.18}$$

an increase in τ at any given level of λ decreases the tax-free threshold. When $\tau = 0$, there is no tax-free threshold and the tax code is proportional in its truest sense. An increase in λ at any given $\tau \in (0,1)$ increases the tax-free threshold.

We calibrate the parameters of the function to approximate the tax-free threshold and average tax rates by income level during the period. We set the tax level parameter $\lambda = 4.45$[5] and the curvature parameter $\tau = 0.15$ such that the tax-free threshold is around \$21,000.

In order to ensure that our tax function is a suitable approximation, in addition to matching the tax code, we also calibrate the parameters to match the distribution of tax liabilities and the Suits (1977) index which calculates the concentration of tax liability relative to the distribution of taxable income.

Consumption tax and company income tax. The consumption and company income tax rates during the period were 10% and 30% respectively. However, we adjust these statutory

[5]This corresponds to $\lambda = 0.45$ in the model. See Appendix on model scaling for details.

rates in our benchmark model to match the actual tax revenue to GDP ratios. In the case of company income tax, we also target the net investment to GDP ratio. This results in a slightly lower consumption tax rate of 7% and a significantly lower company income tax rate of 11%. A lower consumption tax rate is justified by the fact that a large number of consumption goods are tax exempt. In the case of the company income tax, it is important to note that our model only includes a single representative firm. The lower tax rate on companies reflect the significant number of small and medium enterprises in the economy who would be tax exempt.

Means-tested age pension. The income test taper rate is set at $\omega_y = 0.5$ which reflect the reduction in pension by 50 cents for every $1 above the low income threshold $\bar{y}_1$. Similarly, we set the asset test taper rate $\omega_a = 0.0015$ for every $1,000 above the low asset threshold $\bar{a}_1$. Below these thresholds, households obtain the maximum pension denoted by $p^{\max}$. We calibrate $p^{\max}$ and the thresholds $\bar{y}_1$and $\bar{a}_1$to match pension participation rates over the life cycle and the public pension to GDP ratio.

Other public transfers. We lump all public transfers other than pension such as family benefits, disability support pension and unemployment benefits in to $st\left(\rho,\eta_j,j\right)$. We estimate the share of other public transfers by skill type ρ, shock level η_j and age j using HILDA data and set the total amount of public transfers to match its share of GDP.

General government expenditure and debt. We define government expenditure other than public transfers and age-pension as general government expenditure G. We target government expenditure between 10-20% of GDP to reflect the average of these expenses over the benchmark period. Similarly, public debt is set at 10-20% of GDP which reflects the average net public debt share of GDP during the period. Both these aggregates are increased or decreased within this range during our calibration in order to adjust for tax revenue shares of GDP.

4.3.6 The benchmark economy

Prior to turning to our experiments, we examine our benchmark economy to highlight its strengths and shortcomings when it comes to approximating the Australian economy. We dis-

Table 4.3: Key variables in the benchmark economy

Variable	Model	Data
Investment	18.94	26.51
Consumption	52.91	56.30
General government expenditure	11.00	18.05
Age-pension	2.29	2.54
Public transfers other than age-pension	6.62	6.42
Government debt	16.00	18.85
Personal income tax	15.72	9.77
Consumption tax	3.70	3.29
Company income tax	4.40	4.25

Note: All variables are expressed in terms of percentage of GDP. Data are averages of annual variables from 2012-2016 taken from the International Monetary Fund, World Economic Outlook Database, October 2020 and the World Development Indicators.

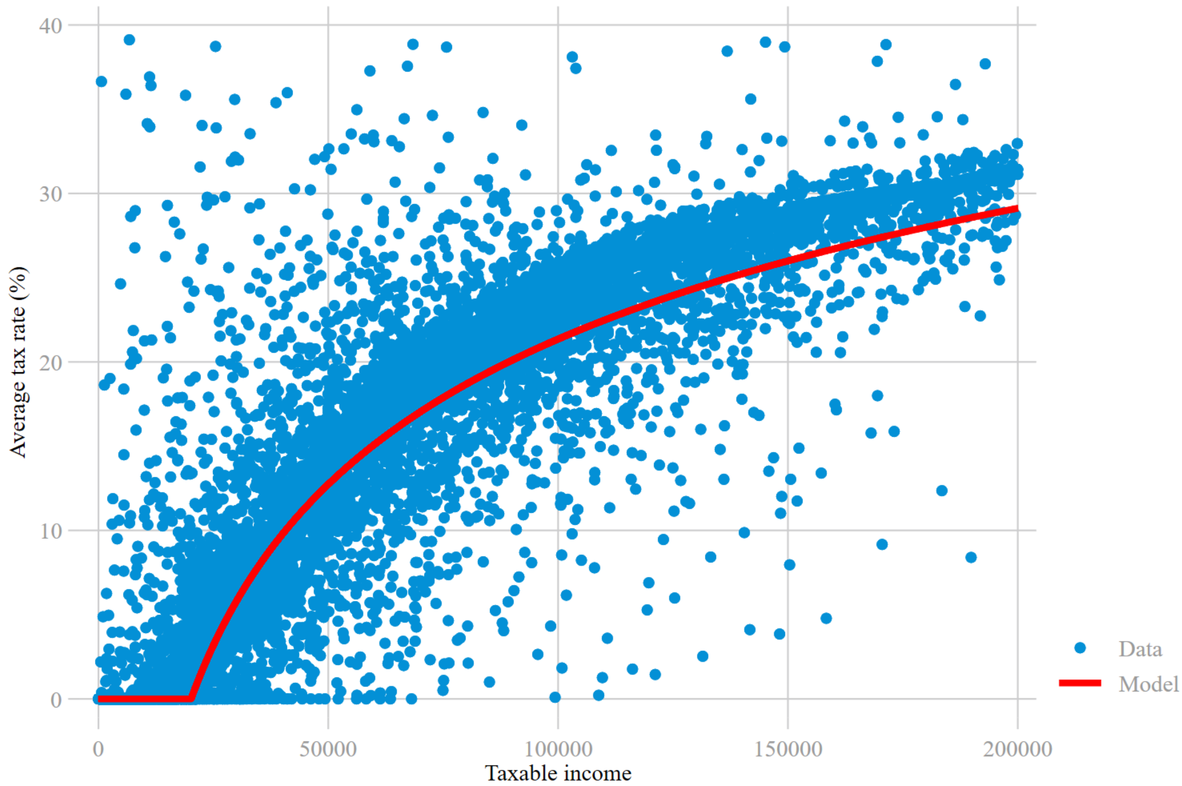
cuss the aggregate statistics and distributional properties of our benchmark economy in comparison with the data for 2012-2016.

Macroeconomic aggregates. Table 4.3 compares key macroeconomic aggregates generated by the model with the data. The main source of tax revenue in both the model and data is personal income tax. However, the income tax share of GDP is higher in the model compared to data. The model is able to approximate investment and consumption shares of GDP relatively close to the averages for 2012-2016. As mentioned earlier, both consumption and company income tax is calibrated to match their respective shares in the data.

Income tax function. Figure 4.1 shows a scatter plot of average tax rates by taxable income obtained from HILDA for the period together with the average tax function plotted with the benchmark parameter values. Apart from dropping observations where the average tax rate exceeds 40% the data is used in its raw form. This is to illustrate the complexities in the tax code in the real data that needs to be fairly approximated in our model.

Income and tax distribution. The parameters in the tax function as well as the labor productivity profiles are calibrated to match the distribution of taxable income and tax liabilities. Table 4.4 shows that our model closely approximates the cross-sectional distribution of taxable income and tax liabilities, as well as generate a tax code that reflects actual data. Our model generates a Suits index that is equal to the average Suits index for the period. Moreover, we

Figure 4.1: Average tax rates (data versus model)



are able to get close to income shares, tax shares and average tax rates at the top of the income distribution. However, one limitation of our model is that income shares are slightly higher at the bottom compared to data.

4.4 Quantitative analysis

In this section we describe our computational experiments and define key concepts that are crucial for our analysis.

Experiments on alternative income tax codes. Our experiments involve examining changes to the personal income tax code, comparing the behavioral responses and the resultant changes to the tax base and tax revenue relative to our benchmark model.

To change the income tax code, we change the value of the two parameters of our tax function, λ and τ. As explained in Section 4.3.5, τ determines the curvature of the tax function.

Table 4.4: Distribution of taxable income and tax liability (model and data)

	Income share		Tax share		ATR	
	Model	Data	Model	Data	Model	Data
Quintile 1	0.46	0.00	0.00	0.00	0.00	0.00
Quintile 2	2.56	0.01	0.00	0.00	0.00	0.00
Quintile 3	6.71	6.73	1.43	0.73	4.07	0.65
Quintile 4	26.37	26.84	21.11	17.00	17.27	12.50
Quintile 5	63.90	66.42	77.46	82.26	27.01	24.19
Top 1%	9.35	10.98	13.06	19.06	32.02	37.86
Gini coefficient	0.6	0.69				
Suits index			0.23	0.23		

Note: Data are averages from HILDA for 2012-2016. Taxable income is expressed as the share of total taxable income by each quantile. Tax liability is the share of total income tax by quantile. ATR denotes the average tax rate, averaged within each quantile.

Throughout the paper we refer to τ as the curvature parameter[6]. The parameter λ shifts the tax function upwards, or downwards such that $1-\lambda$ measures the average level of taxation in the economy. For the sake of brevity, we refer to $1-\lambda$ as the "tax level".

Our experiments are as follows:

Experiment 1 We begin by keeping the tax level fixed at our benchmark by holding $1-\lambda$ constant at 0.45 and changing the curvature of the tax function by varying τ. A decrease in τ in this manner results in a clockwise pivot of the tax function, decreasing the tax-free threshold and increasing the average tax rate at the bottom of the income scale. An increase in τ results in the reverse.

Experiment 2 Next we investigate the effect of changing the tax level $1-\lambda$ while holding the curvature constant at the benchmark $\tau = 0.15$. An increase in the tax level $1-\lambda$ results in a shift of the tax function upwards. Small shifts preserve the curvature while at very high tax levels, the tax function becomes relatively flat regardless of the level of τ. The fact that changing λ even while holding τ constant affects progressivity of the tax function is an important point that is often overlooked in literature.

Experiment 3 We finally search for the revenue maximizing tax code by varying both λ and τ.

[6] τ is commonly known as the progressivity parameter. But for $\tau > 0$, it only measures the progressivity at a specific point on the income scale. However, a decrease in τ at any given λ leads to a less progressive tax function such that $\tau = 0$ implies a proportional (flat) income tax code.

We illustrate the tax functions in each of our experiments before their respective results in Section 4.5. In all our main experiments, we balance the budget by adjusting general government expenditure[7] G.

Laffer curve. We rely on the Laffer curve approach to compare the tax revenue generated from alternative income tax codes. Typically, Laffer curves yield an increase in tax revenue as tax rates initially increase. However, higher tax rates impose a disincentive for households to work and save. This implies a fiscal limit to raising tax revenues and is manifest in the peak of the Laffer curve beyond which further increases in tax rates result in decreasing tax revenues. Since our income tax code is non-linear, rather than constructing Laffer curves for tax rates, we construct them for different values of our two parameters. In each of our experiments, we determine the maximum tax revenue level $R^{\max}$ at the peak of the Laffer curve.

4.5 Fiscal limits of income tax

In this section, we explain the results of our computational experiments described in Section 4.4. For each experiment, we first illustrate the changes in tax code and then explain the behavioral responses that result from the changes. Next, we show the effects on aggregate economic activity followed by the main results on the Laffer curve and maximum income tax revenue. We focus on total tax revenue and fiscal space in Section 4.6.

4.5.1 Experiment 1: Change in τ at benchmark λ

Changes to the tax code. Figures 4.2(a) and (b) show the effect of changing τ at benchmark λ on marginal and average tax rates. As explained in Section 4.3.5, an increase in τ makes the tax function steeper, while a decrease makes it flatter.

It is important to note the way in which the tax function becomes less progressive when τ decreases while λ is constant. A reduction in τ in this manner leads to a rise in average tax rates at the bottom while the top remains relatively unchanged (around 45% at $1,000,000). In fact, when $\tau = 0$, the average tax rate for across all income levels becomes 45%. A reduction

[7] We examine alternative policy tools to balance the budget in our sensitivity checks described in Section 4.8.

in τ leads to completely different effects on the marginal tax rate for those on either side of \$350,000. For those below \$350,000 marginal tax rates increase as τ decreases and for those above this threshold, marginal tax rates increase.

Behavioral responses. The changes to the tax code depicted in Figure 4.2 imply significantly different incentives to work and save for households with different earnings abilities. Those with low earnings ability face significantly high average tax rates and marginal tax rates as τ decreases. Thus, negative incentive effects would outweigh any positive effects of a flatter tax code. In contrast, those with high earnings ability who are likely to be on the higher end of the income scale do not experience a large increase in average tax rates. In addition, the marginal tax rates that they face as their income increases are lower as τ decreases.

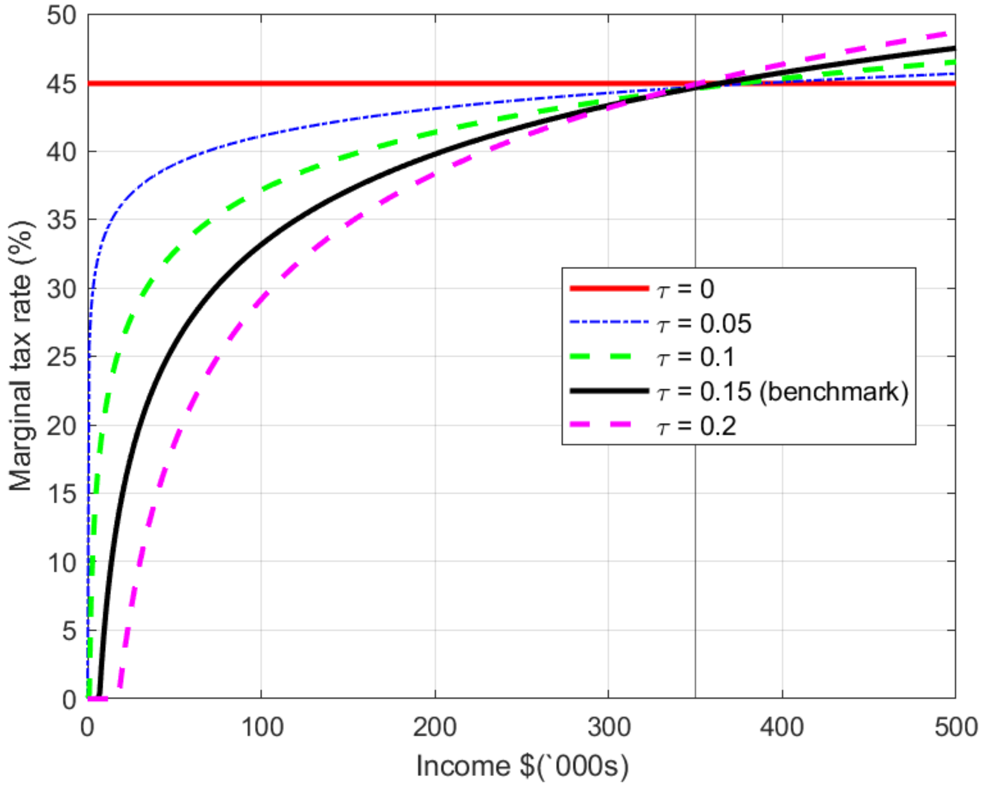
Figure 4.3(a) shows the change in labor hours by skill type as τ changes relative to the benchmark. Except for the lowest skill type, a flatter tax code results in a positive incentive effect on working. It is interesting to note that the medium skill type experiences the largest increase in labor hours. As they are likely to fall within the middle of the income scale, they are most affected by rising marginal tax rates that discourage them from increasing their hours. A flat tax code removes all distortions that results from rising marginal tax rates and encourages those with high earnings ability to work more.

Figure 4.3(b) shows the change in the supply of capital by skill types as τ changes. A flatter tax code has a negative effect on saving for all skill types. As our tax code taxes labor and capital incomes jointly, increasing average tax rates as τ decreases leads to two complementary effects. First, rising average tax rate on labor income results in a negative income effect on saving via lower after tax incomes for households. Second, higher average tax rates directly affect saving due to the negative substitution effect induced by a lower after-tax rate of return. The effect on savings is not uniform across skill types. Lower skill types face a sharper decline compared to higher skill types as they face a more significant increase in average tax rates.

Aggregate effects. Figure 4.4(a) show changes to aggregate labor hours, labor income and the wage rate as τ changes. Due to the small open economy assumption, wages remain constant. Overall, there is a positive effect on aggregate labor hours as τ decreases. As evident from

Figure 4.2: Tax functions with fixed λ at different τ

(a) Marginal tax rate



(b) Average tax rate

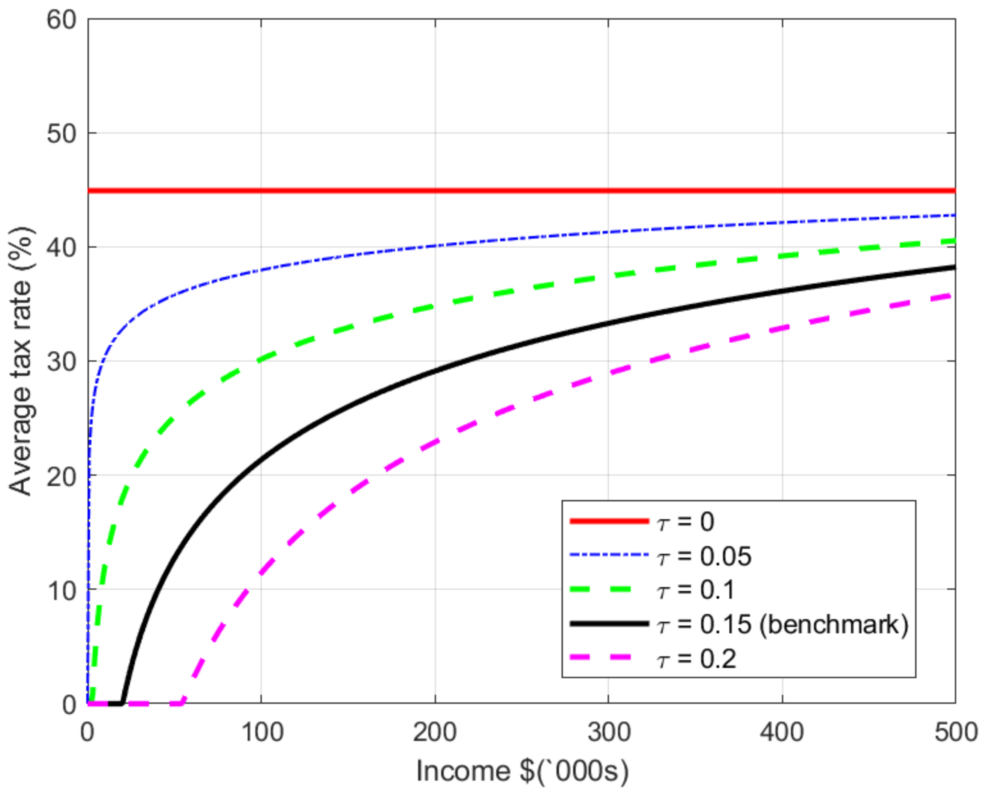
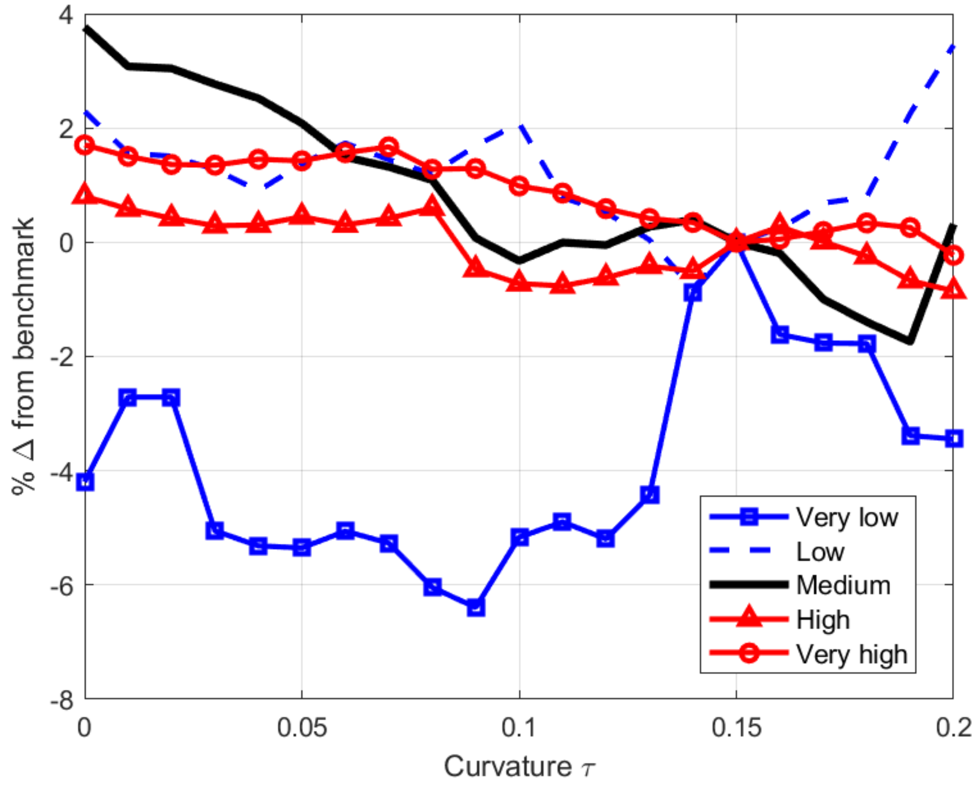


Figure 4.3: Labor and capital supply by skill type with fixed λ at different τ

(a) Labor hours by skill type



(b) Capital by skill type

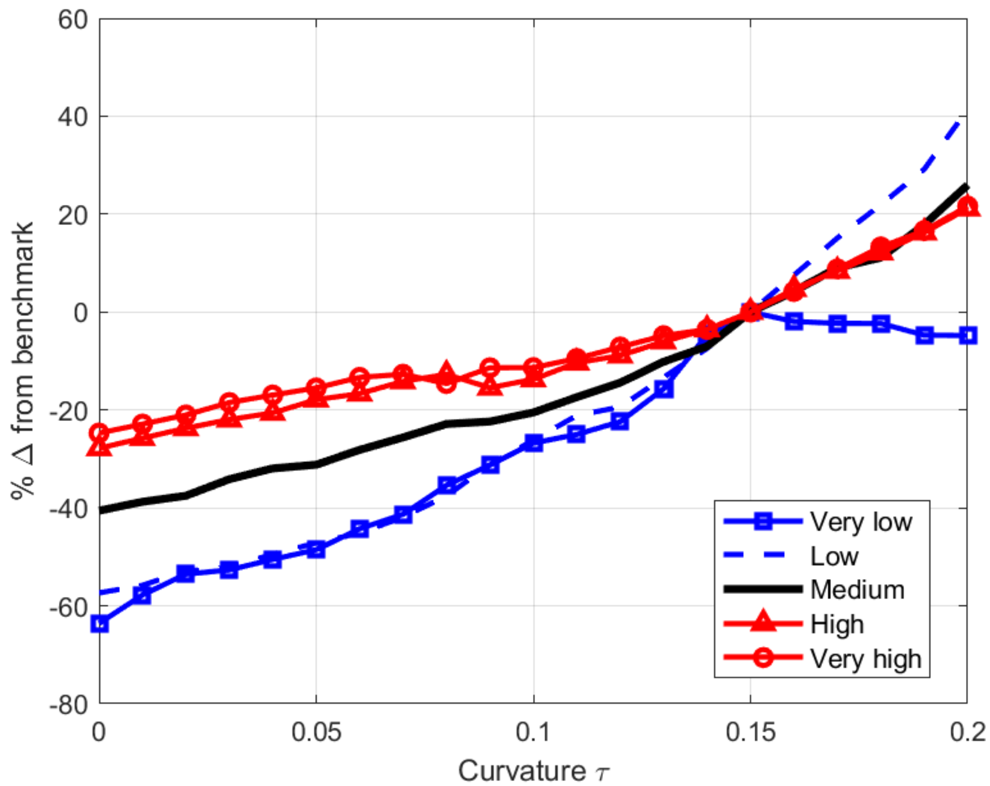


Figure 4.3(a), high skill types who earn higher incomes experience a larger increase in labor hours. This explains the increase in labor income to 5.5% of the benchmark level when τ decreases to 0.

