Uneven Growth, Redistribution and Inequality: The Australian Case*

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Abstract

To what extent can a tax and transfer system moderate the distributional impact of unven economic growth? We address these question using the Australian experience of uninterrupted economic growth and rising tax progressivity 1991-2019. Using tax records of millions of taxpayers, we document that majority of Australians are beneficial from market income growth; however, the gains have been shared unevenly across households and generations, with top income groups reaping disproportionate benefits while bottom income groups lag behind. The progressive tax and transfer system plays an important role in moderating unequal gains across groups and over time. The income gap between the rich and poor is significantly reduced after accounting for taxes and transfers. When examining lifetime income, taxes and transfers of nine cohorts over a span of 20 years, we find rising inequality between cohorts over time; however, the magnitude of within-cohort inequality is much less. This finding highlights potential biases when using a point-in-time approach to assessing income inequality. Finally, we construct a structural model and explore the potential impact of different tax system designs. Our simulation results highlight trade-offs between aggregate efficiency and income inequality when relying on higher tax-transfer progressivity to reduce inequality in a dynamic general equilibrium framework.

JEL: E62, H24, H31

Keywords: Growth, inequality, taxation, progressivity, redistribution, dynamic general equilibrium.

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1 Introduction

Over the past decades, income inequality has seen a marked increase across numerous advanced economies. This trend of escalating inequality is particularly conspicuous in Anglo-Saxon nations, with the United States being a prime exemplar (Piketty and Saez;Krueger et al. 2010; Guvenen et al.; Saez and Zucman 2020; Heathcote, Storesletten and Violante 2020; Lippi and Perri 2023). There are three possible explanations for the US experience: (i) long-run growth trends that has favored relatively high skill/income groups (Katz and Murphy 1992; Acemoglu and Autor 2011), (ii) cyclical fluctuations that has long-lasting impacts on low skil/income groups (Heathcote, Perri and Violante 2020; Glover et al. 2020) and (iii) a declining progressivity in the US tax system (Piketty and Saez 2007; Ferriere and Navarro 2022; Borella et al. 2023). Meanwhile, the magnitude of rising income inequal trends has been much less in Europe (OECD 2011) and Australia (Productivity Commission 2018), where the tax and transfer systems are relatively larger and more redistributive.

The goal of this paper is to revisit the redistributive role of a progressive tax and transfer system in moderating the distributional impact of uneven economic growth. We provide new insights by exploring the Australia unique experience of uninterrupted economic growth for three decades from 1991 until the onset of the COVID-19 pandemic in early 2020.

We undertake this investigation in two parts. In the first part, we document the rising tax progressivity in Australia and how the economic benefits of three decades of uninterrupted economic growth have been shared among Australians before and after accounting for taxes and transfers. We use administrative data from the confidentialised tax records of the Australian Tax Office (ATO)'s Longitudinal Information Files (ALife) spanning the period from 1991 to 2019 and containing about 10% of Australian tax payers per year. We employ both point-in-time and lifetime approaches to measuring how growth is distributed before and after taxes and transfers. In the second part, we develop a dynamic general equilibrium model to align with the aforementioned facts. We then use the quantiative structural model to explore the dynamic general equilibrium effects of alternative designs of the progressive tax and transfer system on income inequality and aggregate effciency.

The main findings emerged from our empirical analysis are summarised as follows. First, the 1990s marked a golden period of economic growth, with real GDP per capita growth averaging around 3%. Market income growth during this period closely mirrored GDP growth, particularly between 1996 and 2000, when the average market income growth was approximately 3.68%. However, this momentum decelerated in the 2000s. Coinciding with slower GDP growth, the rate of market income growth reduced to around 1.43% between 2001 and 2005, and further receded to below 1% over the subsequent 15 years. After all, the uninterrupted economic growth has resulted in a significant improvement in market income, rising by around 45% from $45,000 in 1991 to $65,000 in 2019.

Second, majority of Australians reaped the benefits of uninterrupted growth; however, the distribution of economic gains was uneven across groups with a large variation over time. From 1991 to 1995, market income growth was on average negative below the median. Nevertheless, the tax and transfer system effectively mitigated this decline, resulting in a post-government growth that hovered around 0. During the rapid growth period of 1995 to 2000, the bottom 25% experienced higher growth rates (around 5-10%) relative to the median and upper quantiles, barring the top 1%, which observed approximately 5% growth in market income. However, due to stagnant income tax policy during these years, bracket creep occurred, and more income at the lower end was appropriated as taxes. Consequently, post-government income growth was significantly lower, averaging around 1% at the bottom. In the following years, the distribution of market income growth and post-government income growth was relatively more even. Strikingly, there has been little or no benefit from the three decades of uninterrupted economic growth for individuals at the low end of the income distribution. Our analysis reveals a rising trend in market income inequality since 1991. Especially, there was a steep increase in the Gini coefficient of market income inequality between 1991 and 1995, commensurate with the distribution of market income growth favouring those above the median income during those years. With the distribution of market income growth becoming more uniform in the 2000s, market income inequality also plateaued. The income gap between the rich and the poor is significantly reduced after accounting for taxes and transfers. Post-government income inequality generally paralleled market income inequality, albeit at a lower level, indicating the efficacy of the tax and transfer system in alleviating income inequality.

Third, our lifetime approach substantiates findings derived from the point-in-time approach. The cohorts who turned 30 and spent most of their 30s during the 1990s witnessed relatively uneven market income growth, with the bottom deciles exhibiting growth rates of lifetime market income around 1%-1.5%, while the top deciles experienced growth around 3%. The growth incidence curves for cohorts who entered the sample between 1993 and 1996 exhibit a U-shaped pattern, wherein growth at the bottom decile was higher at 2% compared to 1% at the median, while growth at the top reached around 1.5%. This pattern reverses for the younger cohorts (after 1997) at the top, where the top decile demonstrates lower lifetime market income growth in comparison to both the median and the bottom decile.

Although point-in-time market income inequality escalated over the three decades, inequality viewed from the lifetime perspective reveals a significantly different trend, one that remains relatively stable. This is attributable to the transition in growth incidence curves from a steep upward sloping pattern for older cohorts to a U-shaped pattern for middle and younger cohorts. Specifically, for these middle and younger cohorts, we observe higher lifetime market income growth at the lower quantiles. Furthermore, for the younger cohorts (those entering the sample between 1996 and 1999), we note lower growth rates for the very top percentiles compared to the rest of the lifetime market income distribution.

Fourth, a salient trend we can discern is that the tax system has grown increasingly redistributive over time. This is evident by a marked increase in the Reynolds-Smolensky index of the redistributive effect of lifetime tax from the 1991 cohort to the 1999 cohort.

This escalation is primarily due to the concurrent increase in both lifetime tax progressivity and the magnitude of lifetime tax. Notably, we observe a significant rise in these three measures from the 1995 cohort to the 1999 cohort. This trend aligns with the experiences of cohorts who faced an increase in point-in-time tax progressivity since 2006 for a more extended period of their working lives.

Finally, our focus shifts to examining the redistributive role of the tax and transfer system on the long-run balanced growth path. To accomplish this, we formulate a general equilibrium overlapping generations model, calibrated to align with the essential macro-fiscal and distributional characteristics of the Australian economy between 2000 and 2004. We employ our model to scrutinize the effects of progressive income tax on long-term income inequality. This involves an assumption that the economy is on a balanced growth path, with a growth rate approximating the 2000-2004 levels. We then contemplate counterfactual steady-state economies with alternative income tax codes exhibiting varying degrees of progressivity.

Our experiments demonstrate that the incentive effects on work and savings, which are induced by tax and transfer policies, significantly influence market income inequality. Notably, under the current transfer system, an increase in tax progressivity results in a minimal increase in market income inequality, as progressive tax tends to disincentivize saving and work at the lower end of the income distribution. If the transfer system is eradicated, market income inequality diminishes as those at the bottom save more. However, our most significant finding is the substantial role of the tax and transfer system in considerably reducing post-government income inequality, underscoring the impact of both progressive tax and transfers.

The paper proceeds as follows. Section 2 provides a description of the dataset and empirical methods. Section 3 presents empirical facts on trends in income growth, distribution and redistribution in Australia from 1991 - 2019 from the point-in-time and lifetime perspectives. Section 4 presents a structural model and calibration. 5 uses the structural model to examine the role of tax and transfers in long run growth and redistribution. Section 6 concludes. Appendix reports additional information and results.

Related studies. There is a literature studying the distributional impact of business cycles (e.g., see Hur 2018; Heathcote, Perri and Violante 2020; Glover et al. 2020). These studies show that the welfare effects of a severe and long-lasting recession such as the Great Recession, are unevenly distributed. Differently, we focus on the distributional impact of a long-lasting economic growth, using the Australian unique experience of uninterrupted economic growth. We show how the effects of the long-run growth trend due to persisten aggregate shocks are unevenly distributed across households and generations over time.

We contribute directly to the large literature on income inequality in advanced economies (e.g., see Piketty and Saez 2003; Krueger et al. 2010; Guvenen et al.; Saez and Zucman 2020; Heathcote, Storesletten and Violante 2020; Lippi and Perri 2023). Our paper is also related to a large literature documenting income dynamics and inequality trends (e.g., see Guvenen et al. 2021; De Nardi et al. 2021; Guvenen et al. 2023). In particular, Guvenen et al. (2023) use panel data on individual labor income histories from 1957 to 2013 to document empirical facts about the distribution of lifetime income in the United States. We contribute to that literature new insights from Australia's unique experience.

Our paper is closely related to the literature on approximating progressive income tax codes using parametric tax functions (Benabou 2002; Heathcote, Storesletten and Violante 2017; Heathcote and Tsujiyama 2021). Several papers estimate the tax functions and levels of tax progressivity for the U.S. and other OECD countries (Heathcote, Storesletten and Violante 2020; Ferriere and Navarro 2022; Borella et al. 2023). This literature substantial evidence suggests a declining progressiveness in the US tax system. We contribute to that literature an estimation of the Australia income tax code. We show that, unlike the US, there is an increasing progressiveness in the Australian tax system since 1991, which contributes to moderating the rise in income inequality in Australia.

There is a growing literature documented inequality in Australia (e.g., see Leigh 2005; Wilkins 2015; Chatterjee, Singh and Stone 2016; Kaplan, Cava and Stone 2018; Productivity Commission 2018; Fisher-Post, Herault and Wilkins 2022). Our paper initiates first steps to account for lifetime income when analysing the trend towards growing inequality and the role of fiscal progressivity in Australia. Our paper is also related to a number of empirical studies on the redistributive and social insurance effects of the Australian tax and transfer system (Herault and Azpitarte 2015; Tran and Zakariyya 2021; Tin and Tran 2023). These previous studies rely mainly on household survey data. This paper offers a different perspective from administrative data.

2 Data and measurements

We begin by giving a brief overview of our primary data source, income concepts, measures and empirical methods.

2.1 Data

ALife data. Our primary data source is the ATO Longitudinal Information Files (ALife). This consists of a 10% random sample of individual tax filers in ATO's 2016 client register. The data contains tax records for each individual over the period. Each year a 10% random sample of new tax filers are added to the sample.[1] Our unit of measurement is the individual. In the Australian income tax system, all income tax liabilities are at the individual level and there is no joint-filing of tax returns. Our empirical analysis relies on two seperate samples.