There is a significant decline in capital as τ decreases as evident from Figure 4.4(b). However, perfect capital mobility ensures that the domestic interest rate remains constant. In addition, since higher skill types experience a smaller decline in their savings as shown in Figure 4.3(b). These two factors mitigate against a large decline in aggregate capital income.

Income tax revenue and tax base. As τ decreases to 0, aggregate labor income increase to 5.5% while capital income declines by 10%. Thus, overall, there is a slight decline in total taxable income. However, decreasing τ at constant λ leads to a decreasing tax free threshold until it becomes negligible around $\tau = 0.08$. As shown in Figure 4.5(b), this increases the tax base by close to 60%. As a result, we find that income tax revenue increases as τ decreases (Figure 4.5(a)). Revenue is maximized at $\tau = 0$ with a proportional income tax code where total income tax revenue is twice that of the benchmark level.

4.5.2 Experiment 2: Change in tax level $1-\lambda$ at benchmark τ

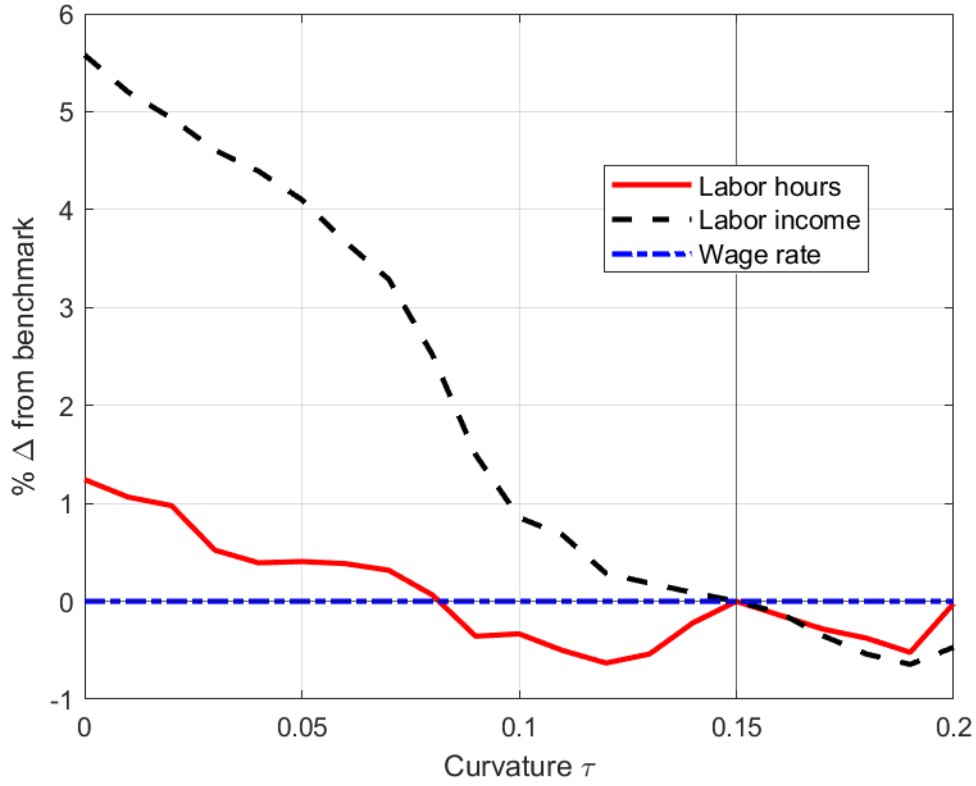
Changes to the tax code. Figure 4.6 illustrates these changes to λ at our benchmark $\tau = 0.15$. In all our graphs, we depict the average tax level by $1-\lambda$ as this directly translates into the average level of taxation. For instance, as Figure 4.6(a) shows, when $1-\lambda = 0.95$, the average tax rate is 95%.

An important point that is often overlooked in literature is that changing λ even while holding τ constant affects progressivity of the tax function. Small changes as seen from the move from 0.45 to 0.50 preserves the curvature as evident from Figures 4.6(a) and (b). However, as $1-\lambda$, increases, the tax function becomes less progressive. In fact, at $1-\lambda = 0.95$, the tax function is almost proportional with a negligible tax free threshold.

Behavioral responses. Although varying λ affects progressivity, the stark difference from varying τ is that an increase in $1-\lambda$ increases average tax rates quite uniformly across all levels of income. This uniformity is observed in the behavioral responses by the very low -

Figure 4.4: Aggregate labor and capital with fixed λ at different τ

(a) Aggregate labor



(b) Aggregate capital

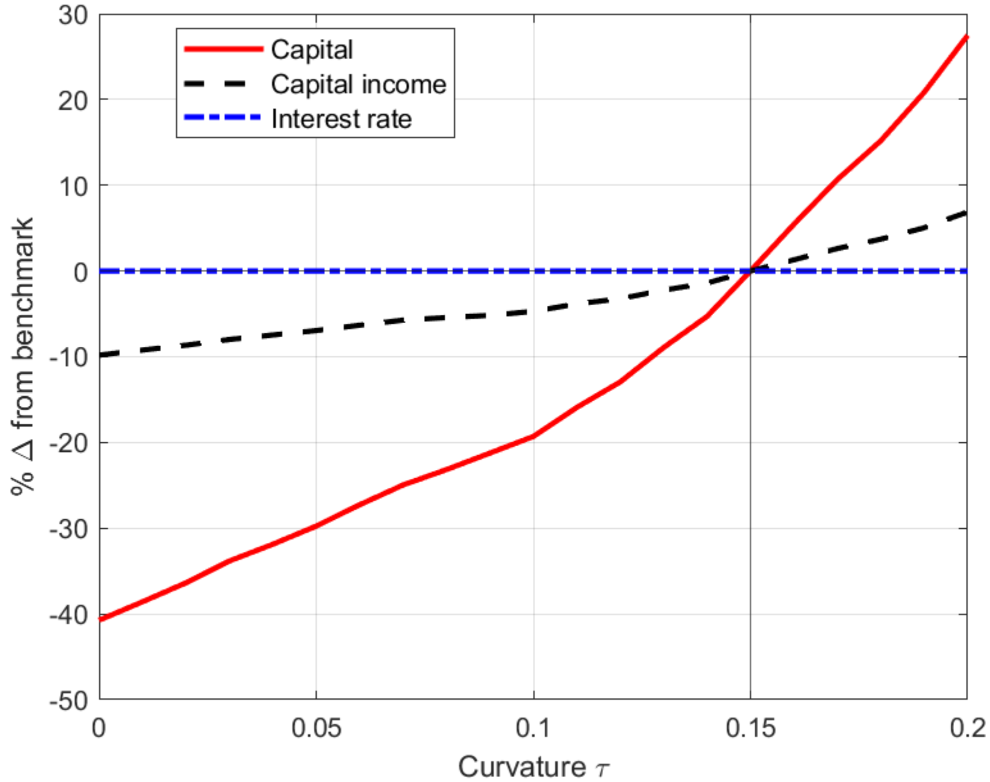
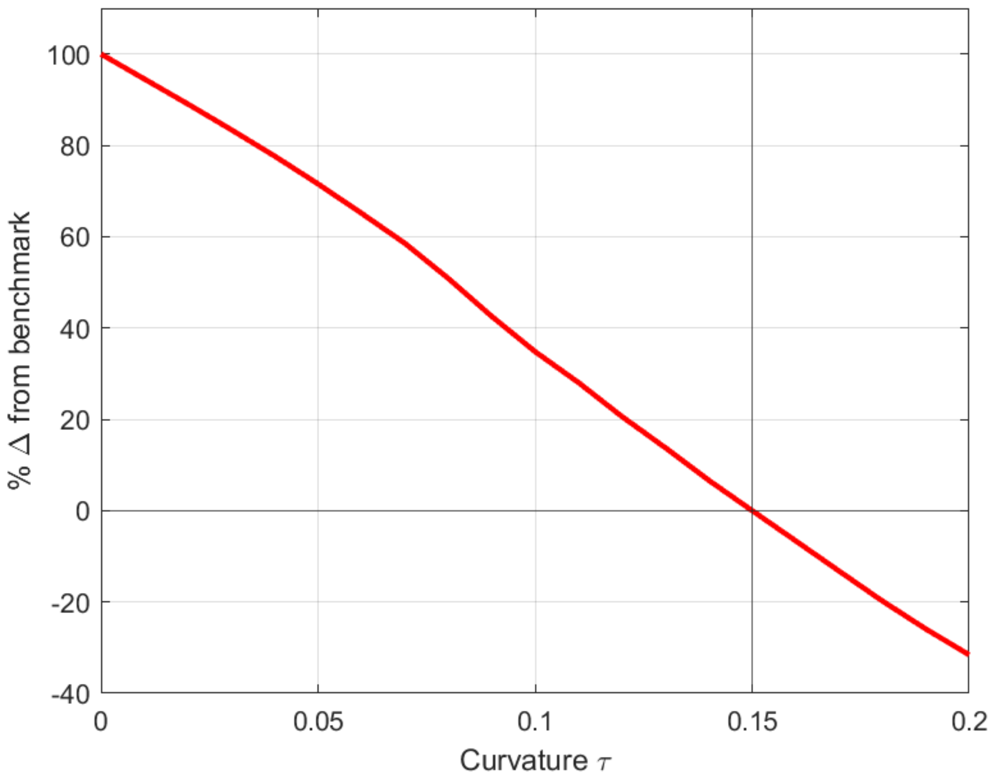


Figure 4.5: Income tax revenue and tax base with fixed λ at different τ

(a) Revenue



(b) Tax base

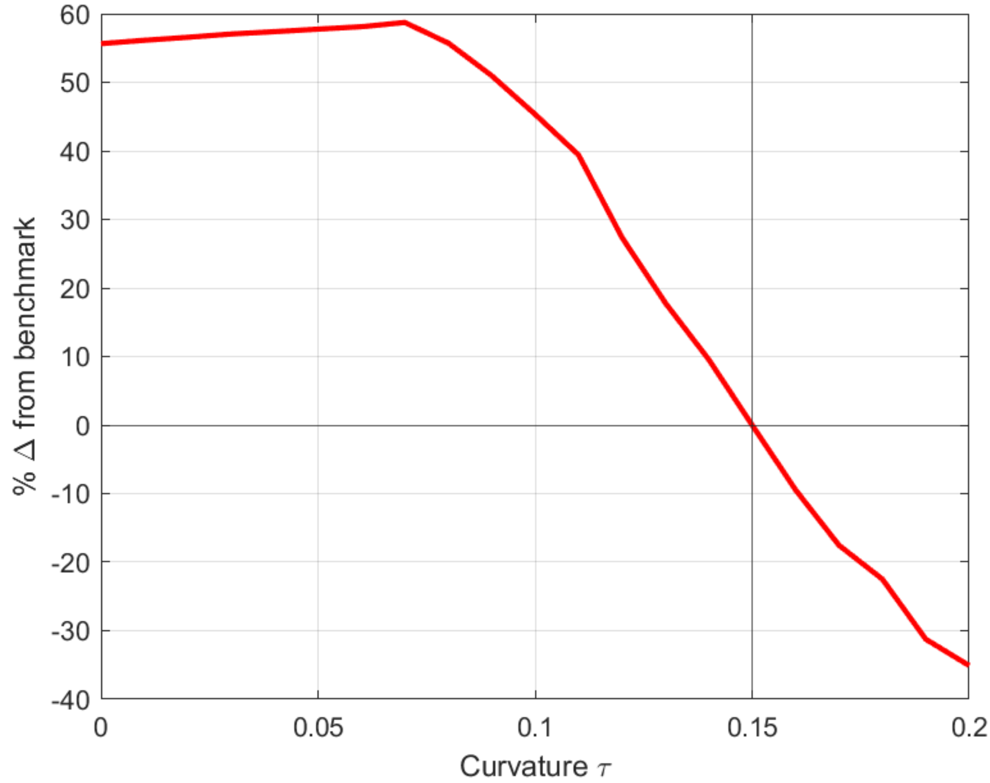
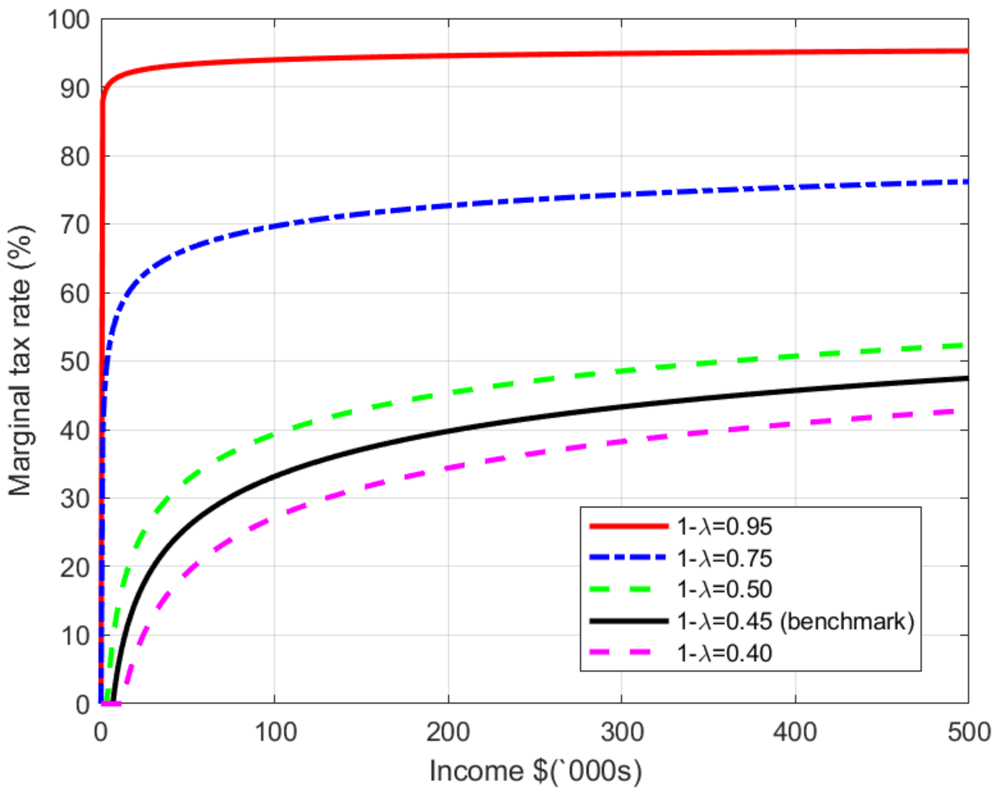
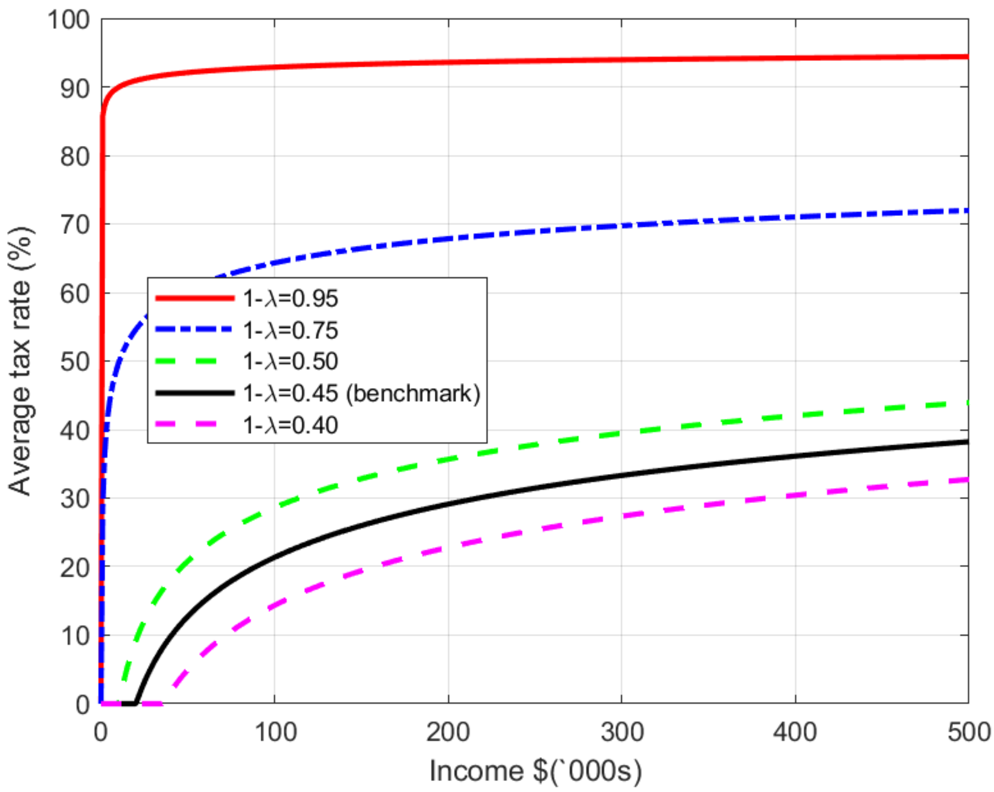


Figure 4.6: Tax functions with fixed τ at different λ

(a) Marginal tax rate



(b) Average tax rate



medium skill types in Figures 4.7(a) and (b) as $1-\lambda$ increases above the benchmark level (depicted by the vertical black line at $1-\lambda = 0.45$).

As evident from Figure 4.7(a), the decline in labor hours for the bottom 3 skill types below the tax rate of $1-\lambda = 0.70$ is fairly steady, but declines sharply afterwards. In contrast, labor supply elasticity with respect to λ is fairly constant for high skill types. The top two skill types experience a steady decline in labor hours starting at $1-\lambda = 0.20$ and do not face large decreases compared to the others even at very high tax levels.

Figure 4.7(b) plots the decline in savings by skill type. The elasticity of savings to the tax level is higher for higher skill types. However, savings for all skill types become less responsive to increases in the tax rate beyond $1-\lambda = 0.6$. The negative incentive effects at higher $1-\lambda$ arise mainly due to increasing average tax rates.

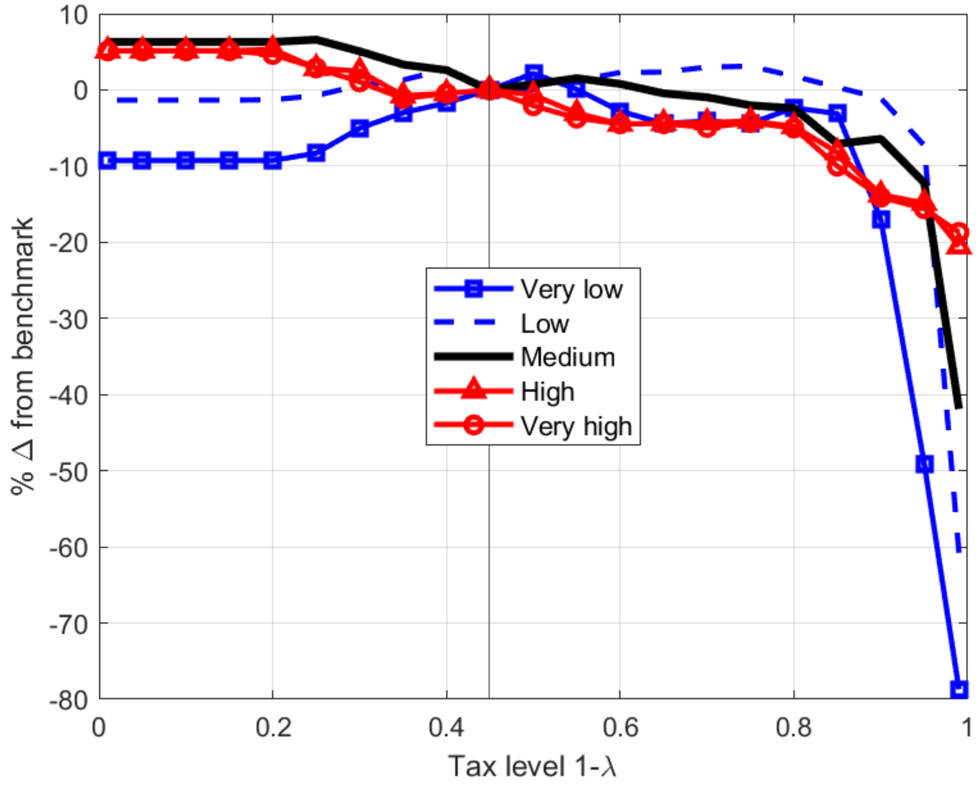
Aggregate effects. Figures 4.8(a) and (b) plot aggregate labor and capital and their respective incomes. Declines in aggregate capital and labor are mitigated by relatively inelastic responses by those with high earnings ability beyond the benchmark tax level as evident in Figures 4.7(a) and (b). This is also observed in the patterns in total labor and capital income in Figures 4.8(a) and (b). In fact, capital income only declines by a small amount and stabilizes around $1-\lambda =$ 0.7.

Income tax revenue and tax base. Figure 4.9(a) plots the percentage change in income tax revenue against the tax level. We find a slight kink around $1-\lambda = 0.95$ where income tax revenue is 190% higher than benchmark. The average tax rate across most income levels at this point is 95%. The positive relationship between the tax level and revenue and the peak at the very high tax level can be explained as follows.

Labor and capital supply is relatively inelastic at high tax rates for high skill types. This ensures that even at a tax rate of 95%, there is only around a 30% decline in total capital income and a 20% decline in labor income (total taxable income declines by 30%). Second, the decline in the tax free threshold (which becomes 0 around $1-\lambda = 0.55$) ensures that more households are taxed. This ensures the sharp increase in the tax base shown in Figure 4.9(b) which peaks at 0.75 around 55% of its benchmark.

Figure 4.7: Labor and capital supply by skill type with fixed τ at different $1-\lambda$

(a) Labor hours by skill type



(b) Capital by skill type

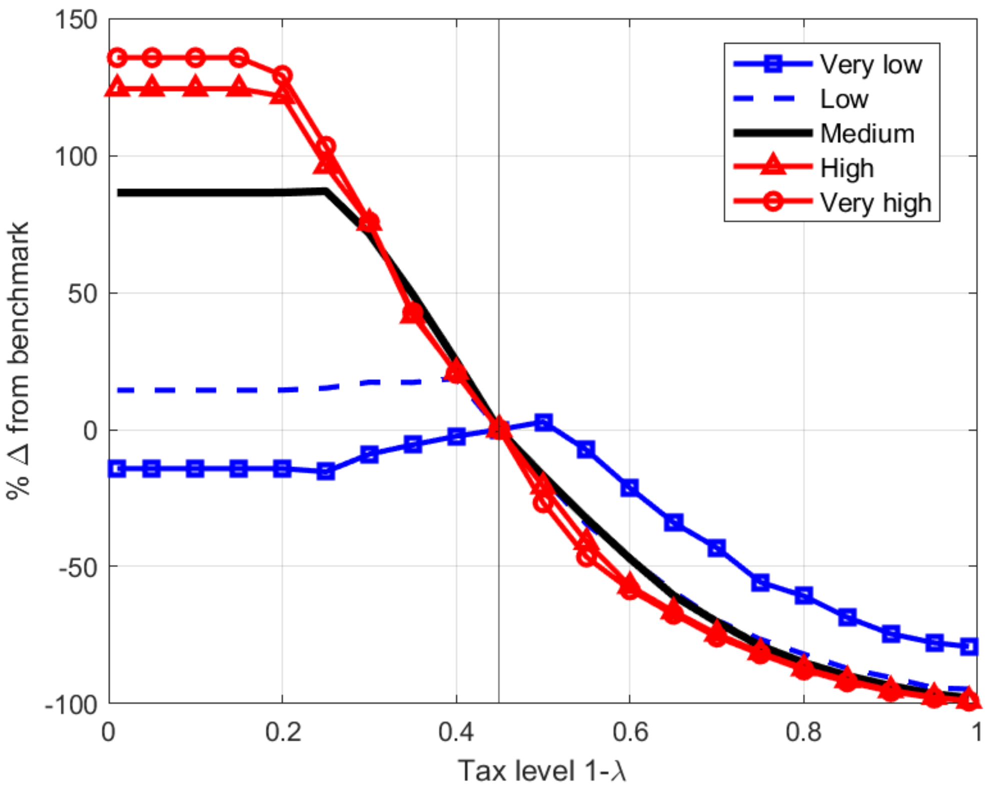
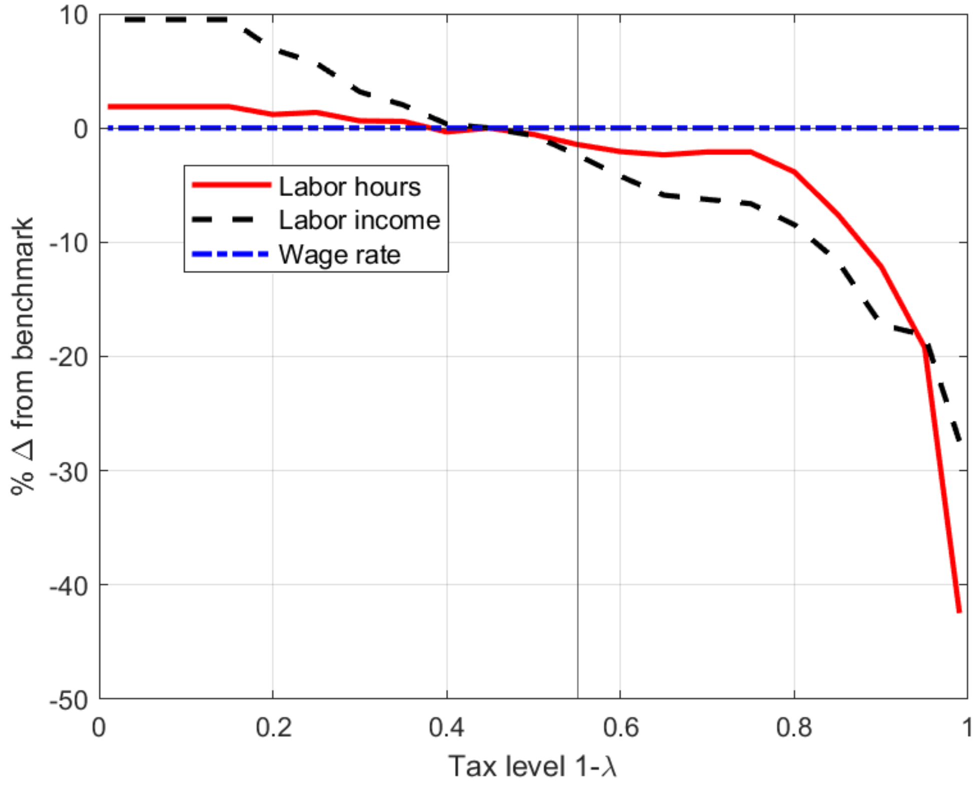


Figure 4.8: Aggregate labor and capital with fixed τ at different $1-\lambda$

(a) Aggregate labor



(b) Aggregate capital

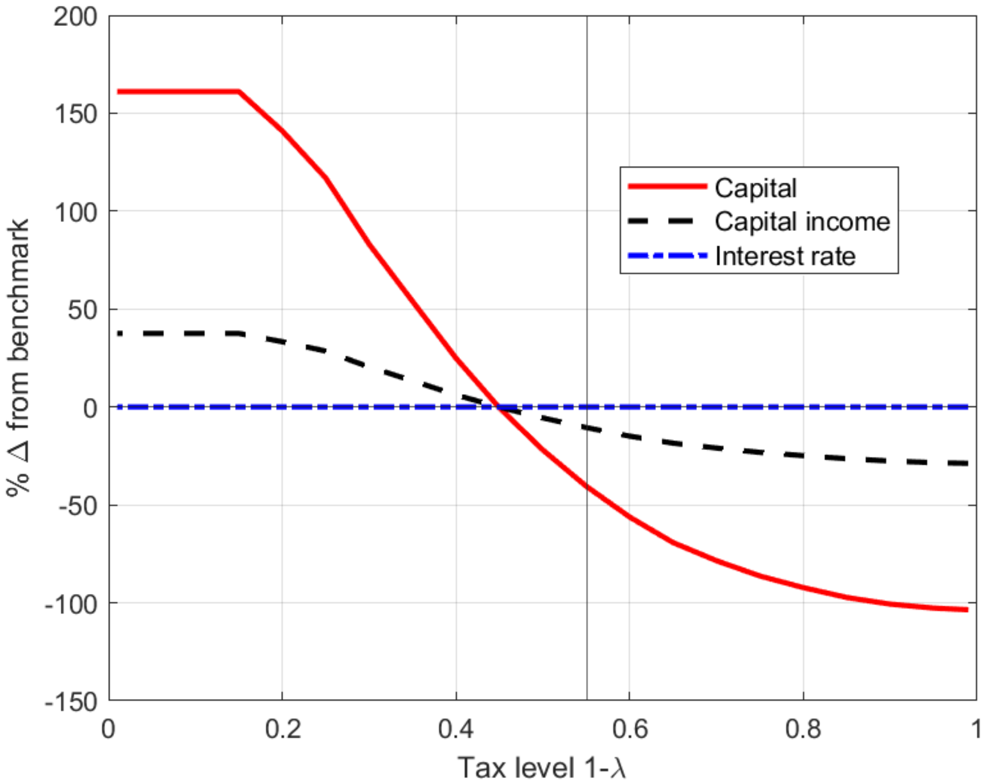
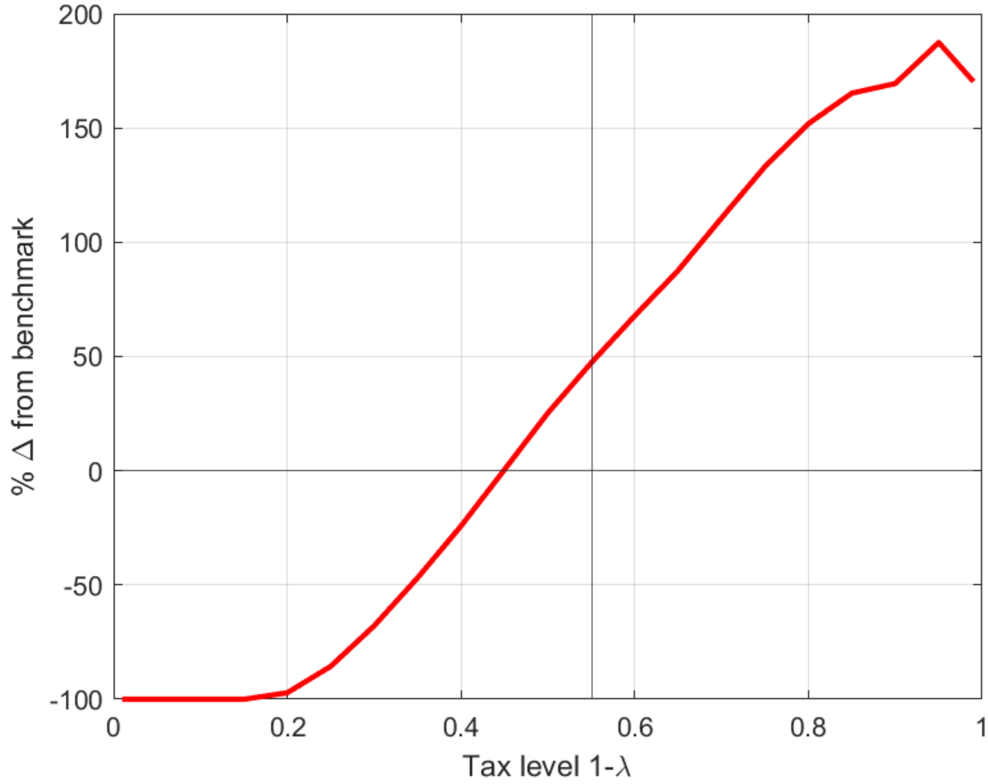
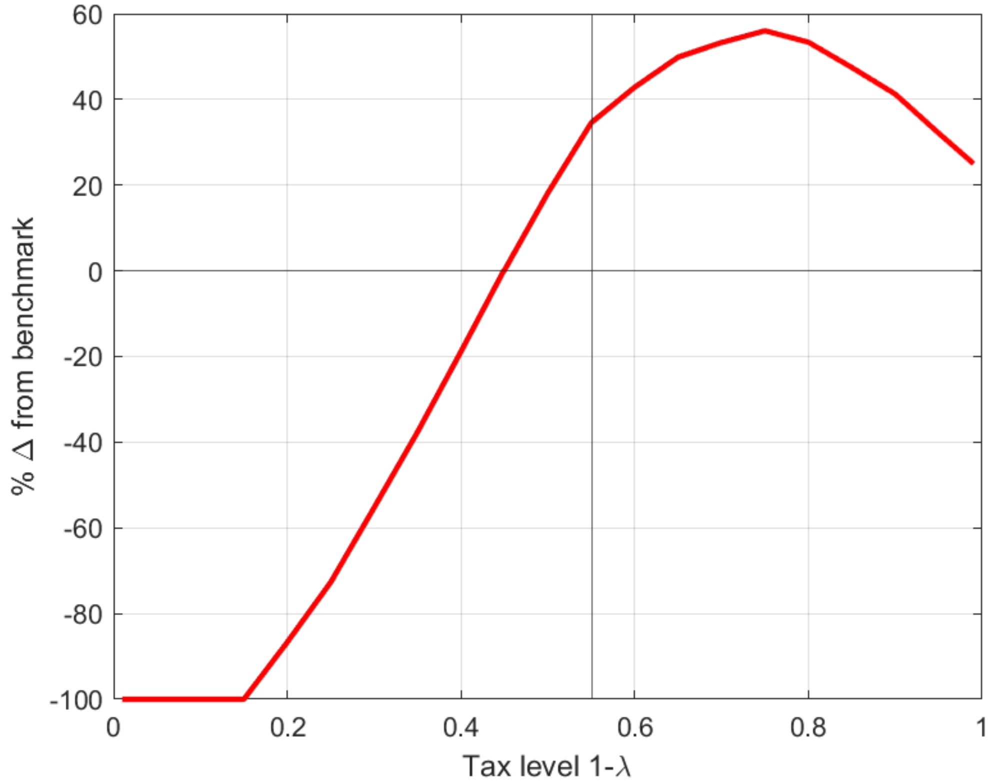


Figure 4.9: Income tax revenue and tax base with fixed τ at different $1-\lambda$

(a) Revenue



(b) Tax base



4.5.3 Experiment 3: The revenue maximizing τ and λ

At higher tax levels (higher $1-\lambda$), the there is relatively little difference between tax codes generated by different values of τ. We illustrate this in Figure 4.10 where we compare average tax rates generated by the same values of τ at two different levels of average tax - (a) $1-\lambda = 0.45$ and (b) $1-\lambda = 0.95$. Even at very high tax levels, the tax function is not completely flat unless $\tau = 0$ and there is small difference in the average tax rates at the bottom when $\tau > 0$ compared to purely proportional tax.

Hence, it is important to examine whether there are gains in revenue from moving to a completely flat tax code. In our final experiment, we vary both τ and λ to search for the revenue maximizing tax code.

Figure 4.11 plots the change in income tax revenue relative to the benchmark as the tax level $1-\lambda$ increases at different levels of τ. As the figure shows, at all values of τ, revenue increases as the tax level increases up till $1-\lambda = 0.95$. This represents an average tax rate of 95% for most income levels when $\tau > 0$ and a flat tax rate of 95% when $\tau = 0$. At all tax levels, revenue is maximized when $\tau = 0$. Hence, in our small open economy, maximum revenue is attained with a flat tax code at a 95% tax rate.

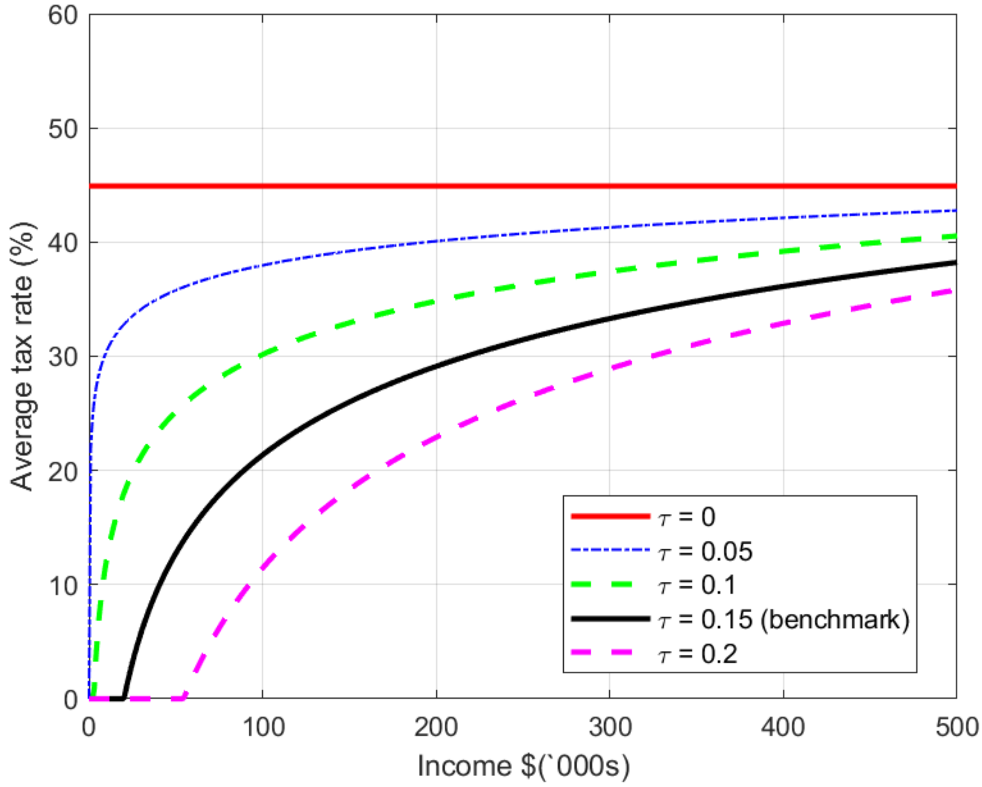
Given the similarities in the tax functions generated by different values of τ at the revenue maximizing tax level (Figure 4.10(b)), there is only a very small gain in revenue from reducing the curvature parameter τ. As Table 4.5 shows, changing from a progressive tax code to a proportional tax code at this level only leads an increase of 22 percentage points relative to the benchmark. The difference in responses in labor hours and capital is insignificant.

Table 4.5: Aggregates at different levels of τ at $1-\lambda = 0.95$

	$\tau = 0$	$\tau = 0.05$	$\tau = 0.10$	$\tau = 0.15$	$\tau = 0.2$
Revenue	209	194	191	187	185
Labor hours	-23	-22	-21	-19	-17
Capital	-103	-103	-103	-103	-103

Figure 4.10: Average tax rates at different τ and λ

(a) $1-\lambda = 0.45$



(b) $1-\lambda = 0.95$

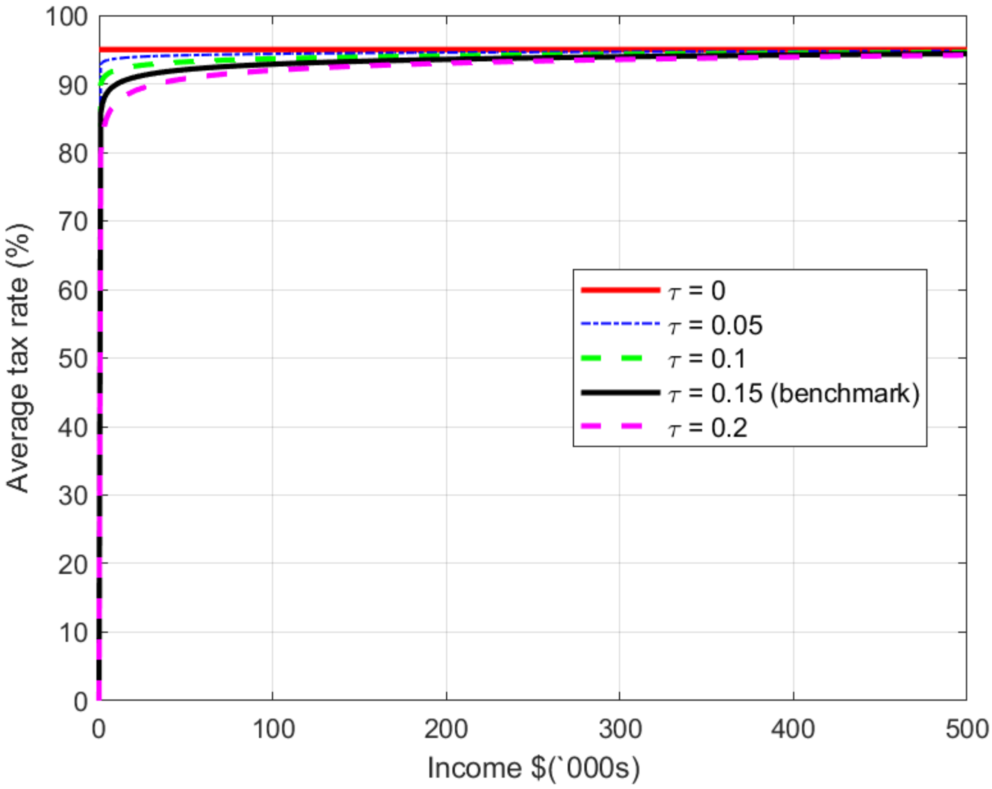
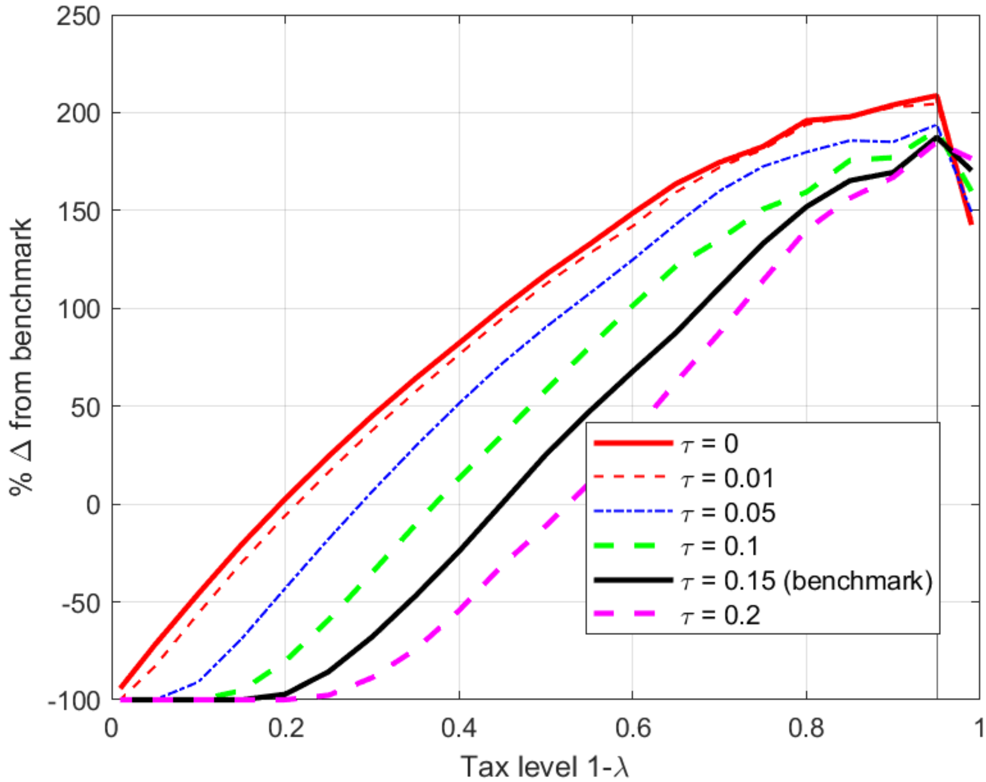