[1] For more information on the ALife data and its compilation, see Abhayaratna, Carter and Johnson (2021).

Cross-sectional (point-in-time) sample. Our cross-sectional sample provide us a point-in-time snapshop of annual income, tax and public transfer data between 1991-2019. We use consumer price index (CPI) to convert variables to 2019 Australian dollar value. We exclude those who earned negative market income from our sample. Table 1 provides the number of individuals in our sample for 1991, 2010 and 2019[2].

Table 1: Frequency of individuals - ALife data and sample

Year	Data	Sample	% Included
1991	983,476	736,584	75
1995	1,012,619	770,549	76
2000	1,076,254	838,057	78
2005	1,203,103	897,518	75
2010	1,338,919	976,803	73
2019	1,530,918	1,185,275	77

The sample for each year is quite balanced between males and females, with males composing of 50%-55% of individuals. The proportion of females in the sample steadily increases from 45% in 1991 to 49% in 2019 (Table 2). The age distribution is fairly constant across all years and genders with the mean age for both males and females are around 41 (SD = 15).

Table 2: Frequency and age distribution of males and females in selected years

		1991	1995	2000	2010	2019
Gender						
+ Male (%)		55	55	54	54	51
+ Female (%)		45	45	46	46	49
Age						
+ Male	Mean	41	41	42	41	42
	SD	15	15	15	14	15
	Median	38	39	40	40	40
+ Female	Mean	40	41	42	41	42
	SD	15	15	15	14	14
	Median	38	38	40	40	40

2.2 Income concepts

Our analysis employs various income concepts to provide a statistical description of growth, redistribution and inequality. For illustration, we consider an individual i aged j at time t, where $i \in \{1, ..., N\}$, $j \in \{j_1, ..., J\}$ and $t \in \{1991, ..., 2019\}$. The household budget constraint at a point-in-time is given by

[2] We provide more detailed summary statistics in Appendix

$$c^i_{j,t} + a^i_{j+1,t} = \overbrace{\underbrace{w^i_{j,t} n^i_{j,t} + r^i_{j,t} a^i_{j,t-1}}_{y^{i,market}_{j,t}\text{: market income}} - t^i_{j,t} + tr^i_{j,t}}^{y^{i,post-gov.}_{j,t}\text{: post-government income}} + b^i_{j,t} + a^i_{j,t}, \tag{1}$$

where $c^i_{j,t}$ is consumption, $a^i_{j,t-1}$ and $a^i_{j+1,t}$are asset holdings (net wealth) at age j and $j+1$ respectively, $w^i_{j,t}$ is wage rate, $n^i_{j,t}$ is labour supply, $r^i_{j,t}$ is rate of investment return, and $t^i_{j,t}$ is tax payment. Three are four sources of income: labor income $w^i_{j,t} n^i_{j,t}$, capital income $r^i_{j,t} a^i_{j,t}$, public transfer income $tr^i_{j,t}$, and $b^i_{j,t}$ private transfer income including inheritances, inter-vivos transfers and private gifts.

Accordingly, our market income concept includes labour and capital income, $y^{i,market}_{j,t} = w^i_{j,t} n^i_{j,t} + r^i_{j,t} a^i_{j,t-1}$. After-tax income is $y^{i,after-tax}_{j,t} = y^{i,market}_{j,t} - t^i_{j,t}$, while after-transfer income is $y^{i,after-transfer}_{j,t} = y^{i,market}_{j,t} + tr^i_{j,t}$. Finally, post-government income is given by $y^{i,post-gov.}_{j,t} = y^{i,market}_{j,t} - t^i_{j,t} + tr^i_{j,t}$.

Point-in-time income. The household budget constraint encompasses all flows accruing to and from the individual at any given point in time. ALife data provides us with fairly accurate information on annual market income. We calculate labor income ($w^i_{j,t} n^i_{j,t}$) from salaries, wages and other employment income. Similarly, we calculate capital income ($r^i_{j,t} a^i_{j,t-1}$) from dividend income, interest and investment income, rental income, net capital gains/losses and superannuation income. Our income tax payment ($t^i_{j,t}$) is measured in terms of net tax payments reported in ALife. Public transfers ($tr^i_{j,t}$) includes all government allowances, pensions and other transfer payments reported in the tax file. Note that, ALife data has some information on private transfer ($b^i_{j,t}$), but does not have any information about consumption ($c^i_{j,t}$) and assets ($a^i_{j,t}$).

Our empirical analysis above relies on point-in-time measures of annual income. This cross-sectional approach offers a snapshot of income inequality across individuals at a given point in time. However, it neglects the substantial fluctuations in individual income flows and wealth stocks over their life time and the changes in demographic structure. This limitation of the point-in-time approach can be illuminated through a simplified example of identical individuals observed at varying stages in their lifecycle. Assuming that these individuals work and pay taxes only during their younger years and receive transfer payments exclusively in old age, everyone would consume the same amount throughout their life, thus maintaining identical lifetime living standards. Consequently, a lifetime assessment would indicate no real-term inequality in living standards, either across or within generations. To rectify this measurement bias, we turn to lifetime income measures in our calculation of summary statistics and trends.

Lifetime income. We follow a similar approach as in Guvenen et al. (2023) to measure lifetime income, taxes and transfers. More specifically, we define lifetime income as the total income earned by individuals from age 30 to 50. Utilizing a balanced panel of individuals over a 29-year span, we are capable of monitoring nine cohorts of individuals who reached the age of 30 between 1991 and 1999. Income, taxes, and transfers are measured in nominal values, with the Consumer Price Index (CPI) employed to convert these nominal values to real terms. Note that, while 30 - 50 years cover a major portion of an individual's working life, it does not complete the entire lifecycle. However, if we consider a longer age span we have few cohorts as ALife tracks only the past 30 years.

Technically, lifetime market income is given by

$$LY_{t_\kappa}^{i,market} = \sum_{j=j_1}^{J} w_{j,t+j-1}^{i} n_{j,t+j-1}^{i} + \sum_{j=j_1}^{J} r_{j,t+j-1}^{i} a_{j,t+j-1}^{i} \tag{2}$$

We group individuals by cohort and index each cohort by the year they entered the sample t_κ. We track each cohort for 20 years from the year they turned 30 ($j_1 = 30$) till the year they turned 50 ($J = 50$). Similar to Guvenen et al. (2023) we do not discount future incomes when computing lifetime income. We compute lifetime taxes, public transfers, after-tax income, after-transfer income and post-government income in the same manner.

Lifetime sample. We consider a lifetime sample of individuals between 30 and 50 years of age that filed a tax return in each consecutive year over a period of 21 years. Table 3 list the cohorts (labeled by year they turned 30), their birth years, the year they turned 50 ("last year"), frequency and the composition by gender. In each cohort, around 60% are male and 40% are female. The cohort sample size is sizable at around 11,800-12,400 individuals per cohort. The lifetime sample has more male individuals for each cohort, but the proportion of male decreases over time from 60% for c1991 to 57% for c1999.

Table 3: Sample composition by cohort and gender

Cohort	Birth year	Last year	N	Males (%)	Females (%)
c1991	1961	2011	12,447	60	40
c1992	1962	2012	12,454	61	39
c1993	1963	2013	12,453	60	40
c1994	1964	2014	12,311	60	40
c1995	1965	2015	11,834	60	40
c1996	1966	2016	11,711	59	41
c1997	1967	2017	11,754	58	42
c1998	1968	2018	11,779	57	43
c1999	1969	2019	12,501	57	43

2.3 Measurements

Income growth. To investigate the changes in income inequality that occurred over the past three decades, we begin by analyzing the patterns of growth in market income and post-government income. Our analysis employs both point-in-time and lifetime approaches to define income growth. Specifically, we use growth in income between two consecutive years as a point-in-time measure, while we use the growth in lifetime income between two consecutive cohorts as a measure from the lifetime perspective. In both cases, we examine income growth across the market income distribution as well as average and median income growth.

Income distribution. To further explore the distribution of aggregate point-in-time and lifetime income, we employ a range of local and global measures outlined in this section. We provide a detailed exposition of income and tax distributions, lorenz curves and distributional indices in Appendix A. Our base income concept is market income. Hence, we examine distribution and redistribution across quantiles of the market income distribution. Our primary measure of market income inequality is the Gini coefficient, denoted as G_X. We denote the market income level of an individual i as x and the total market income as X.

Tax distribution. Let $t(x)$ represent the tax liability at income level x and total tax revenue be T. The overall average tax rate is $t = \frac{T}{X}$. Let L_{X-T} and L_T denote the concentration curves (plotted against percentiles of market income p) for post-tax income, and tax respectively. The concentration coefficients for post-tax income is then

$$C_{X-T} = 1 - 2\int_0^1 L_{X-T}(p)\, dp \tag{3}$$

Similarly, the concentration coefficient for tax is

$$C_T = 1 - 2\int_0^1 L_T(p)\, dp \tag{4}$$

Tax progressivity. The concentration coefficients above can be used to measure tax progressivity. In this regard, one useful measure is the Kakwani (1977) index of tax progressivity given by the difference between the tax concentration index (C_T) and the Gini index for pre-tax income.

$$K_T = C_T - G_X \tag{5}$$

The limits of the Kakwani index depends on the degree of pre-tax income inequality. The range is $[-(1+G_X), (1-G_X)]$. The closer to the latter the more progressive is the tax system.

Another useful measure of tax progressivity is the Suits (1977) index S_T, calculated by plotting the cumulative proportion of tax liability ordered by pre-tax income against the cumulative proportion of pre-tax income. The indexed is measured as twice the area between the 45° line and this relative concentration curve. The range of the Suits index is $[-1, 1]$.

In the case of both Kakwani and Suits indices, an index value of 0 indicate a proportional tax.

Redistributive effect and decomposition. In order to quantify the redistributive effect of progressive income tax, we use the Reynolds and Smolensky (1977) index of redistributive effect RS_T . Technically, the Reynolds-Smolensky index measures the difference between the Gini coefficient of market income (G_X) and the Gini coefficient of after-tax income (G_{X-T}). The range of the Reynolds-Smolensky index is $[G_X - 1, G_X]$.

Lambert (2001) points out that tax progressivity is just one aspect of redistribution and the scale of the tax system also influences its impact on income inequality. We follow a similar approach and decompose the redistributive effect of income tax into two components: (1) size of tax and tax progressivity.[3]

$$RS_T = \overbrace{\frac{t}{1-t}}^{\text{[1] Size: Average rate of tax on \textbf{net} income}} \times \underbrace{K_T}_{\text{[2] Progressivity: Kakwani index}}. \tag{6}$$

Following a similar manner we construct the distributions of public transfer and post-transfer income, concentration curves, and transfer progressivity indices and the redistributive effect index for public transfer.