Figure 4.11: Revenue by tax levels at different levels of τ



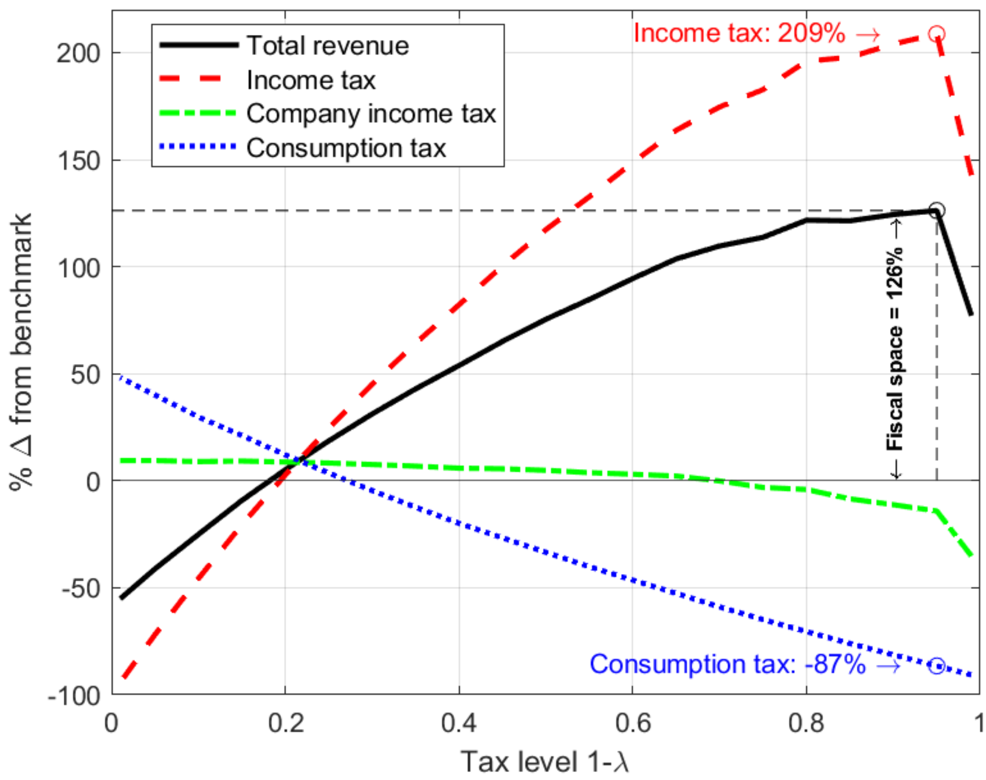
4.6 Fiscal space

The peak of the Laffer curve indicates the fiscal limit of income taxation. In addition to fiscal limit, it is important to quantify the fiscal space. In general, fiscal space gives the budgetary room between the current (benchmark) level of tax revenue $\bar{R}$ and the maximum revenue $R^{\max}$ at the peak. We quantify fiscal space from two different parallel perspectives - (1) fiscal space in terms of tax revenue and (2) fiscal space in terms of sustainable debt.

Fiscal space in terms of total tax revenue. From the first perspective, fiscal space FS describes the government's fiscal capacity to raise revenue to meet its spending commitments without compromising fiscal sustainability. As such, it is a relative measure of the potential for the fiscal system to generate more tax revenue. We measure fiscal space in terms of the percentage change from current level of tax revenue as

$$FS = \frac{R^{\max} - \bar{R}}{\bar{R}} \times 100 \tag{4.19}$$

Figure 4.12: Laffer curves for all tax revenues at the revenue maximizing income tax code



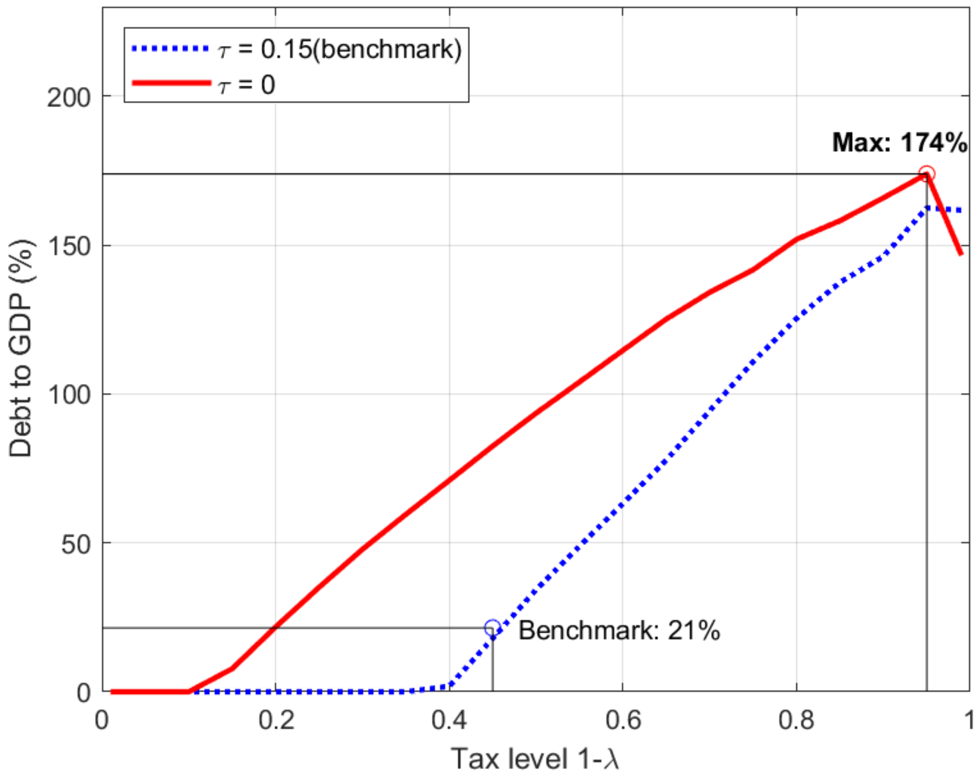
The focus in this regard is on total tax revenue rather than income tax revenue alone. This is due to the fact that in general equilibrium, raising income tax rates creates spill over effects that affect other sources of taxation, and in turn total tax revenue.

Figure 4.12 plots the percentage change in tax revenues relative to the benchmark when $1-\lambda$ is varied at the revenue maximizing curvature level of $\tau = 0$. Both total tax revenue and income tax revenue follow the same trajectory as the tax rate increases, peaking at an average tax rate of 95%. However, as the income tax rate increases, after-tax incomes decrease, leading to large reductions in consumption and in turn, consumption tax revenue. As a result, the fiscal space is signifcantly lower at 126% compared to the maximum income tax revenue of 209%.

Fiscal space in terms of sustainable debt. The second perspective defines fiscal space in terms of the distance between the current debt levels and the debt limits above which the debt becomes unsustainable[8] (e.g. see Heller (2005) and Ostry et al. (2010)).

[8]We abstract from political economy arguments that are more likely to determine fiscal limits in democratic societies.

Figure 4.13: Debt to GDP ratio (maximum versus benchmark)



In order to search for the maximum amount of sustainable debt, we search over the two parameters of the tax code by adjusting the amount of public debt in order to balance the government budget. Figure 4.13 plots the debt to GDP ratios against the tax level at the benchmark curvature $\tau = 0.15$ and the revenue maximizing curvature of $\tau = 0$.

An increase in tax revenue increases the government's ability to borrow and service more debt. As Figure 4.13 shows, debt to GDP is maximized in the revenue maximizing flat income tax code with a tax rate of 95%. In our small open economy, the fiscal space in terms of debt is 174%. However, it is important to note that our model does not consider the risk premium on public debt. Typically, risk premium increases as debt to GDP increases, shrinking the government's capacity to service debt. Thus, the fiscal space in terms of debt would potentially be much smaller. We leave this issue for further research.

Table 4.6: Comparing revenue maximizing results in the closed and open economies

	[1] Vary τ		[2] Vary λ				[3] Vary τ, λ			
	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open
τ	0*	0*					0*	0	0	0*
$1-\lambda$			0.70*	0.7	0.95	0.95*	0.6*	0.6	0.95	0.95*
Revenue	93.03	99.97	84.31	110.61	14.14	187.42	116.40	148.61	2.81	208.67
Labor	1.10	1.24	-7.69	-2.10	-39.21	-19.22	-3.55	0.71	-52.82	-23.21
Wage rate	-12.29	0.00	-28.58	0.00	-95.83	0.00	-27.59	0.00	-69.54	0.00
Savings	-22.77	-40.73	-58.44	-78.52	-68.66	-102.71	-53.49	-71.53	-96.54	-102.67
Interest rate	21.80	0.00	65.78	0.00	470.29	0.00	62.39	0.00	495.27	0.00

Note: * Indicates the revenue maximizing parameter value. All aggregate variables are reported in terms of percentage change from the benchmark values in their respective economies.

4.7 The advantage of being a small open economy

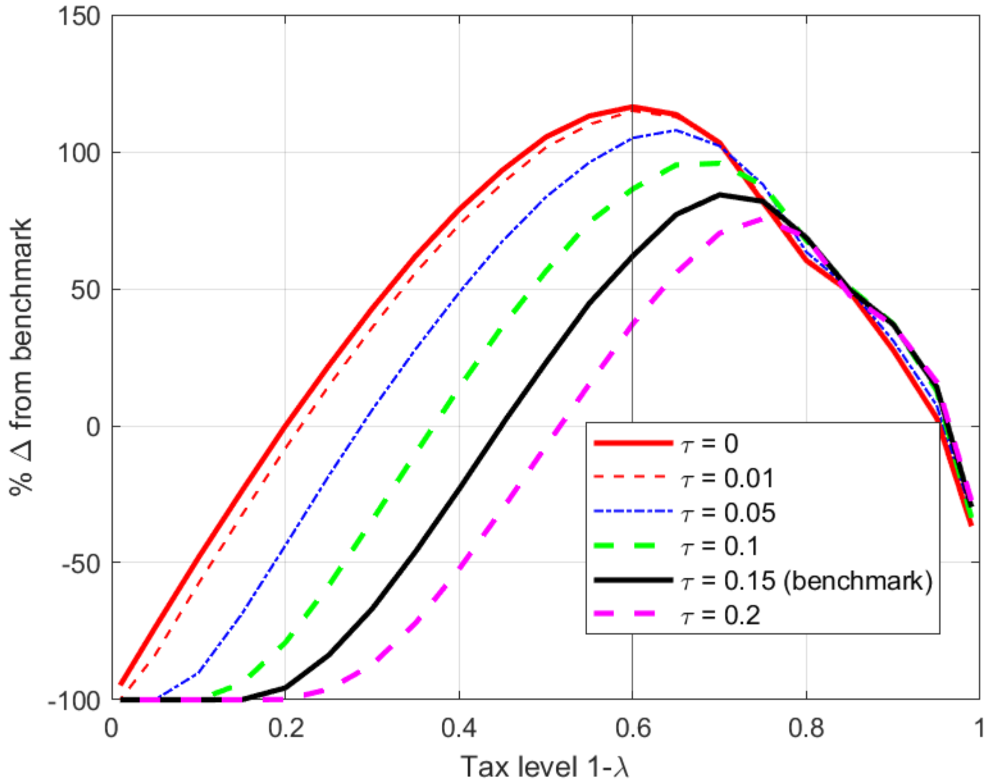
Our benchmark is modeled under the assumption that Australia is a small open economy with perfect capital mobility. As a result, the negative incentive effects on household savings due to rising tax rates are mitigated by foreign capital inflows which prevent the decline in aggregate capital stock. As our results verify, this maintains the wage rate and domestic interest rates at their benchmark levels.

In this section, we highlight the revenue generating potential of being a small economy by contrasting that with the other extreme - a closed economy with no foreign capital flows. In such an economy, behavioral responses to changing tax codes affect equilibrium wages and interest rates. We repeat our experiments on this closed economy and compare results with our benchmark experiments.

Revenue maximizing tax codes: closed vs. open economy. Figure 4.14 plots the percentage change in revenue from the benchmark in our closed economy as we change the tax level $1-\lambda$ at different τ. We present the detailed statistics at the peak of the Laffer curves in the closed economy and compare it with the open economy in Table 4.6.

We find that even in the closed economy, at any given level of $1-\lambda$, revenue is maximized in a proportional tax code ($\tau = 0$). Columns (1) and (2) in Table 4.6 compares the results from Experiment 1 for the closed and open economies where λ is fixed at benchmark. In both economies, savings decrease due to higher average tax rates at $\tau = 0$. However, in the closed economy the reduction in savings is complemented with a 21.8% increase in the interest rate

Figure 4.14: Revenue by tax levels at different levels of τ (closed economy)



and a -12.29% decrease in the wage rate. As a result, there is a slightly smaller increase in labor hours in the closed economy. The percentage change in revenue is fairly similar although the gain in revenue is smaller at 93% in the closed economy compared to 100% in the open economy due to these changes in equilibrium prices.

The solid black curve in Figure 4.14 plots the results from running Experiment 2 in the closed economy. As Column (3) in Table 4.6 reveals, the revenue maximizing $1-\lambda$ at the benchmark τ in the closed economy is 0.7, compared to 0.95 in the open economy (Column (6) lists results in the open economy for comparison). We list the values for the open economy at 0.7 in Column (4) to compare them with the revenue maximizing results in the closed economy. Compared to the open economy at $1-\lambda = 0.7$, the closed economy shows lower increase in revenue (84.31%) due to the large decline in wage rates by 28.58%. At $1-\lambda = 0.95$ (Column (5)), the wage rate is 95.83% lower and hence labor hours and income tax revenue is significantly lower compared to the open economy at the same level (Column (6)).

The revenue maximizing tax code in the closed economy is a flat tax with a tax rate of 60%

(see red curve in Figure 4.14 and Column (7) in Table 4.6). At the same tax rate in the open economy (Column (8)), we observe a slightly positive effect of 0.71% on labor hours compared to the negative effect of -3.55% in the closed economy. Again, this is a result of the wage rate in the closed economy decreasing by around 30%. The effect of decreasing wages in the closed economy is emphasized when we compare both economies at $1-\lambda = 0.95$ (Columns (9) and (10)). When the tax rate is 95%, labor hours decline by 53% of benchmark in the closed economy as wage rate declines by 70%. In contrast, in the open economy, we only observe a 23% decline in labor hours.

Our results for the closed economy are quite similar to Holter, Krueger and Stepanchuk (2019) who find that labor income tax revenue is maximized in the US with a flat tax at 60%. Although our tax code taxes labor and capital income jointly, effects on labor has greater impact on the Laffer curve as total labor income is higher than capital income in both the open and closed economies. Thus it is natural to expect Laffer curves for our closed economy to be fairly similar to Laffer curves for labor income tax.

The truth is somewhere in between. Comparing these two extreme cases reveals some important insights about the significance of capital mobility on the Laffer curve. When equilibrium wage and interest rates are fixed under perfect capital mobility assumptions, we observe an extremely high peak at 95%. As prices are constant, households in our open economy are reacting purely to the change in tax code. However, changes to the tax code can affect equilibrium prices.

We observe this in our alternative closed economy extreme. In that, increasing average tax rates result in large declines in the wage rate. Which in turn causes larger decreases in labor supply. As a result, the Laffer curve peaks at a lower rate of 60%.

In both economies, a flat tax system yields higher revenue compared to a progressive tax system. This confirms that labor and capital market distortions due to progressive taxation have large negative effects on revenue. This gives weight towards a flat tax system if the government's objective is to maximize revenue.

However, a tax rate of 95% as obtained in our benchmark experiments is extreme. In reality capital in the economy is neither immobile nor perfectly mobile across borders. Even in the long run there are frictions in the movement of capital. Thus we can infer that the revenue

Table 4.7: Revenue maximizing tax codes: alternative model assumptions

#	Model type	Budget balancing	τ^*	$1-\lambda^*$	Fiscal space	Hours	Savings
1.	**Linear utility**	**General govt. purchases**	**0**	**0.95**	**208.68**	**-23.21**	**-103.59**
2.	**(constant labor elasticity)**	Other public transfers	0	0.95	202.65	-23.60	-103.85
3.		Consumption tax	0	0.95	208.83	-22.94	-103.60
4.	Linear utility with no pension	General govt. purchases	0	0.90	248.77	-11.13	-94.87
5.	Cobb-Douglas	General govt. purchases	0	0.95	264.01	-5.61	-101.67
6.		Other public transfers	0	0.95	244.83	-19.98	-102.04
7.		Consumption tax	0	0.95	264.01	-5.61	-101.67

Note: All aggregate variables are reported in terms of percentage change from the benchmark values in their respective economies. First row (boldface) presents the main results for comparison.

maximizing tax code is a flat tax with a tax rate between 60% and 95%. If frictions are high, the tax rate would be closer to 60% rather than 95% and vice-versa.

4.8 Sensitivity analysis

As Section 4.7 shows, our results are highly sensitive to the assumption of perfect capital mobility across borders. In this section, we summarize sensitivity checks on other model assumptions.

Table 4.7 lists the revenue maximizing parameters (Columns (4) and (5)), the percentage changes in income tax revenue (Column (6), aggregate labor hours (Column (7) and aggregate household savings (Column (8)) for each alternative model. The model specifications are given in Column (1) which lists the main feature of the alternative specification and Column (2) which gives the policy instrument used to balance the budget in that given model. Each row represents an alternative model.

Alternative policy instruments to balance the budget (Models 2 and 3). We balance the budget in our main experiments using general government purchases. Thus, changes to the tax code does not result in any feedback effects to households through any other government policy. We examine if using the consumption tax rate (Model 2) or the level of other public transfers (Model 3) changes the revenue maximizing tax code. The rationale for this sensitivity check is that changes to consumption tax rates and other public transfers could potentially lead to different incentive effects on households. However, as rows 1 - 3 in Table 4.7 show, the differences in aggregate hours, savings and total income tax revenue is fairly similar across the three budget balancing options.

Eliminating the age-pension (Model 4). Our benchmark model differs from other models commonly used in related literature on the fact that ours include the Australian means-tested age pension system. A means-tested age pension could cause households to tolerate higher tax rates (lower after tax incomes) as there is minimum income guarantee in old age even if their after tax incomes are lower prior to retirement.

We test this hypothesis by switching off the pension system in our benchmark economy (Model 4 in Table 4.7). Although the peak average tax rate in the former is 90% compared to 95% in the latter, the revenue maximizing results from running experiments on Model 4 are quite similar to our benchmark results. We can infer from this that the existence of the means-tested pension system does not play a significant role in our findings. However, it is evident that the pension system amplifies disincentives to work and save as the percentage change in hours worked, labor force participation rates and savings are lower in the benchmark economy compared to the no pension economy. In turn, maximum revenue is significantly higher in no pension economy.

Alternative preferences (Models 5-7). In our benchmark economy, household preferences are specified by an additively separable (linear) utility function where the Frisch elasticity of labor supply γ is constant over the life cycle. We also consider an alternative case where elasticity varies over the life cycle relative to labor supply by replacing our linear utility function with the following Cobb-Douglas function

$$u(c,l) = \frac{\left(c^{\gamma} l^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} \tag{4.20}$$

where γ is the weight of consumption relative to leisure and σ is the coefficient of relative risk aversion. Under this specification, labor supply elasticity is given by $\frac{l}{1-l}\frac{1-\gamma(1-\sigma)}{\sigma}$. We recalibrate the model with $\gamma = 0.25$ and $\sigma = 4$ and run our experiments using alternative budget balancing options specified in rows 5-6 in Table 4.7. Although labor supply responses are smaller compared to the benchmark model, this alternative preference assumption does not alter the revenue maximizing tax code.

4.9 Extensions

Before concluding, we briefly touch on some important extensions to our main analysis. First, we highlight the importance of the personal income tax in maximizing total revenue by comparing the Laffer curves for other taxes in our model. Second, we consider a more realistic policy context by examining the effect of changing the income tax code while keeping. Finally, we draw attention to two important caveats to revenue maximization - that is, changing the income tax code to generate more revenue could potentially result in a reduction in social welfare and an increase in inequality.

4.9.1 Laffer curves for other taxes

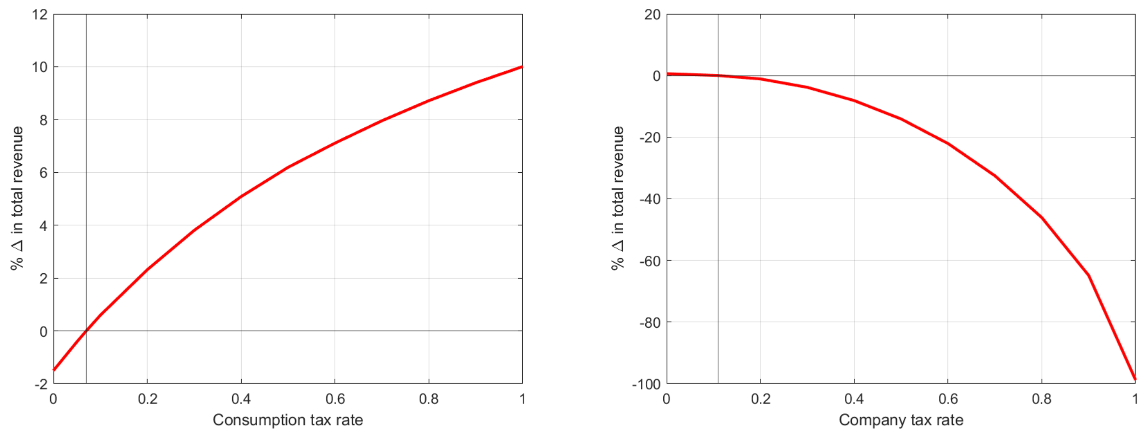
Could we achieve greater gains in total revenue from increasing the tax rates on the other two taxes in our model rather than changing the income tax code? We answer this question by fixing the income tax code at its benchmark parameter values and changing the tax rates on consumption tax and company income tax.

Figures 4.15(a) and (b) plot the Laffer curves for the two taxes. In Figure 4.15(a), we observe a strictly positive relationship between the consumption tax rates and total revenue. However, the percentage change in total revenue is relatively small (10% at the maximum) compared to the change in total revenue at the revenue maximizing income tax code. Figure 4.15(b) shows large decreases in total revenue decreases when the company income tax rate in increased beyond the benchmark.

Thus, this exploratory analysis on our benchmark model establishes the importance of considering changes to the income tax code if the government's objective is to increase its total revenue. This does not mean that changes to other taxes are not necessary. In fact, the revenue maximizing mix of income tax code parameters, consumption tax rate and company income tax rate is an important policy issue. However, it is not within the purview of this paper.

Figure 4.15: Laffer curves for consumption tax and company income tax

(a) Consumption tax (b) Company income tax



4.9.2 The income tax code in a real policy context

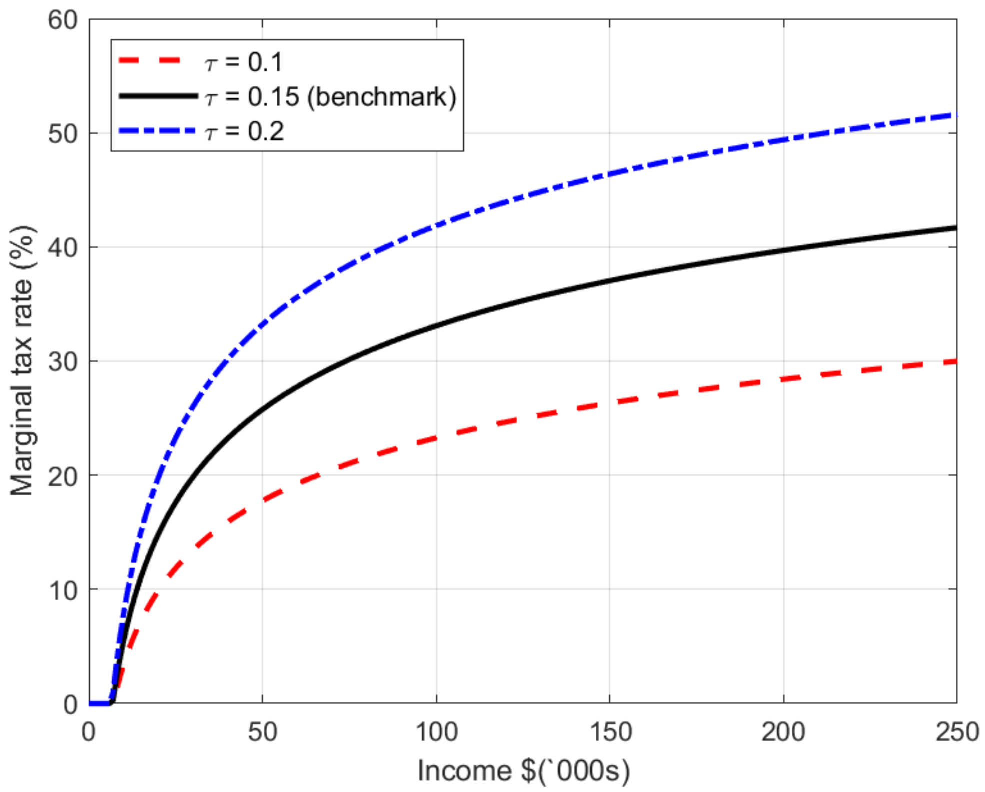
Our main results indicate that tax revenue can increase significantly by reducing the income tax code's progressivity, all the way to a flat tax with effectively no tax-free threshold. However, in a real policy context, reducing tax-free thresholds and increasing tax rates at the lower end of the income distribution is likely a politically untenable policy position. For this reason, we conduct an alternative thought experiment where we adjust the tax code while holding the tax-free threshold fixed.

Changing the income tax code while holding the tax-free threshold constant. In order to keep the tax-free threshold constant at the benchmark level, we adjust the tax level parameter λ as we vary the curvature parameter τ. Given that the benchmark tax-free threshold is represented by $y_0 = \lambda_0^{\frac{1}{\tau_0}}$, when τ changes from τ_0 to τ_1, λ changes from λ_0 to $\lambda_1 = \lambda_0^{\frac{\tau_1}{\tau_0}}$. Hence, both the curvature and the tax level changes in the same direction. This leads to a rise in tax rates at all income levels above the tax-free threshold as τ increases. Figures 4.16a and 4.16b plot changes to marginal and average tax rates as we vary τ and adjust λ.

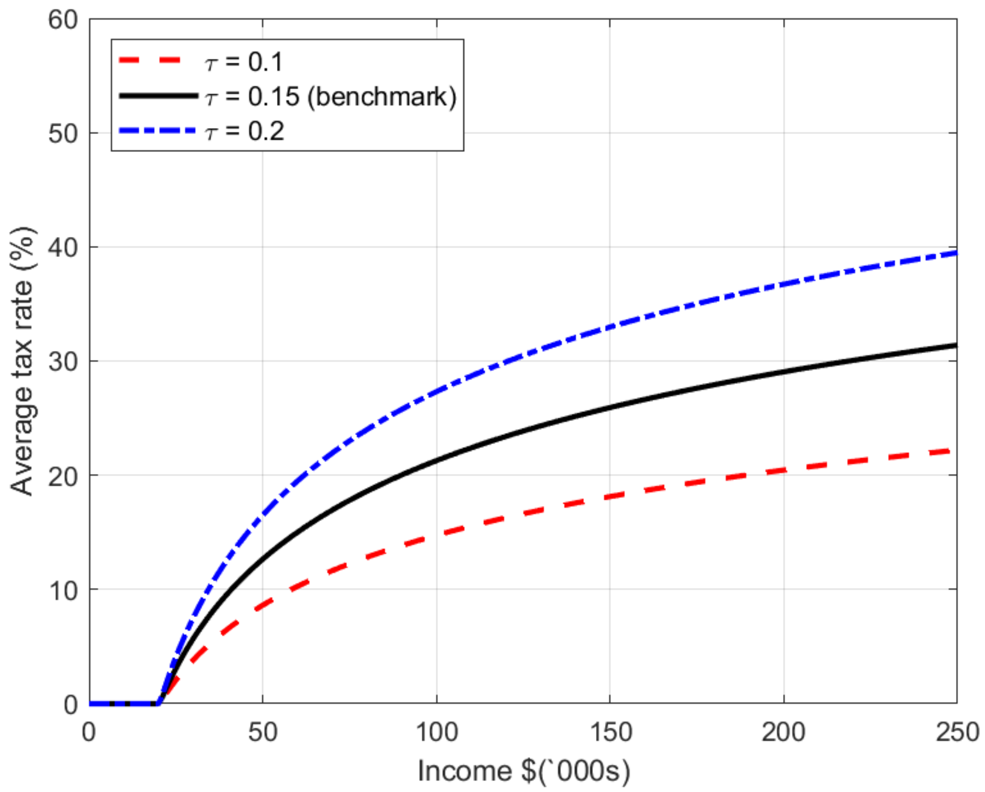
The Laffer curves at different τ and λ at the benchmark tax-free threshold. Figure 4.17a plots the Laffer curves for tax revenues against the different values τ. Income tax revenue is maximized at $\tau = 0.6$ $(1 - \lambda = 0.91)$. The fiscal gap for income tax at this peak is 99%. However, in general equilibrium, the increase in income tax rates results in decreasing in con-

Figure 4.16: Tax codes at different τ and λ at the benchmark tax-free threshold

(a) Change in marginal tax rates



(b) Change in average tax rates



sumption that leads to a reduction in consumption tax revenues by 46%. As a result, the fiscal gap for total tax revenue is 59%.

4.9.3 Distributional and welfare consequences of revenue maximization

We conclude this section by raising an important caveat. It is widely understood that revenue maximization is not the same as welfare maximization. Nevertheless, in a policy context, one ought to consider how changes to the income tax code could affect welfare and the income distribution.

Welfare effects. For brevity, we focus on utilitarian social welfare defined as the sum of ex-ante lifetime utilities of individuals born into the stationary equilibrium given a specified tax code T parametrized by (λ, τ).

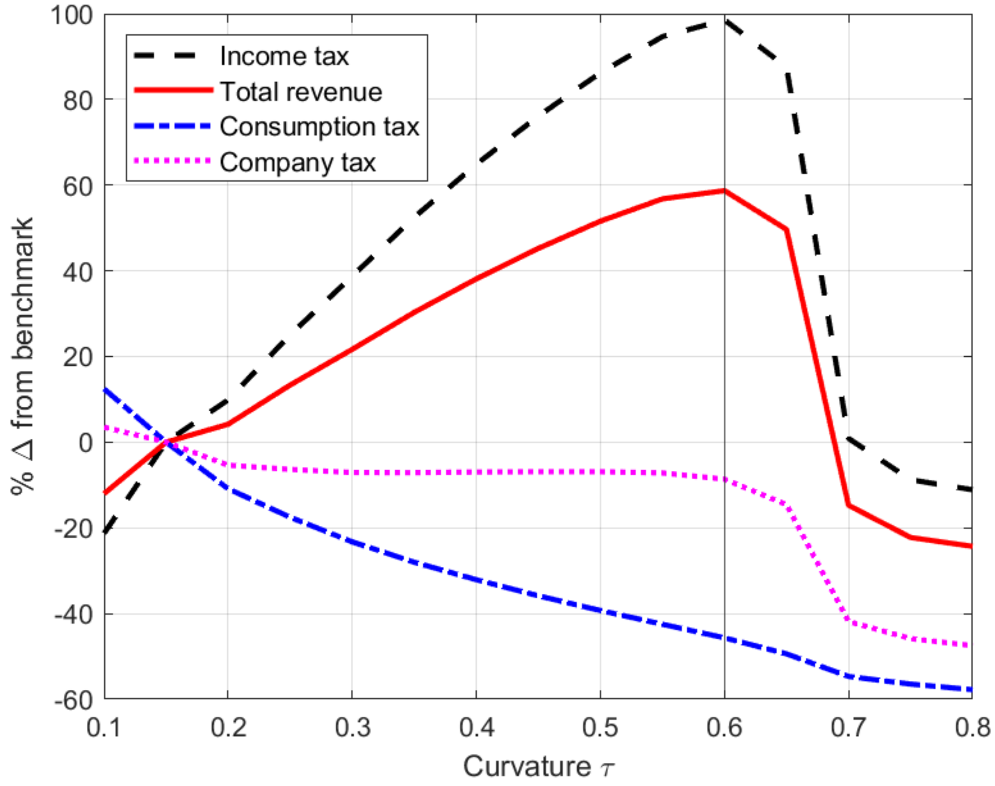
$$SWF = \int V\left(\chi_{j=1}|T\right) d\Lambda\left(\chi_{j=1}\right) \tag{4.21}$$

Figure 4.18a plots the change in certainty equivalent consumption variation (CEV) - the uniform percentage increase in consumption needed to make a household indifferent between being born in the benchmark and being born into an alaternative tax system. An increase in tax rates result in large declines in CEV. At the peak of the Laffer curve, the decline in utilitarian social welfare is 48%. However, as depicted in Figure 4.18b, this decline is not uniform across skill types. The very low skill type experiences a decline of 24% while the low skill type experiences a decline of 44%. Medium, high and very high skill types experience larger declines in their welfare as they are affected more by changing tax codes. As such, their CEV at the revenue maximizing tax code is between -60% and -70%.

Distributional effects. In addition to the decline in welfare, revenue maximization results in an increase in income inequality. Table 4.8 reports the distribution of taxable income, income tax and after-tax income for our benchmark model and at the fiscal limit, where the tax code is a flat tax with a 95% tax rate. This change in the income tax code results in an increase in the Gini coefficient of taxable income from 0.6 to 0.7. This is largely due to the decrease in the

Figure 4.17: Laffer curve and revenue maximizing tax code at the benchmark threshold

(a) Laffer curves



(b) Tax code at $\tau = 0.6, 1 - \lambda = 0.91$

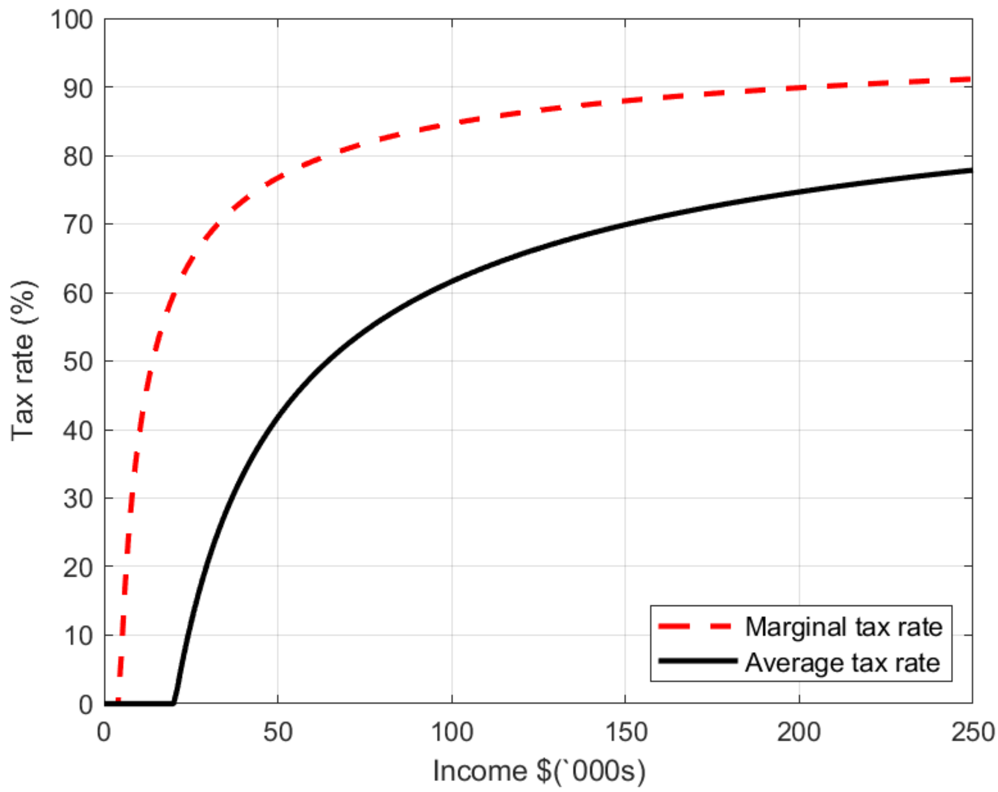
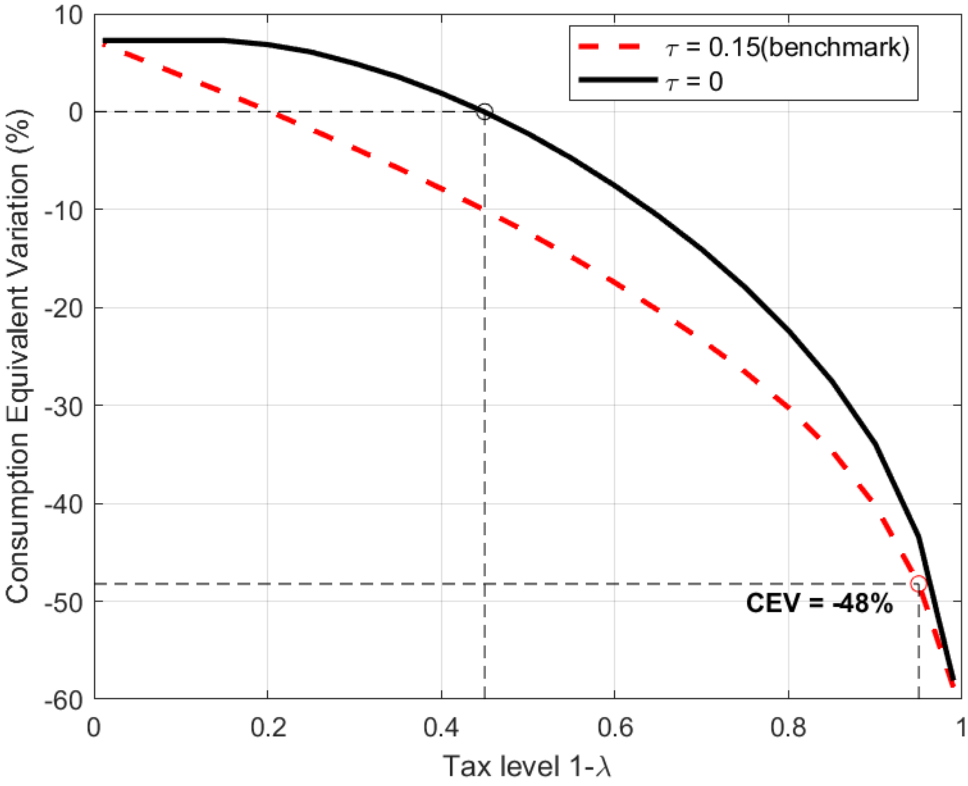


Figure 4.18: Welfare effects of changing the tax code

(a) Utilitarian social welfare



(b) Welfare by skill type at $\tau = 0$

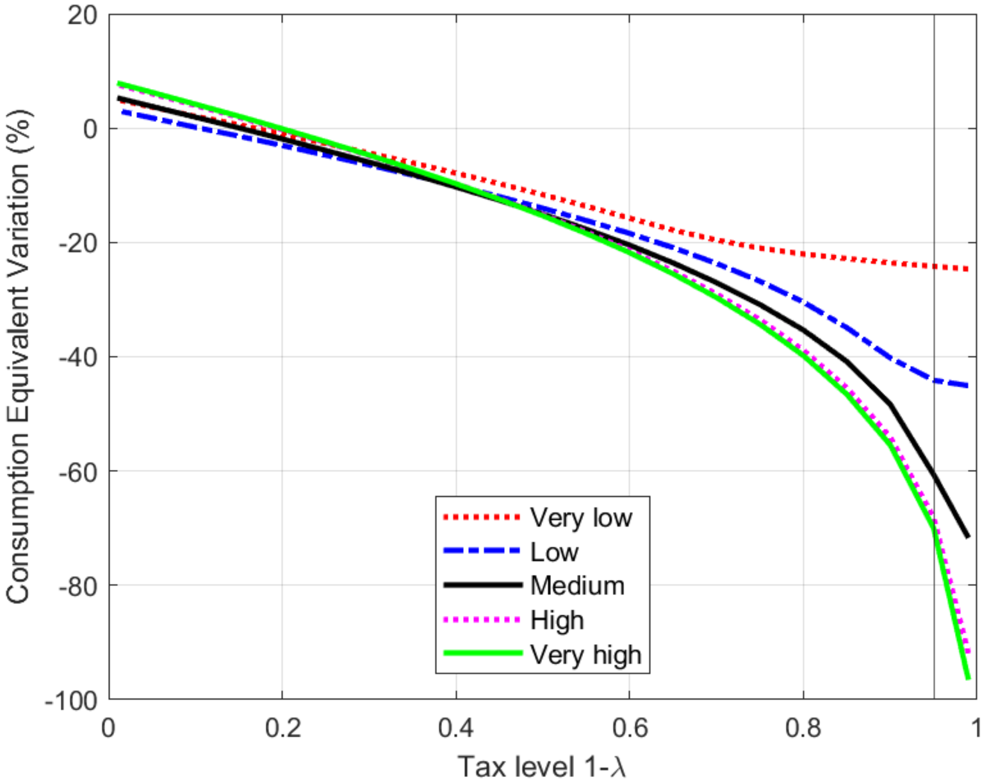


Table 4.8: Distributional effects of changing the tax code

	Income and tax shares in quantiles of taxable income						Distributional
	Quint 1	Quint 2	Quint 3	Quint 4	Quint 5	Top 1%	Index
Taxable income							
- Benchmark	0.46	2.56	6.71	26.37	63.90	9.35	0.60
- Fiscal limit	0	0.29	5.63	22.34	71.75	7.89	0.70
Income tax							
- Benchmark	0	0	1.43	21.11	77.46	13.06	0.20
- Fiscal limit	0	0.29	5.63	22.34	71.75	7.89	0.00
After tax income							
- Benchmark	0.31	2.28	7.36	26.42	63.62	9.87	0.55
- Fiscal limit	0	0.29	5.63	22.34	71.75	7.89	0.70

Note: The tax code in the benchmark is $\tau = 0.15, 1-\lambda = 0.45$. Fiscal limit denotes the peak of the Laffer curve where $\tau = 0, 1-\lambda = 0.95$. Quint denotes quintile of taxable income. Columns (1)-(6) report the share of total income (or tax) by quantile in percentage terms. Column (7) reports the concentration coefficient for the respective income or tax variable. Except for income tax, the respective value in the column is the Gini coefficient. For income income tax, we report the Suits index.

share of income earned at the bottom of the income distribution. A Suits index of 0 at the fiscal limit indicates that the tax code is proportional. Hence, as evident from the table, at the fiscal limit, the tax share in each quantile of taxable income is equal to its respective income share, leaving no role for redistribution via the income tax system.

4.10 Conclusion

This paper quantified the fiscal limits and the fiscal space for the Australian income tax system using a computable general equilibrium OLG model calibrated to match the macroeconomic data and cross-sectional distribution of income and tax liabilities in Australia. Our quantitative analysis relied on approximating the income tax code using the HSV tax function with two parameters - one controlling the curvature and the average level of taxation. We examined changes in each parameter individually and jointly and plotted Laffer curves against the respective parameter and tax revenue.