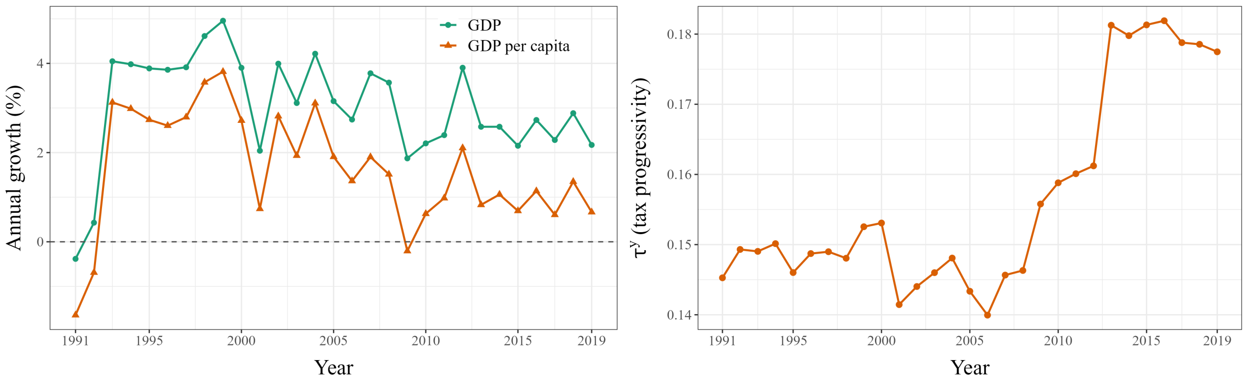
3 Empirical facts

In this section, we present key empirical facts on market income growth, distribution and redistribution in Australia from 1991 - 2019.

3.1 Economic growth and tax policy 1991-2019

We contextualize our empirical analysis around two salient facts. First, Australia experienced 30 years of uninterrupted economic growth since the recession of mid 1990 to late 1991 until the onset of the COVID-19 pandemic in early 2020. Second, although the tax system underwent periods of major reforms, Australia has maintained a highly progressive income tax code, in which income tax thresholds are not indexed to inflation and transfer benefits are widely means-tested to target who in need. Figure 1 shows two plots that summarise these two facts.

[3] Additionally, we note that while redistribution can also be affected by reranking, the Australian income tax system exhibits very little inherent reranking, and the reranking correction is negligible. Please see Appendix A for further details.



(a) Annual growth in GDP and GDP per capita.

(b) Trends in the progressivity parameter τ^y.

Figure 1: Economic growth and income tax policy. Note: Panel (a) plots annual growth rates of GDP and GDP per capita (Source: World Development Indicators (WDI) database). Panel (b) plots the change in the progressivity of the tax system (Source: ALife data. See Appendix A.3 for estimation).

Uninterrupted growth. Figure 1a plots growth in real GDP and real GDP per capita. As evident, while growth was uninterrupted, it fluctuates across time. The 1990s was a golden period of economic growth with annual GDP per capita growth around 3%, while the last decade was a period of secular decline.

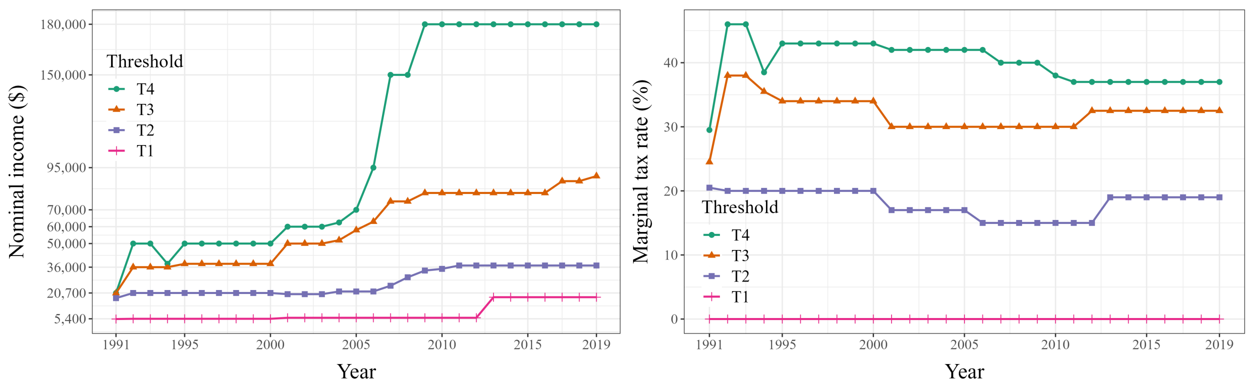
Income tax progressivity. The Australian income tax code is quite complex with numerous offsets, tax credits and levies in addition to the standard tax schedule. We approximate the income tax code using a parametric tax function commonly used in the public finance literature (e.g., see Jakobsson (1976), Persson (1983), Benabou (2002) and Heathcote, Storesletten and Violante (2017)). More specifically, the income tax function is given by $t(y) = y - \lambda y^{(1-\tau^y)}$, where $t(y)$ is total tax liability, y is taxable income , τ^y is progressivity parameter and $(1-\lambda)$ is average rate of taxation .

Figure 1b serves as a summary of key changes to Australia's income tax policy in a single parameter that measures its progressivity.[4] The progressivity parameter τ^y has risen sharply in years. Figure 1b shows the trend in τ^y from 1991 to 2019. Throughout the 29 years, the Australian personal income tax system has been very progressive. The value has ranged between 0.14 to 0.18, which is in the top range of parameter value for OECD countries with highly progressive tax codes (see Holter, Krueger and Stepanchuk 2014). We also observe the period of relative inaction in the 1990s where the tax progressivity trend is fairly flat, and the steep increase since 2006 in line with generous concessions given to low incomes. In the last decade, since the sharp rise in 2012-2013, the level of tax progressivity has been at its highest since 1991.

Bracket creep. In Australia, income tax brackets/thresholds are not indexed automatically to rising nominal incomes. The Australian government is expected to adjust income tax

[4]See Appendix A.3 for more details of the function and estimation using ALife data.

brackets through discretionary changes; however, it often leaves tax brackets unchanged. As a result, growth in nominal taxable income due to productivity growth and inflation moves more and more Australians into tax brackets with higher tax rates. This phenomenon arising from the lack of indexation is known as "fiscal drag" or "bracket creep". Figure 2 displays the personal income tax code and how it has changed over time. There was a period from 2000 to 2009 when the government regularly adjusts income tax brackets, namely an "active" tax policy. These adjustments are resulted from a series of changes after the introduction of a New Tax System (Goods and Services Tax) Act 1999.



(a) Tax thresholds

(b) Statutory marginal tax rates

Figure 2: Statutory income tax code 1991-2019. Note: The figures depict trends in the standard tax schedule. In addition to the standard tax schedule, the income tax system comprises of various tax offsets, credits and levies. We leave them out for the sake of conciseness. However, all components of the tax system are captured in our tax statistics and measures as they are based on net tax liability reported in ALife data.

3.2 Point-in-time measures

3.2.1 Growth over time and across the distribution

We begin by analysing how market and post-government income has evolved over time, and then turn to differences across age groups, genders and income groups. We finally focus on how the gains from the three decades of uninterrupted growth have been shared among the population.

Rising trend in market income. The the trends in mean and median income from ALife data echo trends in GDP per capita. Figure 3 illustrates the annual mean and median market incomes from ALife data, along with GDP per capita. The trend lines start from the early 1990s recession. Overall, both mean and median market income follow upward trends similar to GDP per capita. Specifically, from 1991 to 2019 market income rose by around $20,000, from $45,200 to $65,000.

Income growth was not stable. There is a mix of rapid growth and stagnation periods, with both mean and median market income remaining relatively stagnant until 1997. However, the following decade witnessed a sharp increase in average income that persisted until the Global Financial Crisis (GFC) in 2007. Since then, average incomes have remained relatively stable from 2007 to 2019.

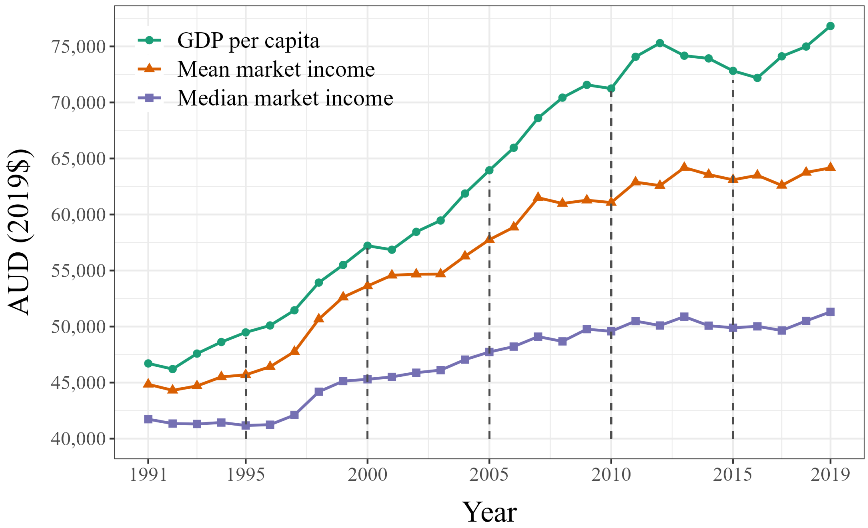


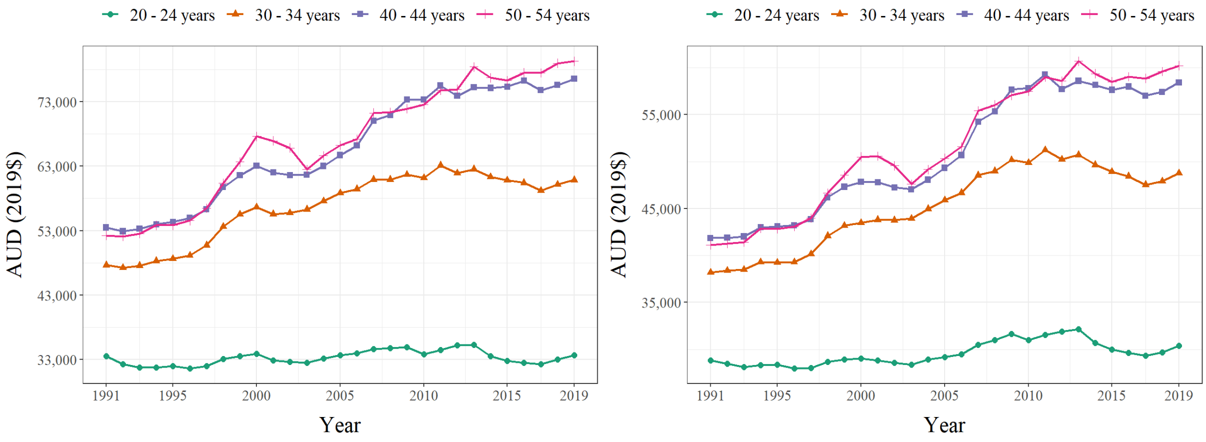
Figure 3: Average trends in market income in comparison with GDP per capita. Note: All values are adjusted for inflation using the CPI with 2019 as base year. GDP per capita (current LCU) was obtained from World Development Indicators (WDI) database.

Table 4: Annualised growth in market income in comparison with GDP per capita growth

Growth (%)	1991 - 2019	1991 - 1995	1995 - 2000	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2019
Mean market income	1.30	0.48	3.26	1.50	1.14	0.67	0.43
Median market income	0.75	-0.34	1.94	1.06	0.77	0.14	0.71
GDP per capita	1.81	1.46	2.95	2.26	2.20	0.46	1.36

To facilitate comparison across time periods, we divide each decade into five-year sub-periods. Table 4 presents the annualized percentage change in mean and median market income, along with the annualized growth rate in GDP per capita. Consistent with the observations from Figure 3, Table 4 highlights a significant growth in market income during the late 1990s and early 2000s. However, in the subsequent years, the growth rates of both mean and median market income exhibited a gradual decline, suggesting a slowdown in the expansion of market income. Notably, the growth rates of mean and median market income are relatively similar, except for a few exceptions. This similarity implies that the overall distribution of market income did not undergo substantial changes over time.

Income growth by age group. We exam trends in income for four age groups: 20-24, 30-34, 40-44 and 50-54. Figure 4 displays the market income trends from 1991 to 2019. We observe uneven income growth across age groups. Market income growth is disproportionally higher for older groups 40-44 and 50-54, while younger groups 20-24 and 30-34 have been left behind. The most strinking fact is that there is virtually no change in the level of mean market income for group 20-24 in the past three decades. An average Australian in 20-24 group practically has a similar income level of around 33,000 AUD after three decades.



(a) Market income

(b) Post-government income

Figure 4: Trends in market and post-government income by age group 1991 - 2019

Income growth by gender. We study how income has evolved over time for males and females separately.

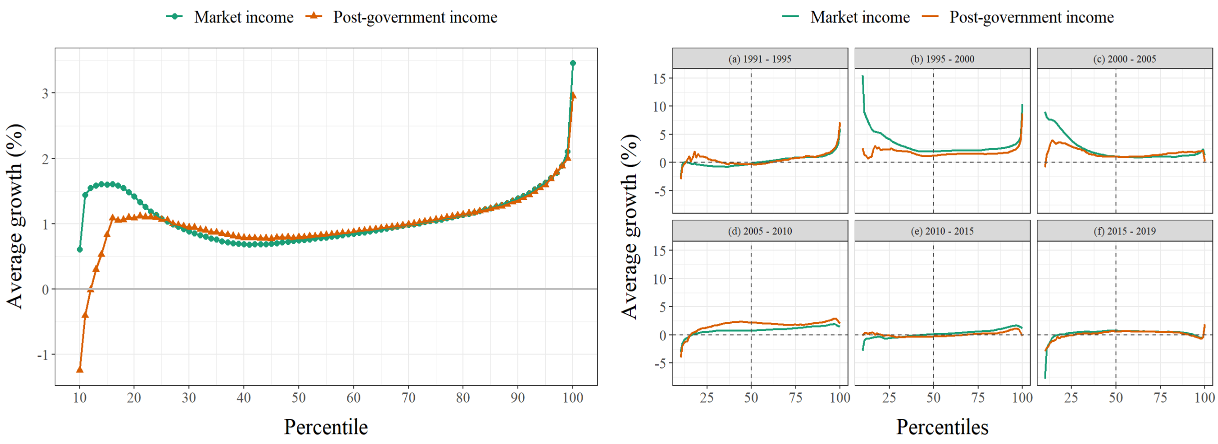
Add Figure: Trends in average market and post-government income by gender 1991 - 2019 (similar to figure 4)

Income growth across the distribution. We now turn to whether income grows evenly across the distribution. We calculate the annualized growth rate by quantiles of the market income distribution (i.e., distributional incidence of growth).

Figure 16a plots the annualized growth rate of market income and post-government income across the market income distribution 1991-2019. There are two growth incidence curves: yellow one for market income and green one for post-government income. It appears that all groups are beneficial from the uninterrupted economic growth as they all have positive annualised growth market income rates. Majority of income groups experience annualised market income growth between 1% and 2%, on average. However, there are a spike to 4.5% and a drop to 0.5% at the very top and bottom end of the distribution, respectively.

We observe that majority of Australians benefited from the three decades of uninterrupted economic growth. Individuals in P30-P70 group have experienced very similar income growth. The annualised growth for post-government income is higher than that for market income among P25-80 group. This implies that the progressive tax and transfer system has redistributed income from the top to the middle of income distribution. Unexpectedly, the post-government income growth is lower for the P25 group.

The growth incidence curve for post-government income is very close to the one for market income among P50-95 groups. There are much bigger gaps at the low end and very top of the distribution. Note that, the distance between these two incidence curves and the variation in their pattern across the income distribution provide insights into the impact of the tax and transfer system.



(a) 1991-2019 (b) Sub-periods

Figure 5: Annualised growth incidence curves for market income and post-government income. Note: Except for the bottom 10%, growth rates are based on the average income in each percentile. Incomes for the bottom 10% are averaged together to smooth the curve.

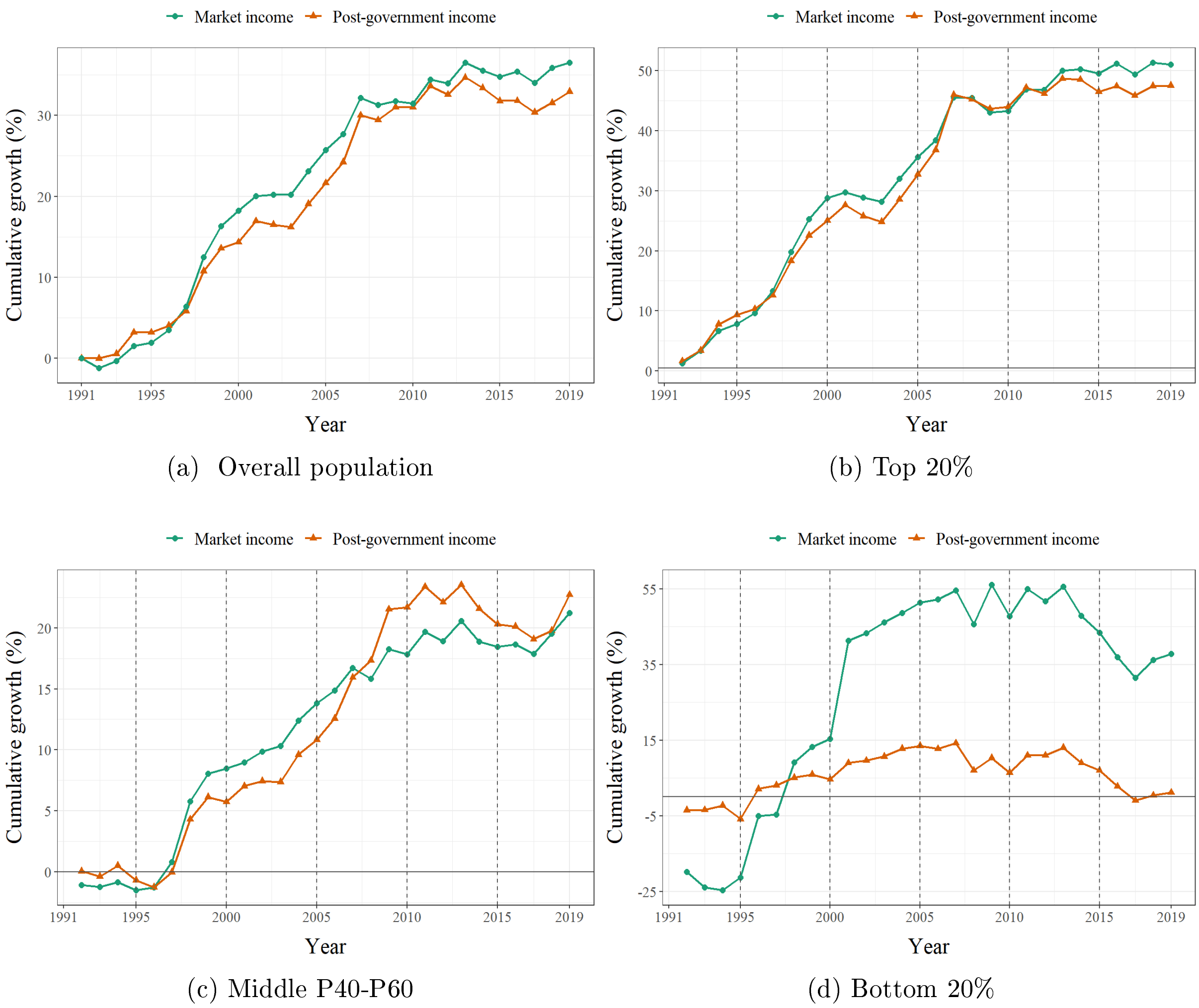
We examine the variation in their pattern of the growth incidence curves over time. Figure 5b plots the incidence curves for 6 sub-periods. The curves' patterns are notably different between the periods, indicating varying levels of government intervention. In panel (a), for the period of 1991-1995, market income growth below the median was stagnant, with negative growth on average. The bottom quantiles experienced the most significant decline in market incomes, with the bottom 10% experiencing over a 5-10% decrease. However, the tax and transfer system played a mitigating role, as post-government incomes remained relatively stable despite the decline in market income.

The benefits of rapid economic growth 1996-2000 were reaped across the market income distribution, with all quantiles experiencing market income growth. The bottom and top quantiles experienced the most significant growth in market income compared to the middle. However, while market incomes were rising, the income tax system was left relatively unchanged during this period. As a result, a significant portion of market income gains were taken away by bracket creep. Individuals faced higher tax thresholds and tax rates as their incomes rose. For this reason, in panel (b), growth in post-government income trended below that of market income. This is most signficant for the bottom decile where market income growth was above 10% while post-government income growth was around 1%. A quite similar growth pattern is observed during 2000-2005 with a big drop in income growth at the top. Yet, the period from 1995-2005 is a pro-poor growth period.

It appears that there was a structural change since 2005. The growth across the income distribution was significanttly lower but remained relatively more equal, with the bottom and top quantiles experiencing much lower market income growth. From 2011 onwards, income growth rates were relatively modest, with negative growth rates below the median in 2011-2015. In 2006-2010, post-government income growth in the middle and top was higher than market income growth. However, the decade that followed shows a relatively inactive fiscal system that resulted in post-government income growth to almost be the same as market income growth across the distribution.

Thus, there has been a variation in income growth across groups over time. However, the uneven growth of market income has been moderated by the tax and transfer system. The post-government income growth is relatively more even and stable over time.

Unequal gains over time. We now focus on how the gains from the three decades of uninterrupted growth have been shared arcoss income groups over time. To do so, we calculate cumulative growth from 1991 to 2019. Figure 6 displays the cumulative growth in market and post-goverment income for different groups.



(a) Overall population

(b) Top 20%

(c) Middle P40-P60

(d) Bottom 20%

Figure 6: Cumulative growth in average income and tax liability.

For the middle income group, income growth was stagnant during the 1990 recession. There is a significant rise in incomes from 1997 to 2007 and then follows by another stagnation after 2009. In contrast to the middle, the top 20% of the distribution experienced sharp income growth during the early 1990s and through to 2007. There was a stagnation of income growth post 2007 and follows by a decline since 2013. This stagnation is not equal across the income distribution with a decline trend for the bottom 20% and a flat trend for the top 20% from 2007 to 2019.

Strikingly, that there is virtually no income gain for the bottom 20% over three decades. Specifically, income at the bottom sharply declined during the recession of the early 1990s. From 1997, there was a large increase in market income at the bottom. However, market income growth was accompanied by a sharper rise in tax liabilities. As a result, post-government income growth between 1997 and 2007 was significantly lower. In this regard, while market income in 2007 at the bottom was 45% compared to 1991, a 75% rise in tax liability resulted in only 15% higher post-government income.