We found that the government can maximize its tax revenue by making the tax code less progressive. This is robust at different levels of average taxation. Our findings on the revenue increasing potential from reducing progressivity are also robust to alternative capital mobility specifications, budget balancing policy instruments, and alternative assumptions on household preferences. Thus, we can draw a strong conclusion regarding the relationship between revenue and progressivity.

However, the revenue maximizing tax rate is highly sensitive to how mobile capital is across borders. Hence we examine the Laffer curve under the assumptions at the opposite ends of the capital mobility spectrum - the small open economy and the closed economy. Maximum revenue is achieved under a flat income tax code with a tax rate of 95% (peak of the Laffer curve) in the small open economy version of the model with perfect capital mobility. At the other extreme, we find that the revenue-maximizing tax rate under the closed economy assumption is 60%.

Therefore we conclude that in the context of our general equilibrium model, the fiscal limit of the income tax code in Australia is a flat tax with average tax rate between 60% and 95%. At this limit, in the small open economy, the fiscal space is at a 126% of the benchmark total tax revenue. It is essential to consider the implications of capital mobility on our results. The current model yields a robust bound on the fiscal limit. However, it is a rather wide margin that needs to be examined further using imperfect capital mobility specifications. Additionally, frictions in the movement of capital also imply the importance of examining transitional dynamics in addition to the long run.

Our exploratory analysis of the Laffer curve for consumption tax and company income tax showed that the maximum revenue at the peaks of these respective Laffer curves were considerably smaller than that of income tax. This gives weight to prioritizing income tax reform if raising tax revenues is a key policy goal for the government. The optimal tax mix for all taxes is also an important issue that needs further consideration.

Out of all the issues analysed in this paper, fiscal space in terms of sustainable debt in the context of fiscal policy is perhaps the most pressing. Although we have briefly explored the maximum amount of sustainable debt, our analysis is limited in that it does not account for increases in risk premium as the level of debt rises. In addition, the rate of return on public debt needs to be analyzed in relation to GDP growth. Raising tax revenue to pay for debt comes to the forefront of fiscal policy, especially when growth is stagnant and bond yields are rising. We leave a detailed analysis of this issue as our potential next step.

Chapter 5

Conclusion

This thesis explored three interrelated issues related to fiscal policy reform in Australia, focusing primarily on the personal income tax system.The central themes are equity, efficiency, and the revenue-maximizing potential of Australia's income tax system. Focusing on equity, Chapter 2 measured the progressivity and redistributive effect of income tax. Chapter 3 examined the trade-offs between equity and efficiency goals, evaluating changes to the income tax code's progressivity from a utilitarian social welfare perspective. Finally, Chapter 4 explored the effect on total revenue from changes to the income tax code's scale and progressivity, seeking the fiscal limit to income taxation in Australia. This chapter summarizes the main findings from each preceding chapter, highlights key messages, and discusses potential for future research.

5.1 Main findings

Income tax progressivity and redistribution. Chapter 2 began with explaining that there is no consensus on how to measure tax progressivity. It then summarized the two main perspectives on measurement – (i) how does tax liability increase as income rises (tax liability progression), and (ii) how is tax liability distributed across the income distribution (tax liability distribution). Using data from HILDA from 2001 – 2018 and ATO tax return data from 2004 – 2016, the Chapter measured income tax progressivity from both perspectives.

The tax liability progression approach relies on estimating the elasticity of tax liability with respect to income. The Chapter estimated this elasticity using a parametric tax function commonly used in public finance literature going back to Jakobsson (1976), Persson (1983) and more recently in the in the dynamic general equilibrium literature by Benabou (2002) and Heathcote, Storesletten and Violante (2017*b*). This function is commonly known as the "HSV tax function". Estimates using both HILDA and ATO data show that the parametric tax function is a suitable approximation for Australia's income tax code. The estimates of tax elasticity indicate a general decline in tax progressivity since 2001.

The tax liability distribution approach measures tax progressivity in terms of how unevenly tax liabilities are allocated across the income distribution. The Chapter used the Suits index and the Kakwani index to measure progressivity from this approach. Both indexes point to a tax progressivity cycle. Over the period analyzed, progressivity moves from greater progressivity to lesser progressivity. The discrepancy in the trends we obtain from the two approaches is because the first is a local measure, while the second is a global measure.

The Chapter examined the tax progressivity cycle in further detail. Progressivity increased when tax policy was active, while it decreased when tax policy was inactive. Notably, between 2006 and 2010, annual adjustments to tax thresholds and offsets led to a sharp rise. In contrast, inactive tax policy lead to falling progressivity between 2010 and 2016. This fall is mainly due to the lack of automatic indexation in Australia's income tax code, resulting in bracket creep.

We found that indexing income tax thresholds to the consumer price index (CPI) could have eliminated bracket creep and partially maintain a rather stable level of tax progressivity in early 2000s. However, indexation to the CPI is not a full substitute for an active tax policy that has frequent adjustments to the tax schedule so as to keep the income tax code in line with the dynamics of income distribution.

The Chapter also examined the income tax system's redistributive role in the overall tax-transfer system's broader context. We estimated the redistributive effect of taxes and transfers by measuring the difference in the Gini coefficient of pre-and post-tax and transfer incomes. While tax progressivity plays a crucial role in the overall redistribution, it is relatively small compared to the redistributive effect of the transfer system. Overall redistribution from the tax-transfer system depends mostly on the size of transfers. These findings give weight to the notion that the income tax system in Australia does not play a significant social insurance role compared to the transfer system.

Optimal income tax progressivity. Chapter 3 examined the welfare maximizing (optimal) level of income tax progressivity, taking into account the presence of the means-tested pension system. We employed a dynamic general equilibrium, small open economy model with overlapping generations of heterogeneous households born with different innate earnings ability (skill types) and faced idiosyncratic shocks to labor productivity.

We approximated the Australian income tax code using the parametric function estimated in Chapter 2 and measured how social welfare changes as we vary the progressivity parameter. We use the utilitarian approach to social welfare. The social welfare function sums ex-ante expected lifetime utilities of all individuals born into the stationary equilibrium. We assumed that a utilitarian planner places equal weight on households within the economy.

The economy attains the highest social welfare under a proportional income tax code at a flat rate of 14% with no tax-free threshold. This implies that the adverse incentive effects of high marginal tax rates dominate the redistribution/insurance effects in our general equilibrium model economy. There are significant gains in welfare for all skill types when switching to the optimal income tax code. We found that this result is robust to alternative preference specifications. However, this result is not robust to eliminating our model's public transfer system. It implies that the optimal progressive income tax code is contingent on the public transfer system providing adequate social insurance.

The Chapter also examined the extent to which the design of the means-tested pension system, as a central pillar of the Australian transfer system, affects the optimal level of tax progressivity. Conditional on the existing maximum benefit and means-test thresholds, social welfare is highest when the income test taper rate is at 10% under the optimal income tax code. This is much lower than the current taper rate of 50%. The welfare effects of lower taper rates are more pronounced at higher tax progressivity levels. With a proportional income tax, the welfare gains from reducing the taper rate are relatively insignificant compared to economies with progressive taxation.

Fiscal limit of income taxation. Chapter 4 examined the revenue implications of changes to the income tax code using an OLG model calibrated to match the Australian macroeconomy's key features and its fiscal system. The Chapter focused on two main concepts - (1) fiscal limit and (2) fiscal space. The fiscal limit of the income tax code is at the Laffer curve peak where total tax revenue reaches a maximum. Fiscal space gives the difference between this maximum tax revenue and the current (benchmark) revenue. It measures the government's capacity to raise revenue to meet its spending commitments without compromising fiscal sustainability.

Similar to Chapter 3, the Chapter approximated the income tax code using the parametric tax function. It first examined changes to the curvature while holding the tax level fixed and compared tax revenue across the resulting steady states. Decreasing the curvature of the tax function leads to increased revenue. At the benchmark tax level, the fiscal limit is a flat income tax system. One main reason for this is that, except for those households with very low earnings ability, a flat tax system eliminates distortions from progressive tax rates as they increase labor hours. We found that this positive effect outweighs any adverse effect from rising tax rates. Although the lowest skill type experiences a negative incentive effect, it is not sufficient to decrease revenue as a flat tax system results in a zero tax-free threshold. This is because those with even very low labor hours pay income tax when there is no tax-free threshold.

The relationship between progressivity and revenue is robust to different average taxation levels. We varied values of both the tax level and curvature parameters. We found that a flat tax system results in maximum revenue at any given taxation level. This echoes findings by Holter, Krueger and Stepanchuk (2019) who find that maximal revenue in the US labor tax code can be raised with a flat tax. However, while Holter, Krueger and Stepanchuk (2019) find that maximal tax revenue is attained with a flat labor income tax rate of 60%, the Laffer curve in our benchmark small open economy peaks at a flat tax rate of 95%.

This result is robust to alternative policy tools to balance the budget, and alternative assumptions on household preferences. Since social insurance from the means-tested pension system plays a significant role in our model, we also checked the robustness of the results to exclude pension from our model and find that the Laffer curve's peak goes from 95% to 90%. Thus the results are fairly robust to this assumption.

At the fiscal limit (Laffer curve peak), total tax revenue is 126% of the benchmark. This gives the overall fiscal space in terms of total tax revenue. It is important to note that this is significantly lower than the maximum income tax revenue of 209% at the peak of the Laffer curve for income tax. In general equilibrium, increasing personal income tax rates lead to negative spill over effects. In this regard, the negative income effect due to increasing the personal income tax rate results in a significant decline in household consumption and consumption tax revenue.

Our results also highlight the advantage of being a small open economy regarding increasing tax revenue. In this regard, effects to the aggregate stock of capital due to negative incentive effects on household savings as the tax rate increases is mitigated by foreign capital inflows. This maintains wages and the interest rate at benchmark levels. In a closed economy comparison, we demonstrated that the fiscal limit is lower at a tax rate of 60%.

5.2 Key messages for policy makers

Some of the results from Chapters 3 and 4 provoke stark policy proposals at face value. All models are approximations and are subject to limitations (discussed in the next section). Thus, rather than the precise values in the results such as tax rates, level of progressivity and so on, the key contribution of this thesis lies in what the results imply for fiscal policy. The following points summarize the main messages that are relevant for policy-makers.

The importance of active tax policy over indexation. In periods where tax policy is static, bracket creep leads to declining tax progressivity. Many in policy believe that indexing tax brackets to inflation or wage growth (or similar) would mitigate this. Chapter 2 showed that although indexation can partially mitigate bracket creep, it is not a substitute for actively adjusting tax brackets in line with changes to the income distribution from one year to another.

Income tax policy is intertwined with the design of public transfers. Chapter 2 also showed that the income tax system plays a minor role in social insurance in Australia compared to the public transfer system. In light of this, we can make strong arguments for flattening the income tax code to remove distortions and increase efficiency. The general equilibrium analysis in Chapter 3 substantiates this using a general equilibrium model. However, this is all contingent on maintaining a generous and progressive public transfer system.

Public transfers in general and the age-pension, in particular, complements a less progressive tax system by providing social insurance for the poorer segment of the population. This conclusion carries a critical policy implication. Governments interested in flattening the income tax code should give careful consideration to the design and generosity of the public transfer system to mitigate any reduction in the social insurance role of the income tax system.

Flattening the tax code is a viable option to increase tax revenue. As illustrated and explained in Chapter 4, making the tax code less progressive implies reducing the tax-free threshold and increasing tax rates at the bottom of the income scale. Reducing distortions from progressive tax rates also incentivizes a significant majority of households to increase their labor supply and savings. By no means does this mean that this is the only way to increase tax revenue. However, many opine that less progressive tax codes generate lower revenue. Chapter 4 shows that this may not always be the case.

5.3 Limitations and future research

This thesis is only a small step towards a more comprehensive examination of fiscal policy reform in Australia. In this section, I draw attention to three main limitations of the present analysis and provide directions for further research.

Transitional dynamics. The analysis in Chapters 3 and 4 involved comparing alternative steady state economies. Bakis, Kaymak and Poschke (2015) show that accounting for transitional dynamics leads to a more progressive optimal tax system than one would obtain by only comparing steady states. An immediate next step to the analysis in this thesis is to examine the transition from the current fiscal system to the alternative systems presented in the two chapters.

Household heterogeneity. All analyses presented in this thesis exclude details related to household composition. In reality, taxes and transfers depend on demographic factors such as age and family structure. Chapter 2 briefly explored the quantitative importance of accounting for household heterogeneity and showed that progressivity measures are sensitive to household composition. Therefore, a crucial next step in examining fiscal policy is to incorporate richer household structure into the existing OLG model by modeling different types of families.

This would enable us to include and analyze more detailed public transfers such as family benefits, child care benefits, and income support payments for single parents. A richer set of public transfers and the inclusion of different types of families could lead to greater heterogeneity in how different households respond to changing tax rates. This can especially be true for single income families (such as single parents) along the extensive margin of labor supply.

Market frictions. Another limitation of the thesis is that it abstracts from market frictions. In particular, both Chapters 3 and 4 assume a competitive labor market with a highly flexible work schedule. The sensitivity analysis in Chapter 3 showed that a proportional tax code does not yield maximum welfare when the work schedule is more rigid. A more systematic way of extending this notion of labor market rigidity is to introduce labor market search and matching frictions into the model. In turn, this could also enable the inclusion of unemployment benefits.

Similarly, the thesis mainly conducted analyses in frictionless capital markets. There are two possible adjustments to the existing model to address this. First, we can add imperfect capital mobility across borders by assuming that the domestic interest rate in our small open economy is partially endogenous. Second, we can include a risk premium on government bonds. These adjustments to the model would enable a more in-depth exploration of the links between taxation and public debt sustainability.

Tax gap and tax progressivity. I conclude the thesis with a slightly more ambitious but highly important avenue for future research. One of the significant gaps currently in the research on income tax progressivity is that of the relationship between tax gaps and tax progressivity.

The majority of empirical studies on tax progressivity, including this Chapter 2 of this thesis, use data that estimates tax liability instead of actual tax payments. In turn, quantitative models use these statistics to analyze tax policy.

In reality, the gap between actual income tax paid and statutory tax liability is significantly different. Australian Tax Gaps data by the ATO shows that in total, the net gap[1] was $8,322 million for the income year 2017-18 (Australian Government 2020). For high wealth individuals alone, the net gap was $808 million.

A more comprehensive understanding of income progressivity requires an examination of the tax gap across the income and wealth distributions. Insights from an empirical analysis on the tax gap could be incorporated into quantitative macroeconomic models to examine the links between optimal tax progressivity and the ability to avoid (and evade) tax.

[1]The difference between the theoretical liability and the amounts paid voluntarily without any ATO directions and from amendments after ATO directions. Theoretical liability is total estimated amount payable assuming all entities are fully compliant with the ATO's interpretation of the law.

Appendix A

Chapter 2: Appendix

A.1 Measuring tax progressivity

In this section we provide more a detailed description of the analytical framework that we rely on to measure tax progressivity. In general, there is no consensus on how to measure the progressivity of an income tax system. The variety of measures can be classified into two main approaches: one based tax liability progression and one based on tax liability distribution. The former measures tax progressivity in terms of tax elasticity as income progresses, namely tax progression metric or tax progression-based measure. Meanwhile, the latter measures tax progressivity in terms of tax liability shares relative to income shares across income distribution, namely tax distribution metric or tax distribution-based measures.

A.1.1 Tax progression metric

In a progressive tax system, tax liability rises with income. The progressive level of a tax system can be measured in terms of tax progression at a given income level, which has a long standing in public finance going back to Pigou (1929) and Slitor (1948). Musgrave and Thin (1948) summarise three common measures of the tax progression approach in Table A.1.

Note that, these three measures of tax progressivity are consistent with each other and can be intuitively interpreted through the lens of tax elasticity with respect to income.

The tax progression approach measures tax progressivity in terms of the elasticity of tax

Table A.1: Progression measures of tax progressivity

	Definition	Formula	Progressive	Regressive
Average rate progression	The change in average tax rate with change in pre-government income.	$\frac{\partial t}{\partial y}$	>0	<0
Liability progression	Elasticity of tax with respect to pre-government income.	$\frac{\partial T}{\partial y}\cdot\frac{y}{T}$	>1	<1
Residual income progression	Elasticity of residual income with respect to pre-government income.	$\frac{\partial(y-T)}{\partial y}\cdot\frac{y}{(y-T)}$	<1	>1

Note: T denotes the total tax liability and y is pre-government income.

liability at a given income level. According to this measure, a more progressive tax system is simply one where the level of tax liabilities progresses with income at a more rapid rate than in a less progressive tax system. Consider an individual at an income level y. The elasticity of tax liability with respect to income is

$$\varepsilon = \frac{\partial T}{\partial y}\frac{y}{T} \tag{A.1}$$

The income tax schedule is progressive if the elasticity of tax liability is greater than unity, $\varepsilon > 1$. Let $m(y) = \frac{\partial T}{\partial y}$ and $t(y) = \frac{T}{y}$ denote marginal tax rate and average tax rate, respectively. The elasticity of tax liability can be expressed in terms of a ratio of marginal tax rate to average tax rate as $\varepsilon = \frac{m(y)}{t(y)}$.

This ratio implies an interpretation of tax progressivity. That is, the income tax schedule is progressive if the additional tax burden on an additional unit of income exceeds the average tax burden at that income level

$$\frac{m(y)}{t(y)} > 1 \ \text{ or } m(y) - t(y) > 0 \tag{A.2}$$

Intuitively, an income tax system is progressive if the marginal tax rate is higher than the average tax rate and becomes more progressive when the gap between marginal and average tax rates, $m(y) - t(y)$, is relatively larger.

A parametric tax function. The elasticity of tax liability can be calculated by assuming a parametric tax function summarizing the complicated structure of taxes in easy-to-interpret and an easy-to-use parametric form. We consider a parametric tax function that maps pre-government income to post-tax income as

$$\tilde{y} = \lambda y^{(1-\tau)}, \qquad \lambda > 0, \qquad 0 \le (1-\tau) \le 1 \tag{A.3}$$

where $\tilde{y}$ is post-tax income, y is pre-government income, λ is a scale parameter that controls the level of the tax rate and τ is a curvature parameter that controls the slope of the function. This function is commonly used in the public finance literature (e.g., Jakobsson (1976), Persson (1983) and more recently, Heathcote, Storesletten and Violante (2017*b*)). [1]

Using this function, we can work out the total tax payment T and the average tax rate $t(y)$ as a function of pre-government income y as

$$T = y - \lambda y^{(1-\tau)} \text{and } t(y) = 1 - \lambda y^{-\tau}.$$

The elasticity of tax liability can be expressed in termed of the adjusted gap between marginal and average tax rates as

$$\frac{m(y) - t(y)}{1 - t(y)} = \tau \tag{A.4}$$

According to the interpretation of tax liability progression in Musgrave and Thin (1948), τ is a measure of the progressivity level in the tax schedule. When marginal tax rate is identical to average tax rate, $\tau = 0$, it implies a proportional income tax system. When marginal tax rate is higher than average tax rate, $\tau > 0$, the elasticity of tax liability is greater than unity and the income tax schedule is progressive.

Alternatively, the elasticity of residual income with respect to pre-government income is given by

$$\frac{1 - m(y)}{1 - t(y)} = 1 - \tau. \tag{A.5}$$

According to the interpretation of residual income progression in Musgrave and Thin (1948), $(1-\tau)$ is the measure of residual income progression (see the third row of Table A.1). An increase in the elasticity implies a reduction in progressivity and vice-versa. A tax system with a lower $(1-\tau)$ is more progressive than one with a higher $(1-\tau)$.

Thus, the curvature parameter τ can be used to a measure of how progressive a income tax system is. Note that, the elasticity approach to measuring tax progressivity can only give an indication of progressivity at a given point on income distribution. This can be viewed as a

[1] The parametric function approach also provides valuable inputs for quantitative studies of fiscal policy in models with heterogeneous agents. Krueger, K and Perri (2016) provide a review of this literature.

local measure of tax progressivity that is dependent on the income level.

Table 9 reports the estimates of the parametric tax function using HILDA and ATO data.

In general, we find these two parameters are estimated with a high degree of precision. Around 99 percent of the variation in the data is explained by the tax function and with very low robust standard errors on both the curvature parameter τ and scaling parameter λ. The estimated values of τ from HILDA data are in a range between 0.055 and 0.067. Meanwhile, the estimated values of τ from ATO data are relatively higher in a range between 0.081 and 0.105 . The parametric tax function quite well represents the Australian income tax code and its changes over time

A.1.2 Tax distribution metric

The tax distribution approach account for changes in income distribution over time that potentially affects tax progressivity. The tax distribution approach measures tax progressivity in terms of the tax liability distribution relative to the income distribution. This approach accounts for both the income tax schedule and income distribution in one measure.