3.2.2 Redistribution and income inequality

We study the redistributive role of the Australian tax and transfer system in moderating the distributional impact of uneven growth. We begin by examining whether more wealthy individuals contribute their fair share of the tax contribution.

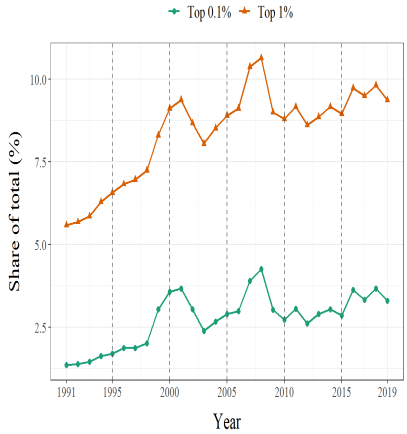
Income and tax shares. We report income and tax shares by quintile for 1991, 2000 and 2019 in Table 5. We find that the higher income group (top 20%) is disproportionally benefited from market income growth, while the lower income groups felt slightly behind. The income tax system is progressive and disproportionally took away a larger share. As a result, the tax share of the top 20% group increases to 64% in 2019, while the tax share of the other groups is smaller. Interestingly, the post-government income shares of Q1-Q4 are also smaller in 2019, compared to they were 3 decades ago in 1991.

Table 5: Share of income and tax for selected years

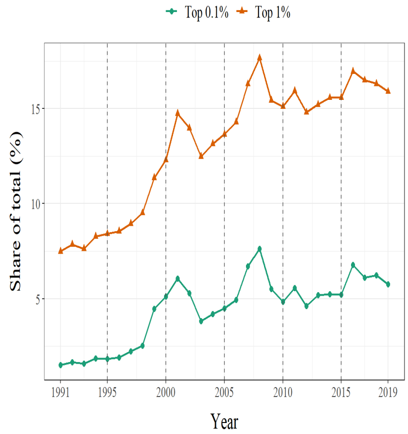
	Quintiles of market income					Top		
	Q1	Q2	Q3	Q4	Q5	Top 10%	Top 1%	Top 0.1%
					Market income			
1991	2.68	11.12	18.61	25.26	42.33	25.99	5.59	1.36
2000	2.49	9.95	16.91	23.93	46.72	30.73	9.12	3.57
2019	2.46	9.78	16.03	23.28	48.45	32.26	9.37	3.3
					Income tax			
1991	0.8	6.39	14.18	24.85	53.77	34.93	7.49	1.52
2000	0.7	5.1	13.11	22.96	58.13	40.1	12.3	5.11
2019	0.37	3.51	10.6	21.45	64.07	46.09	15.89	5.75
					Post-government income			
1991	6.08	12.6	19.15	24.42	37.75	22.69	4.88	1.26
2000	5.51	11.76	17.58	23.43	41.72	26.89	7.85	2.99
2019	4.39	11.71	17.32	23.38	43.2	27.8	7.37	2.55

A closer look at the top earners. We observe faster rising trends in income and tax shares for the top 10% group. Much of the recent debate in rising income inequality has focused on the top earners, especially the top 1% and top 0.1%. The contribution of the top earners to the overall income distribution and tax revenue attract considerable public debate. We have a closer look at the very top earners.

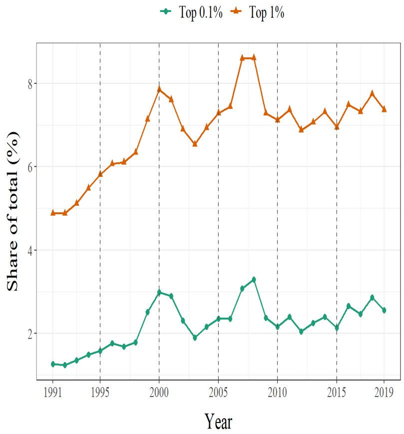
Last two colums of Table 5 report the share of market income, tax and post-government income for the top 1% and top 0.1%. Figure 7 displays the share and level of market and post-government incomes for the top 1% and top 0.1% from 1991 to 2019. In 1991, the top 1% earned close to 5% of the total post-government income. This increased sharply in the 1990s and 2000s. By 2007, the top 1% earned 8% of total post-government income. Shares for the top 0.1% individuals likewise increased with the top income share at 3% in 2007.



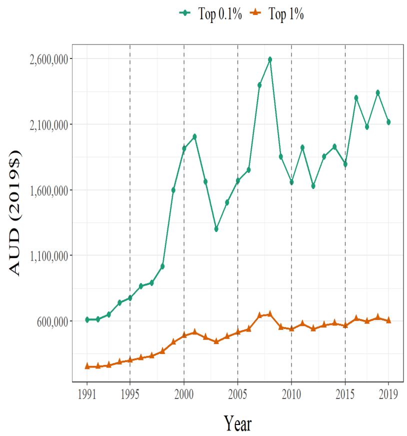
(a) Share of market income



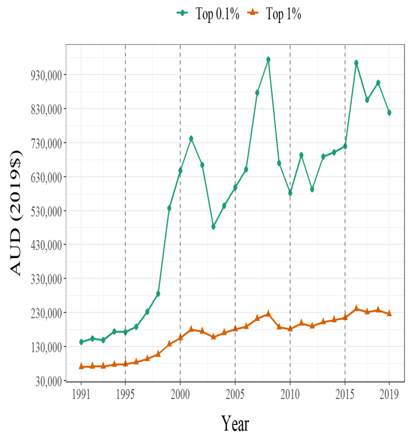
(b) Share of tax payment



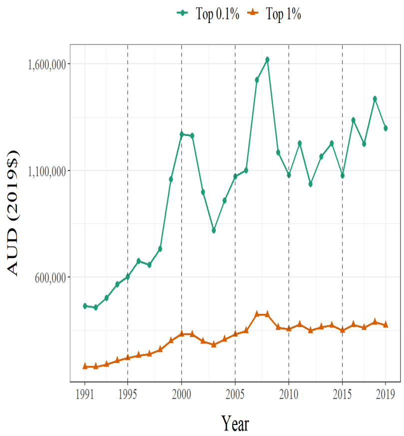
(c) Share of post-government income



(d) Market income (level)



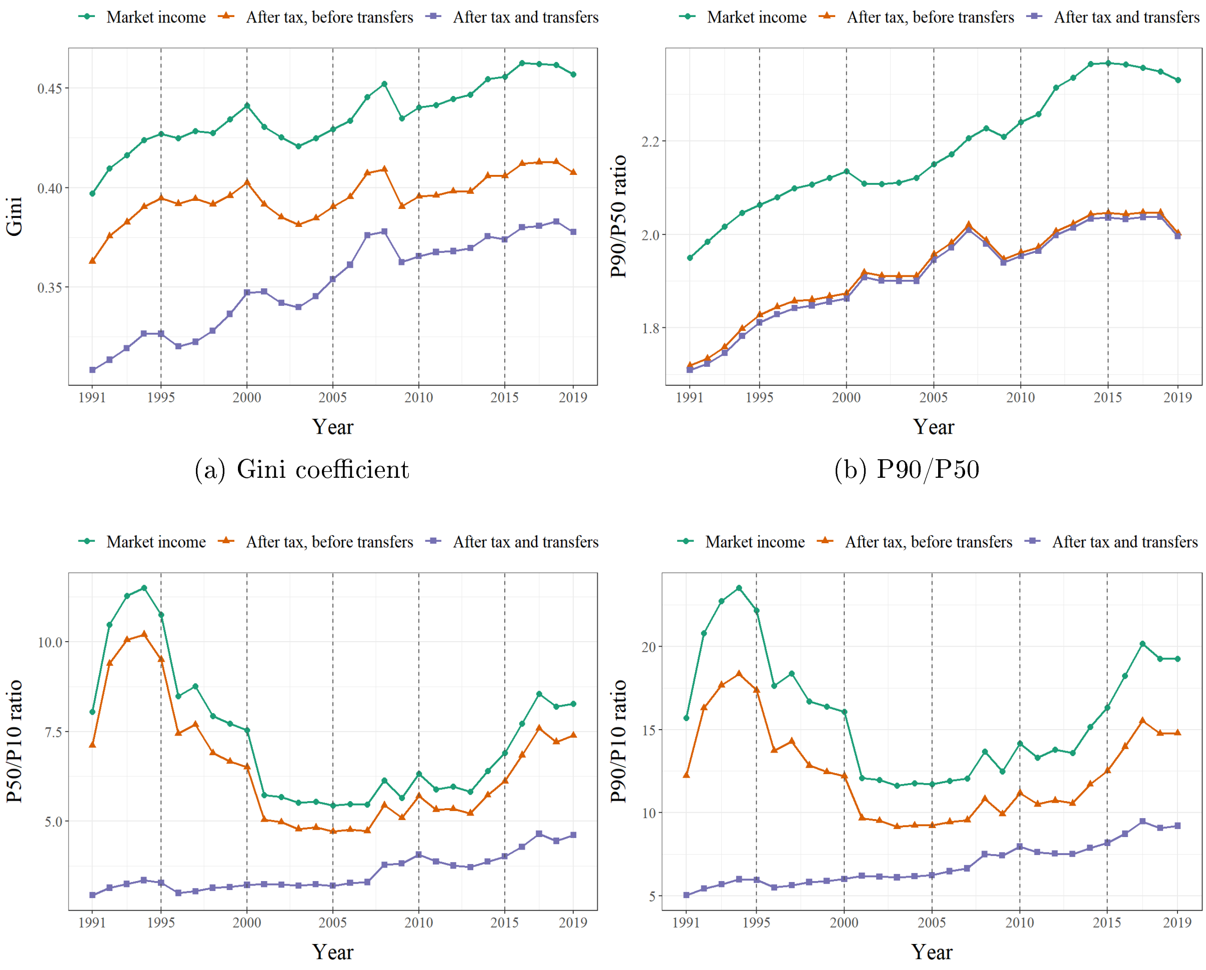
(e) Tax payment (level)



(f) Post-government income (level)

Figure 7: The very top earners: maIncome and tax payment.

Trends in income inequality. The variation in income growth across the income distribution directly affects income inequality. Figure 8 plots the Gini coefficient for market income and post-government income from 1991 to 2019. The dashed vertical lines enable us to relate the trends in income inequality to the shapes of the growth incidence curves in Figure 5. While we plot the Gini coefficient for inequality after transfers, it should be noted that tax returns do not provide a complete picture of the transfer system in Australia. Hence, in our analysis we focus on the income tax system while presenting reported transfers for the sake of completeness.



(a) Gini coefficient

(b) P90/P50

(c) P50/P10

(d) P90/P10

Figure 8: Trends in income inequality 1991-2019.

As evident from Figure 5, between 1991-1995, those above the median experienced positive growth, while those below the median experienced negative growth. The top 1% had the highest growth rate at 5% per annum, while the bottom 10% experienced a 10% decline, resulting in a sharp increase in market income inequality (Figure8).

From 1996-2000, the bottom 10% experienced high growth, but the top quintile's growth was even higher at 10%, further increasing market income inequality. However, a reversal in the trend in the market income Gini began in 2000. This corresponds with the 2001-2005 panel in Figure 5 which shows a relatively flat growth incidence curve.

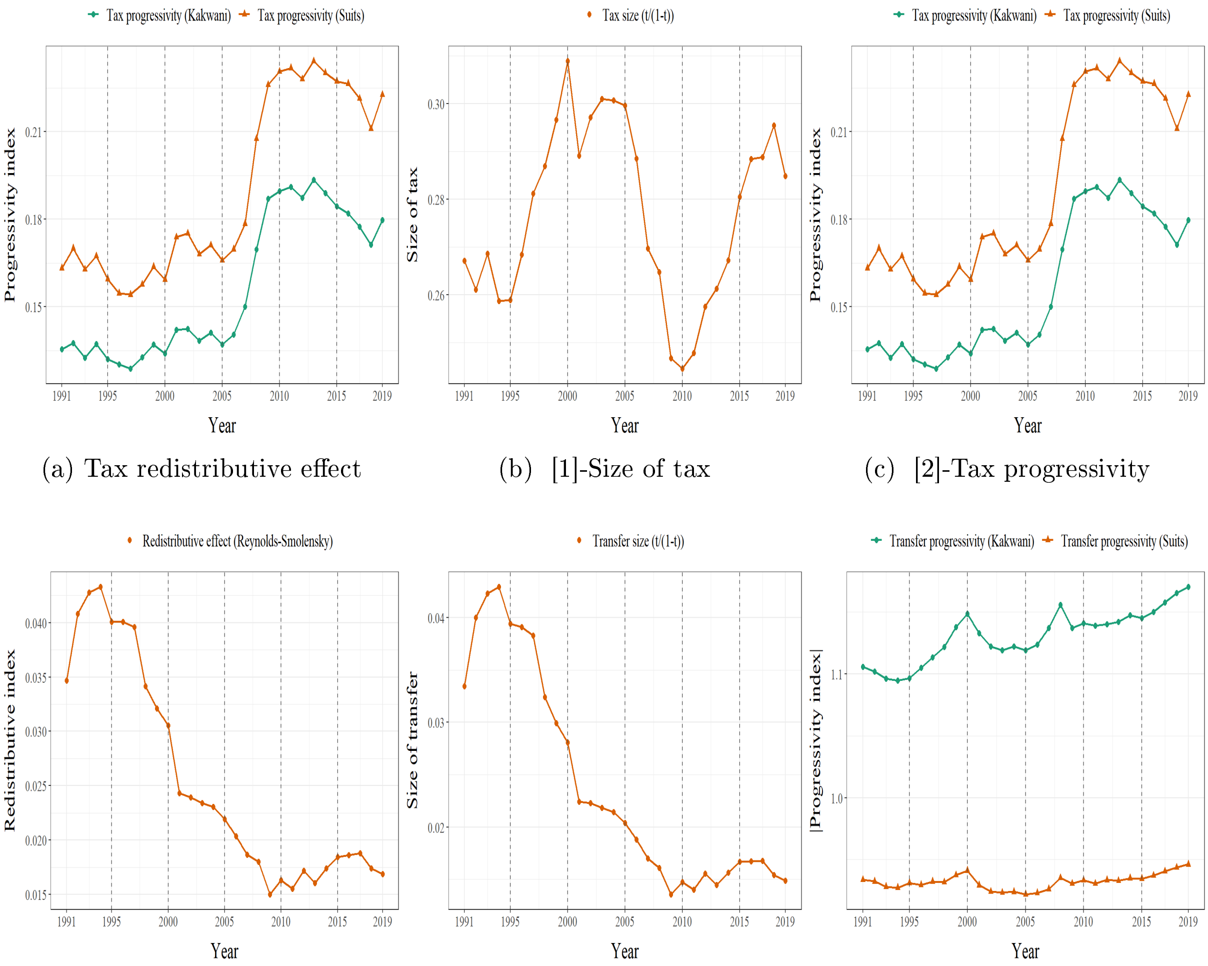
From 2006 onwards, the bottom three panels of Figure 5 indicate stagnant or negative growth in market income below the median, while the top quintile experienced only modest growth. As a result, market income inequality increased overall from 2006, as shown in Figure8.

In general, Figure 5 reveals that the tax and transfer system reduces inequality to a large extent in Australia. However, the trends for the Gini coefficient of post-government income still increass from 1991-2019.

Thus, the tax and transfer system failed to completely flattens the rising income inequality in Australia.

3.2.3 Decomposing the redistributive effects

In this section we have a deeper look into the redistributive effects of progressive income taxes and means-tested transfers. As discussed in Section 2.3 (see equation 6), we decompose the distributive effects into two components: [1] size and [2] progressivity.



(a) Tax redistributive effect (b) [1]-Size of tax (c) [2]-Tax progressivity

(d) Transfer redistributive effect (e) [1]-Size of transfer (f) [2]-Transfer progressivity

Figure 9: Taxes and Transfers: Decomposition of redistributive effects 1991-2019.

Figure 9b plots the average size of the tax measure and Figure 9a plots the Reynolds-Smolensky index. Figure 9c plots the Kakwani and Suits indices of tax progressivity. From 1991-1995, there was fairly little change to the progressivity of the tax system. Further, as market income across the distribution was relatively stagnant (see Figure 5), there was little change in the size of the tax system. As a result, the redistributive effect of the tax system remained fairly constant.

We observed that market incomes grew rapidly from 1996 - 2000. As evident from Figure 5, during these 5 years, the bottom experienced significant growth in incomes. At the same time, there were no major changes to the tax system. Figure 9c shows that tax progressivity was relatively constant between 1996 and 2000. However, growth at the bottom pushes more individuals into higher tax brackets. This explains the sharp increase in the size of the tax system from 1996 to 2000 in Figure 9b. As a result, despite the flat trend in tax progressivity, the tax system became more redistributive during the late 1990s.

Major changes to the tax system in the 2000s lead to a sharp increase in tax progressivity (especially from 2005 to 2010) as seen in Figure 9c. An increase in progressivity results in lower quantiles paying less tax. This resulted in a decline in the size of tax (Figure 9b). However, the positive effects of greater tax progressivity on redistribution outweighed the decline in tax size as we observe a sharp increase in redistributive effect from 2005 to 2010.

One interesting point to note from Figure 9 is that while tax progressivity declined since 2013, the redistributive effect as trended upwards. This can be contextualised in reference to market income growth during that period (Figure 5). Panels 2011-2015 and 2016-2019 show a decline in market income growth at the bottom and a small increase at the top. Given that the tax system is still highly progressive compared to the 1990s despite the recent downward trend, the rise in incomes at the top resulted in an increase in tax size and in redistribution.

3.3 Lifetime measures

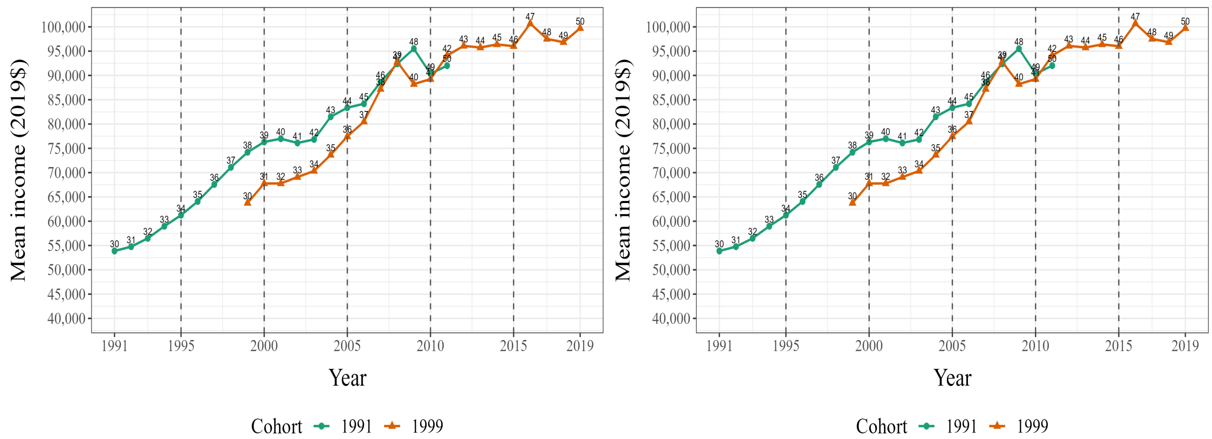
Our empirical analysis based on annual income offers a snapshot of income growth and inequality across individuals at a given point in time. In this section, we turn to lifetime income measures. As discussed, we restrict our sample to individuals between 30 and 50 years of age that filed a tax return in each consecutive year over a period of 21 years. We are able to track 9 cohorts in our lifetime sample.

Table 6 presents the annualised lifetime income and tax statistics for 1991, 1995 and 1999.

Table 6: Annualised lifetime income and tax statistics

Cohort		Market income	Public transfers	Income tax	Post-govt income
1991	Mean	65,527	432	15,954	50,005
	SD	69,850	1,154	28,474	43,664
	Median	55,728	-	11,441	44,749
1995	Mean	69,771	402	17,236	52,937
	SD	66,128	1,141	27,607	40,072
	Median	58,788	-	12,139	47,204
1999	Mean	73,485	368	18,644	55,210
	SD	65,727	1,136	29,452	38,760
	Median	61,234	-	12,850	49,000

Figure 10 report an overview of average market and post-government income by age from the age of 30 to 50 for the c1991 and c1999 cohorts.



(a) Market income (b) Post-government income

Figure 10: Average income by age (c1991 and c1999). Note: The figures plot the average income by age for males in each cohort. The annotations on the markers correspond to the age of the cohort.

In real terms, at age 30, c1991 earned a lower market income on average ($55,000) compared to the younger cohort c1999 at the same age (around $65,000). However, c1991 experienced high growth in market income between 30 to 48 years, a large majority of which was in the high growth periods of the late 1990s and early 2000s. In contrast, while c1999 experiences a steep increase in their market income from 30 to 39 years (between 1999 and 2008), they spend their 40s in the stagnant years post Global Financial Crisis of 2007. As a result, they experience relatively small income growth, with average market income flattening from the age of 42.

Contrasting Panel 10a with the lifecycle profiles of post-government income in Panel 10b reveals an important insight on the tax and transfer system. In that, although market income growth experienced by the two cohorts are different, on average, the tax and transfer system acted to mitigate any stark differences in net income between cohorts. We know from Figure 9a, that the tax system became more redistributive from 1995 to 2015. Thus, while younger cohorts earned a lower income relative to older cohorts, they faced lower tax burdens. Morevoer, c1991 experienced market income growth mostly during the late 1990s when the tax system was relatively unchanged. As a result, they faced significant bracket creep whereby a larger share of their income gain was taxed at higher brackets.

Consequently, we observe a smaller gap between mean net income between cohorts in any given year, as well as at any given age. Both cohorts earned relatively similar levels of net income at 50, despite their different earning levels at 30 years of age.

3.3.1 Uneven growth across cohorts

We now turn to a more detailed examination of how growth and redistribution affects cohorts by analysing differences in lifetime income. To do so, we calculate lifetime incomes as outlined in Section 2.2 for 9 cohorts from the age of 30 to 50. We then use lifetime income to compute similar summary statistics as in Section 3.2.

Active periods for respective cohorts. To contextualize lifetime statistics for specific cohorts within our point-in-time analysis, it is essential to understand the years during which each cohort was represented in the sample. Table 7 list the cohorts (labeled by year they turned 30), the first year in the sample and the year they turned 50 ("last year").