We specifically consider a more general index that takes into account both the income tax schedule and the underlying distribution of income (e.g. see Pfahler (1987)). There are two common global measuresATO unit record data contains 1% sample of records for 2004 – 2011 and 2% sample of records for 2011 – 2016.[2] The samples are selected pseudo-randomly. The units are confidentialised. In that, the top and bottom 1% of each data item is top (or bottom) coded. This is done by creating between one and three cohorts in these top and bottom 1% ranges and each record in that cohort is assigned the average of all records in that cohort for that particular data item. that take this perspective: Kakwani index (Kakwani (1977)) and Suits index (Suits (1977)). Both indices examine the extent to which the tax system deviates from proportionality by comparing the distribution of pre-government income with the distribution of tax liabilities ordered by pre-government income. Intuitively, these two indices measure how tax liabilities are distributed across the income distribution. A more progressive tax system is simply one where the tax liabilities are distributed more unequally toward the higher end of the

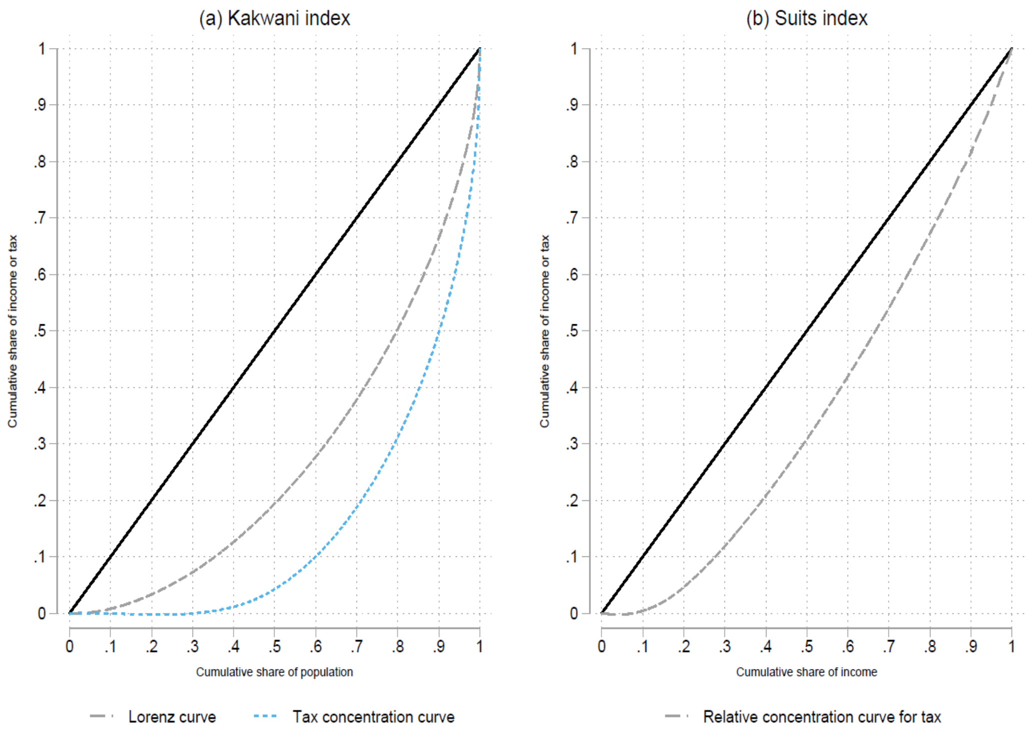
[2]The change in the sampling size does not affect the composition of the sample as the sampling method has been consistently applied on all years.

Table A.2: OLS estimates of the parametric tax function (ATO and HILDA)

	ATO			HILDA		
Year	τ	Constant	Adj R^2	τ	Constant	Adj R^2
2004	0.105	2.467	0.994	0.066	1.625	0.997
	(0.001)	(0.007)		(0.001)	(0.008)	
2005	0.103	2.436	0.994	0.065	1.628	0.997
	(0.001)	(0.007)		(0.001)	(0.008)	
2006	0.096	2.295	0.994	0.066	1.645	0.997
	(0.001)	(0.007)		(0.001)	(0.009)	
2007	0.090	2.182	0.995	0.061	1.606	0.997
	(0.001)	(0.007)		(0.001)	(0.008)	
2008	0.086	2.129	0.995	0.060	1.602	0.997
	(0.001)	(0.006)		(0.001)	(0.008)	
2009	0.086	2.145	0.995	0.057	1.567	0.997
	(0.001)	(0.007)		(0.001)	(0.008)	
2010	0.084	2.123	0.995	0.055	1.545	0.997
	(0.001)	(0.007)		(0.001)	(0.008)	
2011	0.085	2.142	0.995	0.055	1.543	0.997
	(0.001)	(0.008)		(0.001)	(0.007)	
2012	0.082	2.073	0.995	0.058	1.582	0.997
	(0.001)	(0.005)		(0.001)	(0.007)	
2013	0.083	2.101	0.994	0.056	1.559	0.997
	(0.001)	(0.006)		(0.001)	(0.007)	
2014	0.083	2.102	0.994	0.055	1.549	0.997
	(0.001)	(0.006)		(0.001)	(0.007)	
2015	0.083	2.087	0.994	0.058	1.587	0.997
	(0.001)	(0.006)		(0.001)	(0.007)	
2016	0.081	2.048	0.994	0.060	1.626	0.997
	(0.001)	(0.006)		(0.001)	(0.007)	

Robust standard errors given in parantheses.

Figure A.1: Tax concentration curves, Kakwani index and Suits index



income distribution.

To formally define these two indices, we first define the cumulative distribution function and the associated concentration curves. Let Y represent pre-government income and T represent tax liabilities where both are non-negative and continuous random variables where $T = f(y)$. Let μ_Y and μ_T be the means of the pre-government income and tax liabilities respectively. The cumulative distribution function (c.d.f.) is $p = F_Y(y), 0 \leq p \leq 1$. Thus, the Lorenz curve of pre-government income is defined as $L_Y(p) = \mu_Y^{-1} \int_0^p y(x)\,dx$ where $y(p)$ is the pth-quantile of the pre-government income distribution. The tax concentration curve is defined as $L_T(p) = \mu_T^{-1} \int_0^p t(x)\,dx$ where $t(p) = f[y(p)]$. Figure A.1(a) illustrates the Lorenz curve and the tax concentration curves.

The areas under the curves give the concentration index for each respective curve. As such, the concentration index for pre-government income is

$$G_Y = 1 - 2\mu_Y^{-1} \int_0^1 \int_0^p y(x)\,dx \tag{A.6}$$

and the concentration index for tax liabilities is

$$G_T = 1 - 2\mu_T^{-1} \int_0^1 \int_0^p t(x)\, dx \tag{A.7}$$

Kakwani index measures the deviation from proportionality by measuring the difference between the two concentration indices.

$$K = G_T - G_Y \tag{A.8}$$

If each individual's income share is equal to her tax share, the two concentration curves will be equal such that $G_T = G_Y \longrightarrow K = 0$ and the tax system is proportional. If tax shares exceed income shares, the concentration curve for tax will be more convex compared to the concentration curve for income such that $K > 0$ indicating a progressive tax system. Similarly if $K < 0$, the tax system is regressive such that the tax share for each respective individual is lower than the income share.

Suits index takes a different approach but uses the same concept of tax shares relative to income shares. Instead of relying on two concentration curves, the index relies on the relative concentration curve of taxes. The curve plots the cumulative proportion of tax liabilities ordered by pre-government income against the cumulative proportion of pre-government income. The 45 degree line indicates proportionality where tax shares equal income shares. A curve below the line indicates a progressive system where tax shares increase with rising income shares and vice-versa. The Suits index is the area between the 45-degree line and the relative concentration curve. The index ranges from -1 for the most regressive tax possible to +1 for the most progressive tax possible, and takes the value zero for a proportional tax. This is expressed as

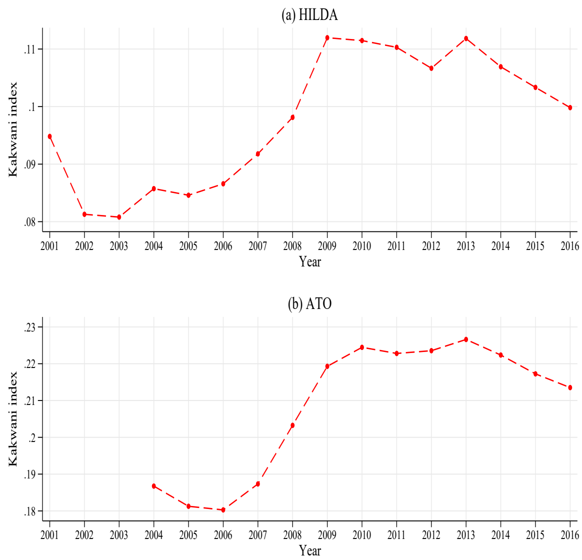
$$S = 2\int_0^1 [q - L_T(q)]\, dq \tag{A.9}$$

where $L_T(q)$ is the relative concentration curve for tax liabilities where $q \equiv L_Y(p), 0 \leq q \leq 1$ is the value of the Lorenz curve for pre-government income associated with the population rank p.

A.1.3 Tax progressivity measured by the Kakwani index

We report in the main paper that there is a cycle of tax progressivity measured by the Suits index. We now report our estimates of Kakwaini index in Figure A.2, using HILDA and ATO data samples. Expectedly, we find again a cycle of tax progressivity since 2001. Thus, the result based on the Kakwani index is consistent with the previous result based on the Suits index.

Figure A.2: Tax progressivity measured by the Kakwani index



Note: The Kakwani index measures tax progressivity in terms of the difference between the Gini coefficient for pre-government income and the concentration coefficient for tax liabilities. The Kakwani index is estimated using HILDA and ATO. Panel (a) reports the estimate from HILDA 2001 to 2016 while Panel (b) reports the estimate from ATO 2004 to 2016.

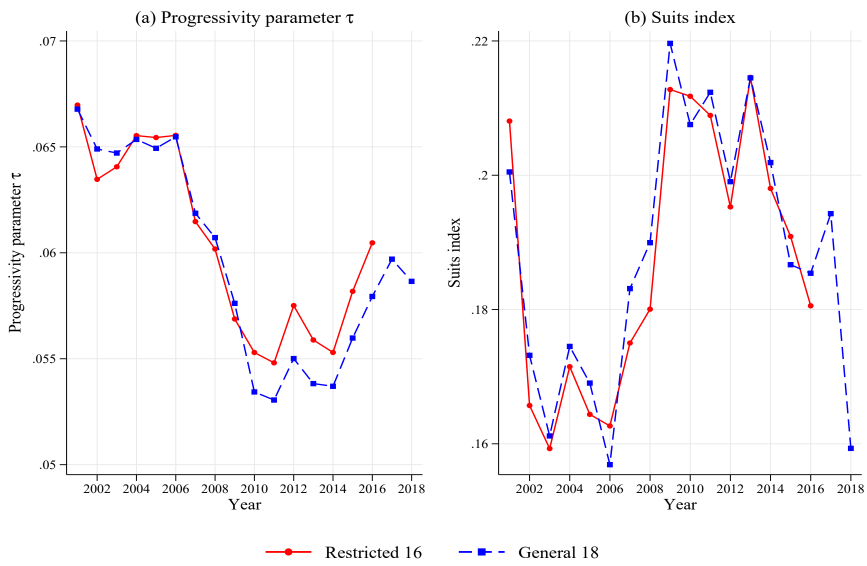
A.2 HILDA: The unconfidentialised vs. confidentialised releases

There are two versions of HILDA: the General (confidentialised) release and the Restricted (unconfidentialised) release which contain more detailed information than the General release, including date of birth, postcodes of residence, and non top-coded income and occupation. In the paper we report the results from the Restricted release 2001 - 2016.[3] In this section we compare the results from the two releases. Figure A.3 plots the two metrics for measuring tax

[3]We currently are in the process of obtaining the unconfidentialised version of HILDA for 2017 and 2018.

progressivity from the General release 2001 - 2018 (dashed blue line) and the Restricted release 2001 - 2016 (red line). Our results indicate that the patterns of tax progressivity trend are fairly similar even though there are differences in the levels of tax progressivity. Moreover, the estimates of the two metrics from the General (confidentialised) release show a sharp decline in the levels of tax progressivity from 2017 to 2018. Panel (b) shows that the cyclical trend in the Suits progressivity index is more pronounced when including the estimates for 2017 and 2018.

Figure A.3: Tax progressivity: General vs. Restricted release



Note: The figure compares trends in tax progressivity using two versions of HILDA: the General (confidentialised) release 2001 - 2018 (dashed blue line) and the Restricted (unconfidentialised) release 2001 - 2018 (red line). Panel (a) plots the curvature parameter τ (tax progression metric), while Panel (b) plots the Suits progressivity index (tax distribution metric).

A.3 ATO data

ATO unit record data contains 1% sample of records for $2004-2011$ and 2% sample of records for $2011-2016$[4]. The samples are selected pseudo-randomly. The units are confidentialised. In that, the top and bottom 1% of each data item is top (or bottom) coded. This is done by creating between one and three cohorts in these top and bottom 1% ranges and each record in that cohort is assigned the average of all records in that cohort for that particular data item.

[4]The change in the sampling size does not affect the composition of the sample as the sampling method has been consistently applied on all years.

The ATO sample used in this paper contains $2,071,348$ units in total and includes 49 variables that provide useful information on demographics and individual components of net income. The large size of the sample enables more precise estimations of mean values and distributions for total income and its respective income components.

However, it is important to bear in mind that the sample only includes those who have lodged a tax return and thus, reported values are not reflective of the entire population. Specifically, the samples drawn from the dataset would be biased towards top income earners and would not include those who earn very little to no income that have no incentive to lodge a tax return. In addition, tax data does not include complete information on all components of income, especially public transfers that are non-taxable. This implies that total income calculated from tax data might not be reflective of actual total income inclusive of all components.

The biggest limitation that we face in using ATO data for our purposes is that it does not contain any information on the actual or estimated tax paid by individuals. Hence, we rely on estimations of the amount of tax paid, the average tax rates and marginal tax rates instead of actual values. Further, information on family structure included in the data is insufficient to accurately estimate tax payments. For instance, there is no information on the number of children and the only information on partner status is a variable that records whether or not a spouse's details such as the date of birth were reported. Hence, levies and offsets that depend on the number of children and partner status are all estimated using the rate for an individual without any dependent children. This results in a biased estimate of tax payments and tax rates.

A.3.1 Differences between tax estimation in ATO and HILDA

Neither of our 2 two datasets have actual tax payments. Taxes and transfers in HILDA are estimated using a comprehensive set of income and demographic variables detailed in Wilkins (2014*a*). We rely on the HILDA tax model and modify its codes to estimate tax liabilities for the ATO data. We now outline the estimate method.

Our calculations for ATO data differ from HILDA on a few major components. First, where HILDA tax calculations account for detailed demographic information, we treat all persons in the ATO sample as being without any dependents. This influences heavily on our calculations

Table A.3: Key differences between HILDA tax and ATO tax estimation

	HILDA	ATO
Dividend imputation credits	Estimated	Actual
Disability support pension (non-taxable)	Estimated	(no data)
Wife pension (non-taxable)	Estimated	(no data)
Carer payment (non-taxable)	Estimated	(no data)
Carer allowance (non-taxable)	Estimated	(no data)
Salary sacrifice pre-2009	0.5% of wages	0.5% of wages
Salary sacrifice post 2009	Estimated	0.5% of wages
Deductions	Estimated	Actual
Taxable income	Estimated	Actual
Tax on superannuation benefits	Approximate	Approximate
Tax on redundancy payments	Estimated	Estimated
Medicare levy	Estimated	Only singles and couples (no dependents)
Senior Australians Tax Offset (SATO)	Estimated	Estimated
Pensioners Tax Offset (PETO)	Estimated	Excludes detailed spouse related pensions
Beneficiary Tax Offset (BTO)	Estimated	(no data)
Senior Aust. & Pensioners Tax Offset (SAPTO)	Estimated	Assume all in eligible age group receives offset
Spouse Tax Offset	Estimated	(no data)
Other offsets	Approximate	Approximate

of the Medicare Levy. The lack of such demographic information in the ATO dataset is a significant drawback in our analysis. Second, due to limitations on information on partners (spouses), we were unable to calculate the Spouse Dependent Tax Offset.

On the other hand, our calculations rely more on actual values rather than imputed values compared to the HILDA dataset. For example HILDA sets dividend franking credits as 41% of reported share income. In contrast, the ATO data includes actual amounts for dividend franking credits. Moreover, HILDA does not include actual deductions and approximates based on ATO statistics. Total deductions are included in the ATO data and taxable income after deductions is also included.

The following Table summarises the key differences between the two estimations.

Table A.4: Summary statistics for ATO data in 2016

	Pre-gov income			Tax			Relative share	Tax rate	
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share	Marginal	Average
Decile 1	5,721.35	0.91	0.91	0.18	0.00	0.00	0.00	0.00	0.00
Decile 2	17,839.45	2.83	3.73	13.68	0.01	0.01	0.00	0.09	0.00
Decile 3	26,869.51	4.26	7.99	800.70	0.60	0.61	0.14	0.19	0.03
Decile 4	35,888.03	5.68	13.67	2,454.06	1.84	2.45	0.32	0.24	0.07
Decile 5	44,429.74	7.04	20.71	5,299.62	3.97	6.41	0.56	0.32	0.12
Decile 6	53,760.50	8.51	29.22	8,587.03	6.43	12.84	0.75	0.32	0.16
Decile 7	65,067.75	10.31	39.53	12,394.41	9.28	22.11	0.90	0.32	0.19
Decile 8	79,557.49	12.60	52.13	17,164.47	12.85	34.96	1.02	0.35	0.22
Decile 9	102,141.99	16.18	68.31	25,072.23	18.76	53.72	1.16	0.37	0.24
Decile 10	200,087.66	31.69	100.00	61,832.74	46.28	100.00	1.46	0.41	0.29
Top 1%	493,875.63	7.82	100.00	181,755.81	13.60	100.00	1.74	0.47	0.36

Note: The table reports the descriptive statistics of income and tax liabilities from ATO data in 2016. Column (1) lists the mean nominal pre-government income for each quantile. Column (2) presents the share of total pre-government income earned by the quantile and column (3) shows the cumulative shares. Columns (4) to (6) repeats the same statistics by quantile for tax payment/liability. Column (7) reports the share of tax liability for each quantile relative to their share of income, namely, Relative Share of Tax (RST). Columns (8) and (9) presents the marginal and average tax rates averaged by quantile.

A.3.2 Summary statistics

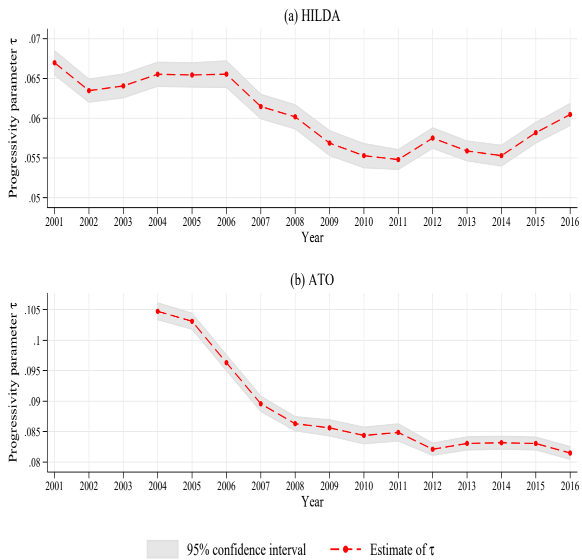
The ATO sample used in this paper contains $2,071,348$ units in total and includes 49 variables that provide useful information on demographics and individual components of net income. The large size of the sample enables more precise estimations of mean values and distributions for total income and its respective income components. However, it is important to bear in mind that the sample only includes those who have lodged a tax return and thus, reported values are not reflective of the entire population. Specifically, the samples drawn from the dataset would be biased towards top income earners and would not include those who earn very little to no income that have no incentive to lodge a tax return. In addition, tax data does not include complete information on all components of income, especially public transfers that are non-taxable. This implies that total income calculated from tax data might not be reflective of actual total income inclusive of all components.

The sample of ATO data does not contain any information on the actual or estimated tax paid by individuals. We impute the amount of tax paid, the average tax rate and the marginal tax rate instead of actual values, using a similar method and codes used to impute tax liabilities in HILDA. Further, information on family structure included in the data is insufficient to accurately estimate tax payments. For instance, there is no information on the number of children and the only information on partner status is a variable that records whether or not a spouse's details such as the date of birth were reported. Hence, levies and offsets that depend on the number of children and partner status are all estimated using the rate for an individual without any dependent children. This results in an approximate estimate of tax payments and tax rates. Nevertheless, trends in progressivity indices are consistent with results obtained from the HILDA sample.

Table A.4 reports the descriptive statistics of income and tax liabilities across the income distribution in 2016 using ATO data. All additional descriptive tables and stylized facts on the distribution of income and tax liability over time from 2004 to 2016 are in the online technical appendix.

A.4 Tax progressivity: Estimates from ATO data

Figure A.4: Tax progressivity measured by the curvature parameter τ



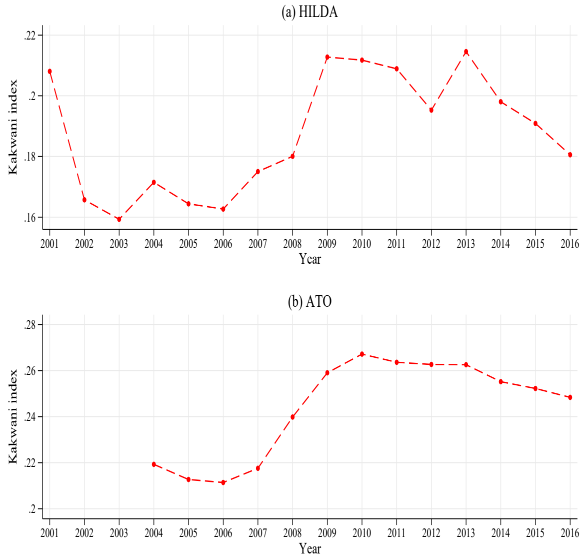
Note: This figure shows the estimates of the curvature parameter τ from 2004 to 2016 using ATO data compared with estimates from 2001 to 2016 using HILDA data, where $\tau = \frac{m(y)-t(y)}{1-t(y)}$.

Figure A.4 displays the estimates of τ and along with the 95% confidence interval using ATO from 2004 - 2016. As shown in Panel (b), there is a declining trend in τ since 2004. Moreover, the trend from ATO data is more pronounced than that from HILDA. The decline in

τ implies that the gap between marginal tax rates and average tax rates has been narrowed down. The main reason is that while the marginal tax rates at the very top of the distribution have not increased by much over the period, the rates at lower quantiles (particularly at the middle) have increased due to the increases in income tax thresholds. The steepest decline in τ is observed between 2005 and 2008 during which the top income threshold was increased substantially resulting in only the top 1 percent paying the top marginal tax rate. Thus, according to this tax progression measure the progressivity level of Australia's personal income tax system, on average, has declined since 2004.

The trend in tax progressivity estimated from ATO data is smoother than the one estimated from HILDA. Most noticeably, the estimates from HILDA data indicate a slightly upward trend while the ones from ATO shows a decline since 2014. This is mostly due to differences in the availability of demographic information between the two samples. Tax liabilities for ATO are estimated ignoring the effect of family structure, while tax liabilities in the HILDA sample take in to account a whole range of demographic information such as the number of dependents enables us to examine the impact of the changes in the income distribution for the subsequent years if a given tax schedule is left unchanged since the first year that indents, age of dependents and marital status. These information are crucial in the calculation of various offsets that reduce tax liabilities.

Figure A.5: Tax progressivity measured by the Suits index



Note: Panel (a) reports the estimates of Suits index, using HILDA data from 2001 to 2016. Panel (b) reports the same using ATO data from 2004 to 2016.

Figure A.5 reports the estimates of the Suits progressivity index using ATO data from 2004 to 2016. Our estimates confirm that there is a tax progressivity cycle, which has a similar pattern to the one previously estimated from HILDA data. That is, there are a modest decline from 2004 to 2006, then a sharp increase until 2010, and a slight decline thereafter. It appears that the tax progressivity cycle estimated from ATO data is smoother than the one estimated from HILDA.

A.5 Further analysis

A.5.1 Household heterogeneity, equivalence scale and tax progressivity

In Australia, all adult individuals are required to file their tax returns separately. However, the characteristics of a household that individuals belong to matter for their actual tax payments. The number of adults and children affect tax liability. The medicare levy and medicare levy surcharge amounts differ based on whether one is in a relationship and in terms of the number of dependent children. Similarly, family benefits and tax offsets such as the family tax benefit Part A and B, and the Senior Australians and Pensioner's tax offset depends on the household composition. In addition, the age of household members and relationship status also affect tax liabilities.

Tables 11 reports the descriptive statistics of the distribution of pre-government income and tax liabilities of Australian households in 2001, 2009 and 2016 . It highlights the substantial degree of concentration of both pre-government income as well as tax liabilities at the top half of income distribution. The top 20% earned around 50% of total pre-government income, while they contributed 60% of the total tax liability.

Table A.5: Household level summary statistics by quantile (HILDA)

(a) 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pre-gov. income				Tax		Relative share
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share
Quintile 1	798.95	0.51	0.51	48.39	0.14	0.14	0.27
Quintile 2	13,430.59	8.51	9.01	1,532.04	4.32	4.45	0.51
Quintile 3	26,921.11	17.05	26.07	4,558.23	12.84	17.29	0.75
Quintile 4	40,485.00	25.65	51.71	8,205.39	23.12	40.41	0.90
Quintile 5	76,224.16	48.29	100.00	21,150.41	59.59	100.00	1.23
Top 1%	218,263.89	6.91	100.00	82,907.41	11.68	100.00	1.69

(b) 2009

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pre-gov. income				Tax		Relative share
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share
Quintile 1	1,866.55	0.76	0.76	43.14	0.09	0.09	0.12
Quintile 2	21,876.56	8.91	9.67	1,802.68	3.88	3.98	0.44
Quintile 3	41,361.16	16.85	26.52	5,694.97	12.27	16.25	0.73
Quintile 4	61,268.15	24.96	51.48	10,968.95	23.64	39.88	0.95
Quintile 5	119,126.58	48.52	100.00	27,898.08	60.12	100.00	1.24
Top 1%	371,402.19	7.56	100.00	101,077.10	10.89	100.00	1.44

(c) 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Pre-gov. income				Tax		Relative share
Quantile	Mean	Share	Cumulative	Mean	Share	Cumulative	Tax share/Income share
Quintile 1	1,901.58	0.62	0.62	88.89	0.15	0.15	0.24
Quintile 2	25,111.74	8.25	8.87	2,094.79	3.56	3.71	0.43
Quintile 3	49,962.62	16.41	25.29	7,345.71	12.49	16.20	0.76
Quintile 4	74,927.98	24.61	49.90	14,084.77	23.95	40.16	0.97
Quintile 5	152,512.34	50.10	100.00	35,193.00	59.84	100.00	1.19
Top 1%	523,166.44	8.59	100.00	113,366.88	9.64	100.00	1.12

Note: Income and tax liability is equivalized using the OECD modified equivalence scale which assigns a value of 1 to the first adult, of 0.5 to each additional adult and of 0.3 to each child below 15 years of age.

Household types are fairly uniform across all years - around 35% are single adult households, 38% are 2 adult households, 8% are 2 adults with 1 child, 10% are 2 adults with 2 children, 5% are 2 adults with more than 2 children and around 6% are single parent households. Table 46 in Apendix A.3 provides more information on summary statistics by household type

The heterogeneity in tax rates by household composition could be examined by including a categorical variable for household type in both the slope and level of our parametric tax function. As such, the function can be written as

$$\ln \tilde{y}_i = \ln \lambda + \beta \mathrm{H}_i + (1-\tau) \times \mathrm{H}_i \times \ln y_i + u_i \tag{A.10}$$

where H is a vector of dummy variables indicating a specific household type and $\tilde{y}_i$and y_i are post and pre-government incomes of household i.

We examine single and couple households, both with children ranging from $0, 1, 2$ and 3 or more children. Since the detailed information of household characteristic is not present in the ATO sample, we solely use the HILDA sample in this analysis. We illustrate how the average tax rates are changed when accounting for different household types.

Figure A.6 shows the average tax rate by multiples of median income for different household compositions for 2016. For both singles and couples, the effective tax free threshold increases with the number of children. Further, the average tax rate at lower income levels decline with the number of children. For couples, the average tax rate converges at higher incomes as benefits associated with children are reduced. Households with 1 adult and dependent children (single parents) have lower average tax rates than couples. This holds true even at higher income levels.

In the presence of such heterogeneity, trends in progressivity generated by individual data can be very different from those generated from household level data. Further, the choice of equivalence scale used to equivalise different types of households could significantly affect results. Since tax and transfers in the HILDA tax model incorporates all household information for each individual, trends generated from equivalised households, it forms a suitable benchmark to compare trends from household level data.

Figure A.7a compares the trend in Suits index from our HILDA individual sample with that from the household sample. Although the pattern in trends are similar, the index generated from the household sample is much lower. It also plots the trend for households equivalised using three equivalence scales used by the Organisation of Economic Cooperation and Development (OECD) Organisation for Economic Co-operation and Development (2013). The first, OECD square root scale divides total household income by the square root of the household size. The second, OECD modified scale assigns a value of 1 to the first adult, of 0.5 to each additional adult and of 0.3 to each child below 15 years of age. The third is the old OECD scale which assigns a value of 1 to the first adult, of 0.7 to each additional adult and of 0.5 to each child below 15 years of age . As seen from the Figure, the square root scale and the modified scale is quite close to unequivalised household data. Yet neither scale matches well with the trends from individual data.

Figure A.7b compares the Suits index trends for the individual sample with trends generated from an alternative specification of the equivalence scale commonly used in the literature on inequality and redistribution (Cutler and Katz, 1992). The scale is defined as

$$s = (a + \theta c)^{\delta} \tag{A.11}$$

where s is the number of adult equivalents that depend on the number of adults a and children c weighted by the resource cost of a child relative to adults θ and a parameter δ that reflect the overall economies of scale of the household. We examine trends generated by different values of θ and δ. Values of δ around 0.4 and θ close to 0.1 to 0.4 generates the closest trend with individual data. In contrast, parameter values of $\theta = 0.6, \delta = 0.8$ used by Herault and Azpitarte (2015) for Australia, and $\theta = 0.7, \delta = 0.6$ used for the U.S by Cutler and Katz (1992) generate significantly lower levels of progressivity. Overall, results from household level data from all equivalence scales support our results using individual level data.

A.5.2 Measuring income inequality

In our paper we use a slightly different definition of income in which we include all incomes accruing to the household in a given year (both regular and irregular income). As a result, our estimates of Gini coefficient are slightly different from previous studies. Figure A.8 displays

Figure A.6: Predicted average tax rates by household type 2016 (HILDA)

(a) Single adults (b) Couples with children

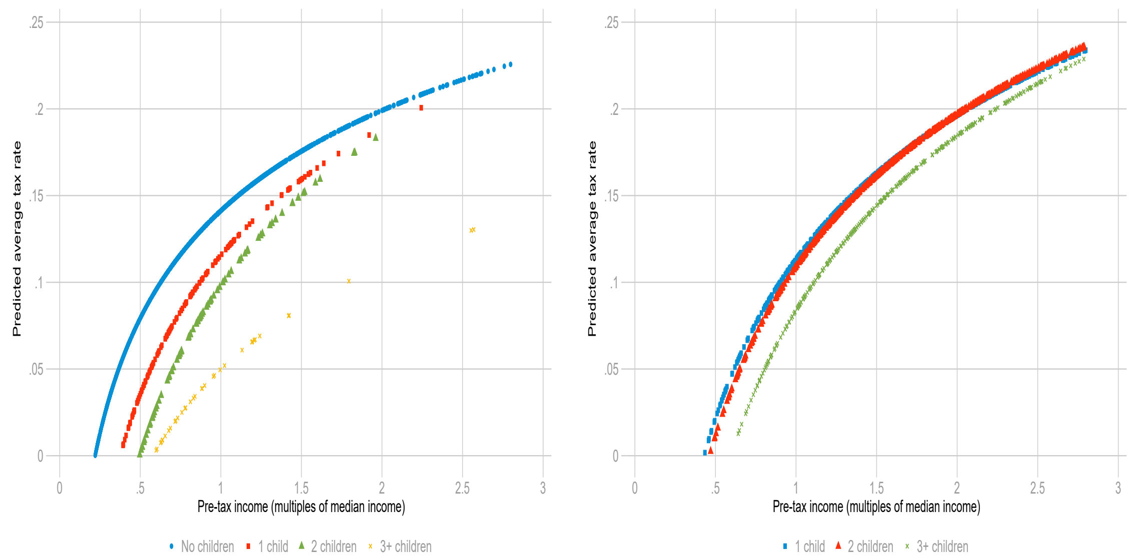
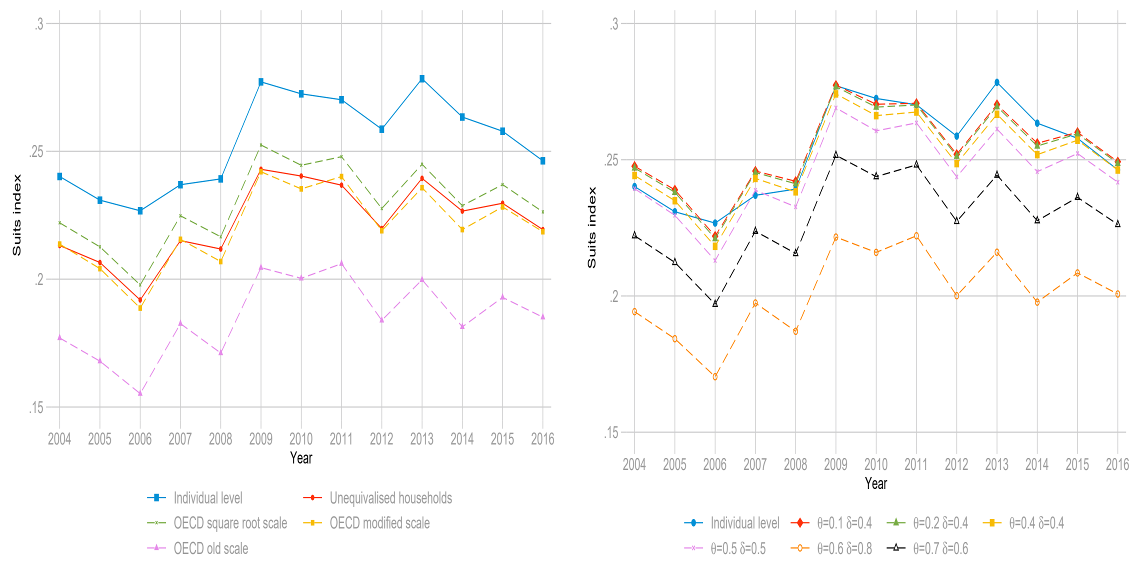


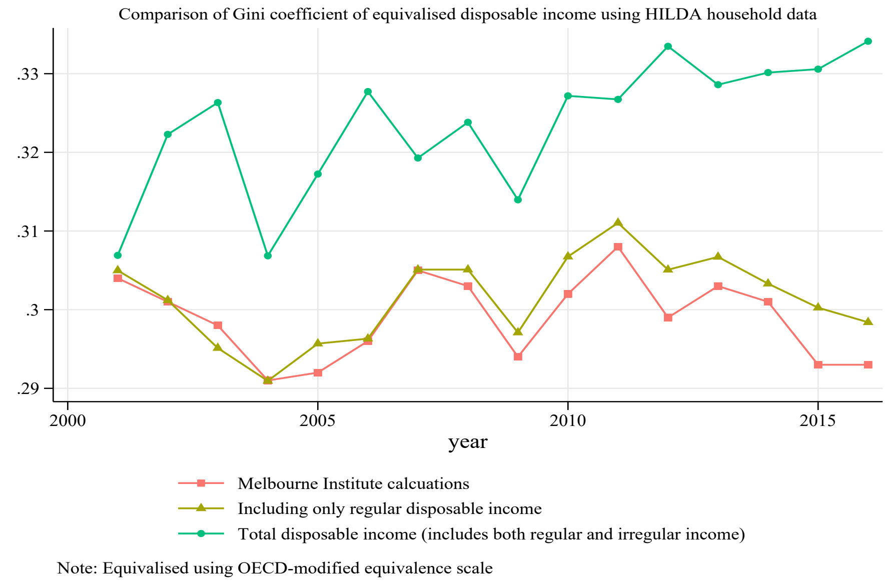
Figure A.7: Comparison of trends in progressivity from individual level data and household data (HILDA)

(a) OECD equivalence scales (b) Parametric equivalence scale



different estimates of Gini coefficient.

Figure A.8: : The Gini estimates in comparison



When using similar definition of income and equivalence scale we are able to closely replicate the trends in Gini coefficient in the previous studies. We reports our Gini estimates in comparison with the Gini estimates by Melbourne Institute in Figure A.8. Note that, only regular disposable income is used in the Gini calculation by Melbourne Institute. When including irregular income the trends in Gini coefficient are slightly higher (see the green line).

A.5.3 Wealth distribution and tax progressivity

Recently, there has been discussions on expanding the asset taxes so as to make Australia's tax system more efficient and fairer. Our analysis could provide some evidence-based foundations for this debate.

We extend the tax distribution metric for measureing tax progressivity in terms of the distribution of tax liabilities relative to the distribution of wealth. We use the household samples from HILDA for the years 2006, 2010 and 2014. Wealth is measured in terms of household net worth which are the total assets net of total liabilities of each household. Table A.6 summarises the distributions of wealth and tax liabilities the years.

Table A.6: Share of wealth by share of income tax liability by percentiles of wealth (HILDA)

	2006			2010			2014		
Percentile	Wealth (%)	Tax (%)	Relative	Wealth (%)	Tax (%)	Relative	Wealth (%)	Tax (%)	Relative
Bottom 20	0.52	6.78	13.09	0.53	6.09	11.55	0.58	5.50	9.50
20 - 40	4.12	15.66	3.80	3.96	15.93	4.02	3.91	16.37	4.19
40 - 60	10.57	16.53	1.56	10.90	18.40	1.69	10.85	19.07	1.76
60 - 80	19.32	21.94	1.14	20.63	21.96	1.06	21.00	21.06	1.00
Top 20	65.47	39.09	0.60	63.98	37.62	0.59	63.66	38.00	0.60
Suits index			-0.38			-0.38			-0.36

Figure A.9: Relative concentration curve for cumulative share of wealth and income tax (HILDA)

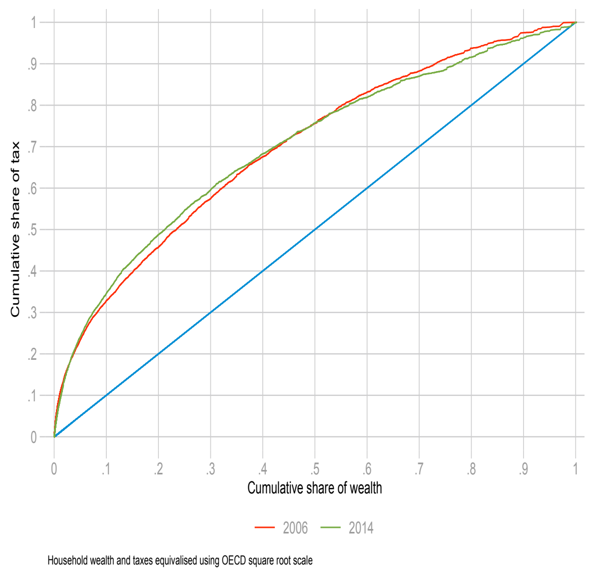


Table 9 provides evidence of significant inequality in the distribution of wealth. In this regard, the bottom 20 percent of households own less than 1 percent of total wealth, while the top 20 percent own more than 63 percent of total wealth - that is, a larger share compared to the all other quintiles combined. Although the share of tax paid increases as wealth increases, the share of tax paid relative to the share of wealth held decreases. In 2006, the share of tax burden of the bottom 20 percent was around 13 times larger than there share of wealth. Whereas, the share of tax paid by the top 20 percent was around half their share of total wealth. Decreasing relative tax liabilities with increasing wealth indicate that income tax is regressive in terms of wealth.

Figure A.9 plots the cumulative share of income against the cumulative share of wealth. The concave shape of the relative concentration curve illustrates this tax regressivity.

Appendix B

Chapter 4: Appendix

B.1 Scaling the model using the parametric tax function

The tax function is highly sensitive to very small changes in the tax function parameters. This has significant impact on how we calibrate our model to match the actual income tax code, and its respective income and tax distributions. In order to match key tax and income statistics, we utilize the tax function to scale the model as follows.

Dropping the subscript i for convenience, let x denote income in the model and y denote actual income of an individual. Let κ be a parameter that maps y to x such that $x = \kappa y$. We utilize the fact that the tax free threshold in the model should reflect the scaled actual tax free threshold $x^f = \kappa y^f$.

Let ${\lambda_x}^{1/\tau}$ denote the tax free threshold in the model, and ${\lambda_y}^{1/\tau}$ denote the actual tax free threshold such that

$$x^f = {\lambda_x}^{1/\tau} \tag{B.1}$$

$$y^f = {\lambda_y}^{1/\tau} \tag{B.2}$$

Since $x^f = \kappa y^f$,

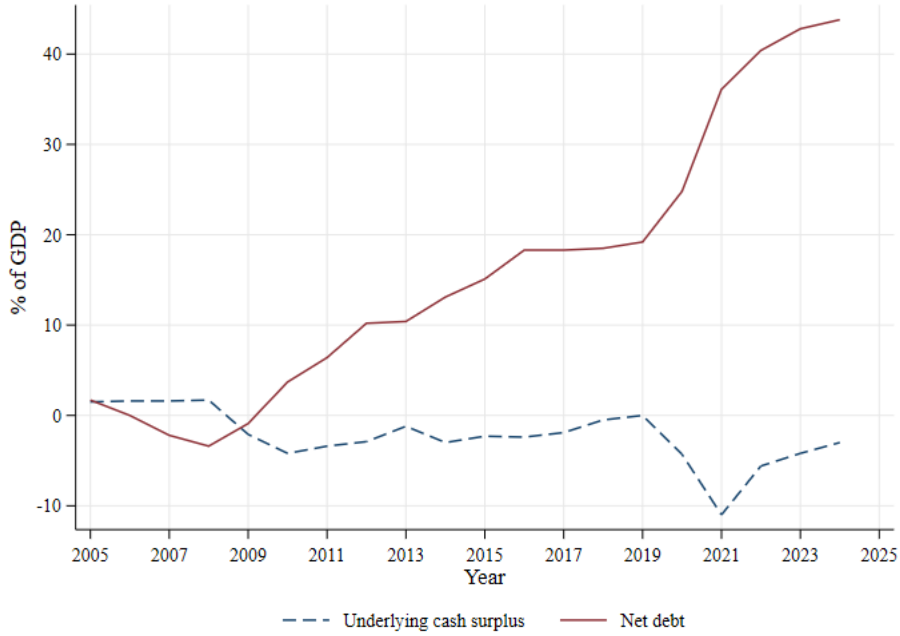
$$\kappa = \frac{{\lambda_x}^{1/\tau}}{y^f} = \left(\frac{\lambda_x}{\lambda_y}\right)^{\frac{1}{\tau}} \tag{B.3}$$

In our computational experiments, we vary λ_x holding the scale parameter κ at the benchmark value. This implies that the actual tax level in the economy λ_y is given by

$$\lambda_y = \frac{\lambda_x}{\kappa^\tau} \tag{B.4}$$

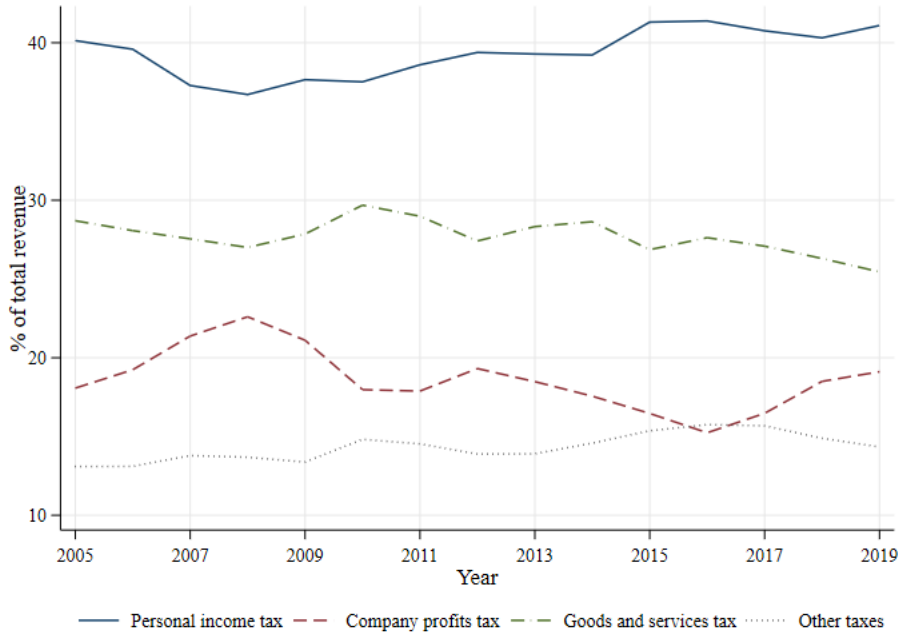
B.2 Extra figures

Figure B.1: Underlying cash balance and net debt 2005-2024



Source: Australian Government Historical Data (Australian Government, 2019). Values for 2021 - 2024 are estimates.

Figure B.2: Composition of main taxes as a percent of total tax revenue



Source: OECD Revenue Statistics.

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