Table 7: First and last years for cohorts

	Older cohort			Middle cohort			Younger cohort		
	c1991	c1992	c1993	c1994	c1995	c1996	c1997	c1998	c1999
First year	1991	1992	1993	1994	1995	1996	1997	1998	1999
Last year	2011	2012	2013	2014	2015	2016	2017	2018	2019

To ease our analysis and facilitate contextualization, we classify the cohorts into three groups: "older," "middle," and "young". The older cohort reached the age of 30 shortly after the 1990s recession and was exposed to the rapid expansion of the late 1990s at an earlier stage in their career. However, they also endured a longer period of inactivity in the tax policy regime during the late 1990s. The middle cohort, on the other hand, spent the majority of their 30s in the rapid growth phase of the late 1990s and early 2000s. They also experienced the sharp increase in tax progressivity. In contrast, the younger cohort experienced a prolonged period of economic stagnation during their prime working years in the mid to late 2010s.

Growth incidence curves of lifetime income. The period in which a cohort is "active" affects their lifetime income and its distribution. We examine the evolution of lifetime income over the 3 decades of uniterrupted growth by comparing lifetime income growth between cohorts. To do so, we first compute quantiles of lifetime market income for each cohort and then calculate the percentage change in lifetime market income in a given quantile from one cohort to another.

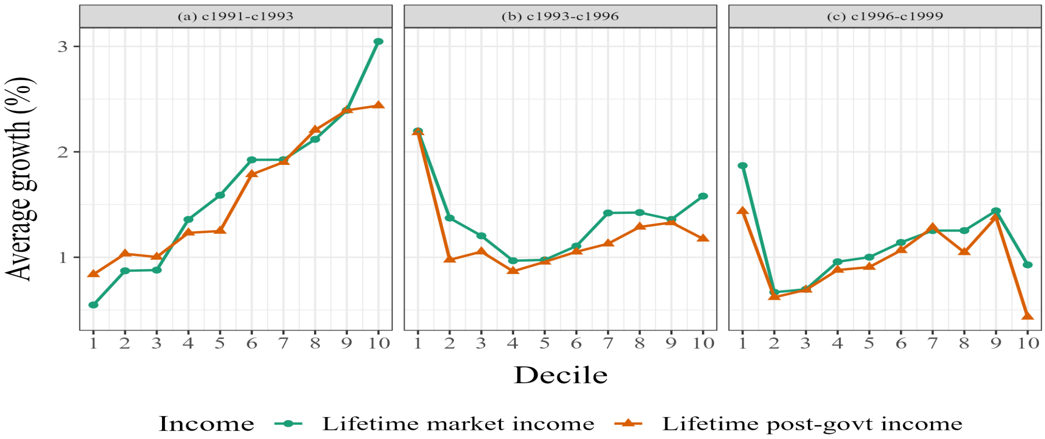


Figure 11: Growth incidence curves for lifetime market income and lifetime post-government income. Note: In panel (a), except for the bottom 10%, growth rates are based on the average income in each percentile. Incomes for the bottom 10% are averaged together to smooth the curve. Panel (b) gives the average growth by decile of lifetime market income

Figure 11 displays the growth incidence curves of lifetime market and post-government income for our three groups of cohorts. Each of the panels plot average growth rates in lifetime income for a respective group of cohorts by deciles of lifetime market income. Panel (a) plots the average growth from cohort c1991 to c1993, (b) plots the growth rates for c1993 to c1996 and (c) plots the same for c1996 to c1999. The first point to note is that generally lifetime market and post-government incomes grew from one cohort to another. However, there are notable differences in the distribution of growth among the different cohorts.

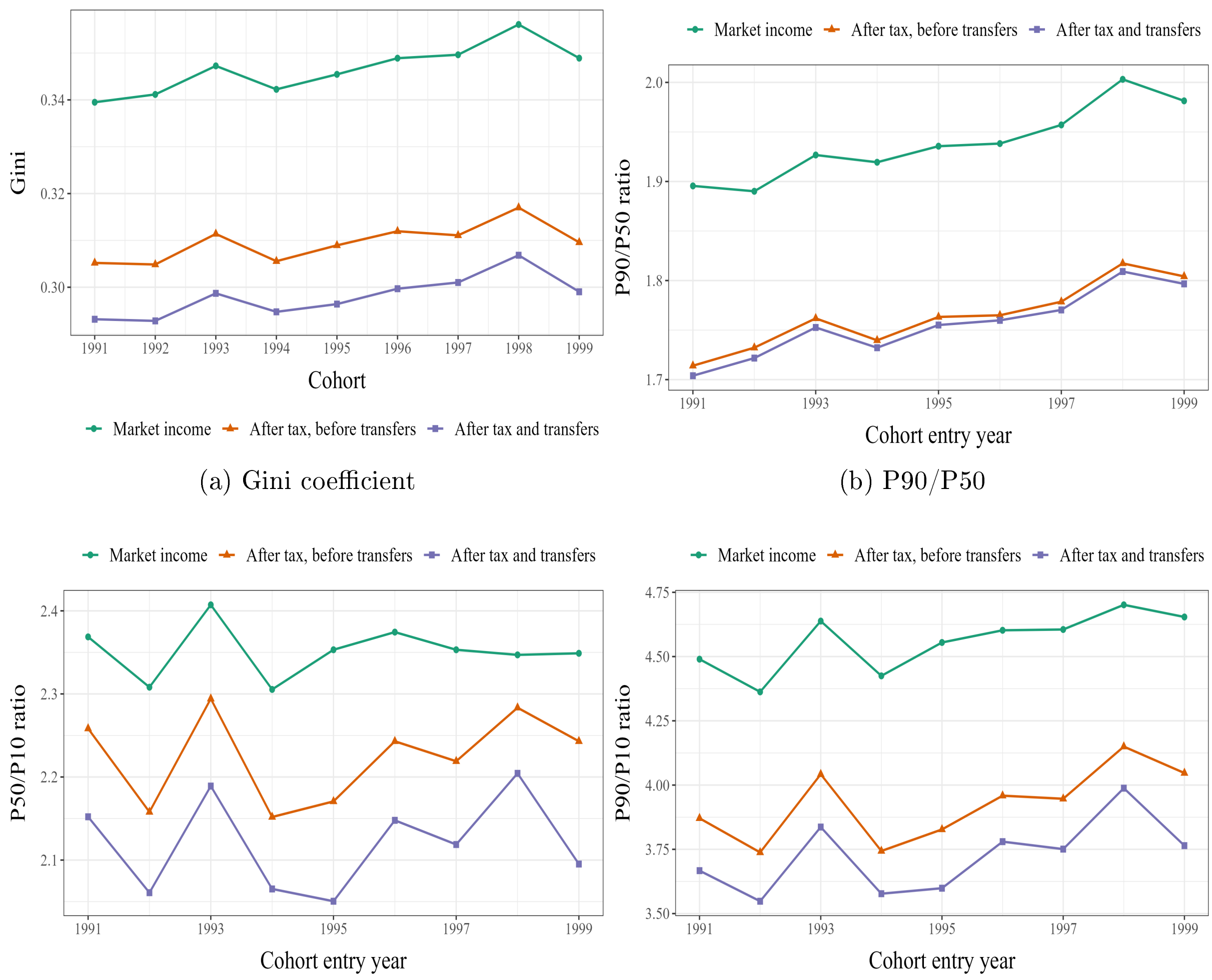
Panel (a) displays a lifetime market income incidence curve with a steep upwards slope, such that the rate of lifetime market income growth was significantly higher the higher up the income distribution. This generally mimics the point-in-time growth incidence curve from 1991-1995 in panel (a) of Figure 5.

Similarly, panel (b) of Figure 11 shows a U-shaped incidence curve for lifetime market income that echoes its point-in-time counterpart between 1995 and 2000. Lifetime income growth for the bottom 10% and top 10% was higher than the middle (at 2% compared to 1% at the median). For the younger batch of cohorts - depicted in panel (c) - we observe a reversal in the pattern at the very top, whereby market income growth rates are generally below that of the median. This reflects the stagnation in point-in-time growth rates in the 2000s above the median shown in panels (c) - (e) in Figure 5.

Except for the older cohorts c1991-c1993, all other cohorts experienced major changes in tax and transfer policy during their respective 21 years. The impact of inactive tax policy resulting in bracket creep can be observed in the older cohort (c1991-1993). This is evident by the fact that lifetime post-government income growth in the middle is lower than the lifetime market income growth.

3.3.2 Lifetime inequality and redistribution.

Lifetime inequality. A clearer picture of lifetime post-government income distribution and the role of the tax system can be obtained by examining trends in lifetime income inequality as depicted in the panels in Figure 12. While point-in-time market income inequality rose over the three decades (Figure 8), inequality from the lifetime perspective in Figure 12a shows a rather different stable trend. This owes to the reversal in the growth incidence curves going from panel (a) to panel (c) in Figure 11. That is, for the middle in younger cohorts, we see higher lifetime market income growth at the bottom quantiles. Moreover, for the younger cohorts (c1996-1999) we observe lower growth rates for the very top percentiles relative to the rest of the lifetime market income distribution.



(a) Gini coefficient

(b) P90/P50

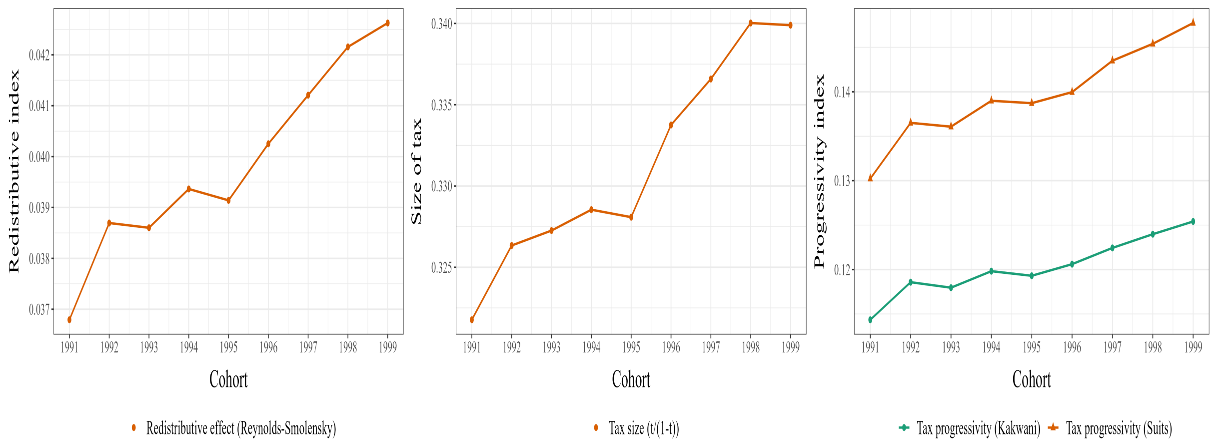
(c) P50/P10

(d) P90/P10

Figure 12: Lifetime income inequality.

Decomposing the redistributive effects. The most important trend that we can observe in Figure 12 is that the tax system has become more redistributive over time. There is a signficant increase in the Reynolds-Smolensky index of redistributive effect of lifetime tax from c1991 to c1999 (Figure 12b). This owes to the fact that both lifetime tax progressivity

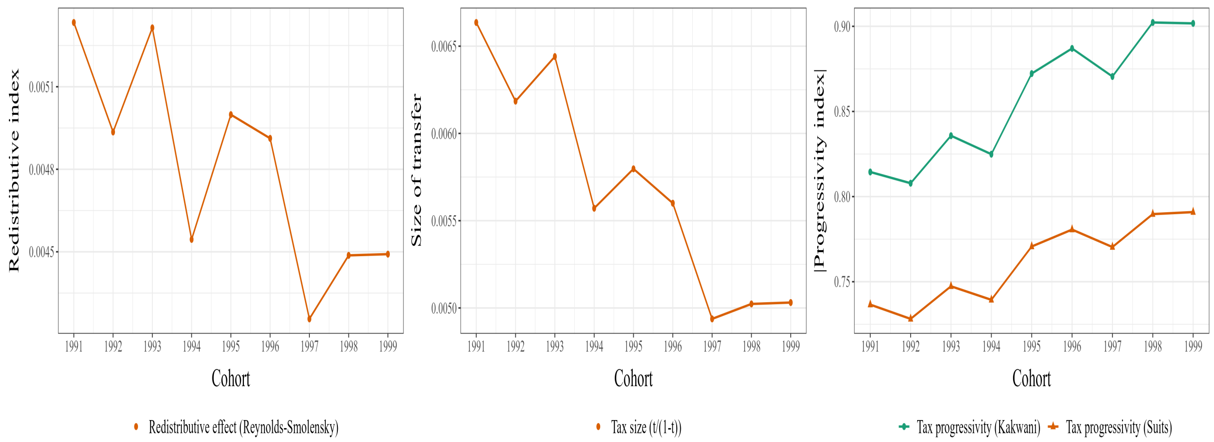
(Figure **??**) and the size of lifetime tax has both increased (**??**). We observe a sharp increase in the three measures from c1995 to c1999 which corresponds to cohorts who experienced the increase in point-in-time tax progressivity since 2006 during a longer period of their working lives.



(a) Redistributive effect of lifetime tax

(b) [1]-Size of lifetime tax

(c) [2]-Lifetime tax progressivity



(d) Redistributive effect of lifetime transfer

(e) [1]-Size of lifetime transfer

(f) [2]-Lifetime tax progressivity

Figure 13: Decomposing the redistributive effects of lifetime tax and transfer.

While Section 3, provides clear trends in point-in-time and lifetime trends, it does not capture long term trends in income inequality accurately. We only have access to 30 years of data, which provides us with information on only a few cohorts for a limited duration of their lives. Further, our analysis is deficient on work hours, consumption, asset accumulation and public transfers which can also provide valuable insights into the dynamics of inequality.

Thus, our empircal analysis documents important lessons from the Australian case. First, majority of Australians are beneficial from increasing market income; however, the gains have been shared unevenly across groups. Second, the progressive tax and transfer system plays an important role in moderating unequal gains across groups and over time. The income gap between the rich and poor is significantly reduced after accounting for progressive taxes and transfers. These facts raise a question whether higher tax-transfer progressivity can further reduce income inequality in Australia. In the next section, we build a structrual model to address this question.

4 A structural model

In this section, we formulate a dynamic general equilibrium overlapping generations model. We calibrate the benchmark model to match the lifecycle behaviors of Australian households as well as the macroeconomic performance. We finally use the model to conduct a counterfactual analysis.

4.1 Demographics, endowments and preferences

Demographics. The model economy is populated by J overlapping generations. In each period, a new generation is born and enters the model at the age of 20, faces random survival probabilities ψ_j, and live to a maximum of J periods. Demographic structure is stationary. 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.

Endowments. Each cohort consists of 3 exogenous skill types that are based on education level $\varrho \in \{\text{low, medium, high}\}$. Those whose highest education attained is high school or below are classified as low skilled, those with a further tertiary training but without a graduate level qualification are classified as medium skilled, and graduates and higher are high skilled. In each period, households are endowed with 1 unit of labor time with labor productivity $\eta_{z,j} \in \{\eta_{1,j}, \eta_{2,j}, \eta_{3,j}, \eta_{4,j}, \eta_{5,j}\}$ which follows a Markov switching process with a transition matrix $\pi_{\varrho,j}(\eta_{z,j+1}|\eta_{z,j})$. This transition matrix differ by skill type, capturing the life cycle shocks faced by those with different levels of education. It also provides for even low skill types to attain higher wage quantiles (albeit with a low probability).

Preferences. Households have preferences over streams of consumption c_j and leisure l_j . The period utility function has a form of $u(c_j, l_j)$.

4.2 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 the rental rate q and the market wage rate w according to

$$\max_{K,H} \left\{ \left(1-\tau^f\right)\left(AK^{\alpha}H^{1-\alpha}-wH\right)-qK \right\}, \tag{7}$$

where $\tau^f \in [0,1]$ is the company income tax rate.

4.3 Fiscal policy

Government revenues. The government finances its fiscal programs by collecting tax revenue via a personal income tax $t(y_j)$, consumption tax $t(c_j)$ at the rate $\tau^c \in [0,1]$ and a company income tax at the rate $\tau^f \in [0,1]$. The government levies a progressive income tax on taxable incomey_j that includes both labor income, capital income and pension. We approximate the Australian personal income tax code using the following parametric tax function explained earlier in Appendix A.3.

$$t(y_j) = \max\left(0, y_j - \lambda y_j^{1-\tau}\right) \tag{8}$$

Total government revenue is given by

$$Tax = \sum_j t(y_j)\,\mu(\chi_j) + \sum_j t(c_j)\,\mu(\chi_j) + \tau^f\left(AK^{\alpha}H^{1-\alpha}-wH\right), \tag{9}$$

where $\mu(\chi_j)$ is the measure of agents in state χ_j.

Government spending. The governments has three main spending programs: an age pension program for retirees, a welfare transfer program for workers and a general government purchase program.

The amount of pension benefit p_j is means-tested and given by

$$p_j\left(y_j^m\right) = \begin{cases} p^{\max} & \text{if } y_j^m \le \bar{y}_1 \\ p^{\max} - \omega\left(y_j^m - \bar{y}_1\right) & \text{if } \bar{y}_1 < y_j^m < \bar{y}_2 \\ 0 & \text{if } y_j^m \ge \bar{y}_2, \end{cases} \tag{10}$$

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

The amount of welfare transfers $st_j(\eta_{z,j}, j)$ is age-dependent and conditional on the level of the labor productivity shock $\eta_{z,j}$. This closely approximates the progressive nature of the targeted transfer system, as well as changes in the level of targeted transfers over the life cycle. This welfare transfer program closely reflects the breadth of the social welfare system in Australia.

In addition, the government spends an amount G on general government purchases.

Government budget constraint. 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

$$Tax = \sum_{j} p_j \left(y_j^m\right) \mu\left(\chi_j\right) + \sum_{j} st_j \left(\eta_{z,j}, j\right) \mu\left(\chi_j\right) + G + rD \tag{11}$$

The model allows for the government to have an additional role in distributing bequests (both accidental and intentional) from dead agents to those alive. However, in our baseline experiments we assume that all accidental bequests are taxed away akin to a 100% estate tax.

4.4 Market structure

We assume a small open economy in which 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.

4.5 Household optimization problem

Households receive income from labor and capital market activities. Their market income is given by $y_j^m = \eta_{z,j} \cdot w \cdot (1 - l_j) + ra_j$. Households might receive welfare transfers $st_j\left(\eta_z, j\right)$ before the pension eligibility age J^p. Upon reaching the pension eligibility age, they are entitled to a means-tested public pension $p\left(y_j^m\right)$ that is subjected to an income test. Households are required to pay consumption tax at the rate of τ^c on their consumption c_j and income tax t_j on their taxable income $y_j = y_j^m + p_{j \geq J^p}$, which is the sum of their market income and age-pension.

Let the state of the household at age j be $\chi_j = (j, \eta_{z,j}, a_j)$. Given time invariant prices, taxes and transfers, the household problem is written recursively as

$$V^j(\chi_j) = \max_{c_j, l_j, a_{j+1}} \left\{ u(c_j, l_j) + \beta\psi_{j+1} \sum_{\eta_{z,j+1}} \pi_{\varrho,j}(\eta_{z,j+1}|\eta_{z,j}) V^{j+1}(\chi_{j+1}) \right\}$$

subject to:

$$a_{j+1} = \overbrace{\underbrace{\eta_{z,j} \cdot w \cdot (1 - l_j) + ra_j}_{y_j^m \text{(market income)}} + p_{j \geq J^p}}^{y_j \text{(taxable income)}} + st_{j<J^p} - t(y_j) - (1 + \tau^c) c_j + a_j,$$

$$a_j \geq 0 \text{ and } 0 < l_j \leq 1. \tag{12}$$

4.6 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 $\{c_j(\chi_j), l_j(\chi_j), a_{j+1}(\chi_j)\}_{j=1}^J$ solve the household problem given by equation (12);

(ii) the firm chooses effective labor and capital inputs to solve the profit maximization problem in equation (7);

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

$$B = \sum_{j \in j} \frac{\mu_{j-1}(1 - \psi_j)}{(1 + n)} \int a_j(\chi_j) \, d\Lambda_j(\chi_j) \tag{13}$$

(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

$$K = \sum_{j \in j} \mu_j \int a_j(\chi_j) \, d\Lambda_j(\chi_j) + B + A_f \tag{14}$$

$$H = \sum_{j \in j} \mu_j \int (1 - l_j) e_j(\chi_j) \, d\Lambda_j(\chi_j) \tag{15}$$

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 (11) is satisfied.

4.7 Mapping the model to data

We map the steady state equilibrium to reflect key statistics for the Australian economy for $2000 - 2004$. Choosing the 2000s rather than the 1990s allows us more detailed longitudinal information on public transfers and hourly wage rates from the Household Income and Labour Dynamics in Australia (HILDA) survey.

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.

4.7.1 Income and tax distributions

The central focus of our analysis is the impact of income tax on inequality. Hence, we calibrate our model carefully to match key distributional measures for the period. Table 8 presents the main income and tax distributions that were approximated, their respective targets and the values in the benchmark model.

Table 8: Income and tax distribution, targets and values in the benchmark economy

		Model performance		
	Parameters	Measure	Data	Target
Labour income	Labour productivity process.	Gini	0.5	0.5
Taxable income	Matched using labour productivity.	Gini	0.4	0.4
Income tax	$\lambda = 0.6557$	Share of GDP (%)	16	11
	$\tau^y = 0.15$ (estimated)	Suits index	0.17	0.19
		Kakwani index	0.14	0.17
		Tax size	0.3	0.3
		Redistributive effect	0.04	0.04
Public transfers	Estimated by wage quintile.	Share of GDP (%)	8	8
Pension	$p^{\max} = 0.06$, $\omega^y = 0.5$	Share of GDP (%)	2	2
	$y_1 = 0.0126$	Pension participation rates by skill and age.		
Post-govt income	Matching this distribution is a combination of all the other income components.	Gini	0.34	0.34

Note: Estimation details are provided in this section. Macroeconomic and fiscal aggregates are sourced from the World Development Indicators (WDI) database. Distributional targets (Gini coefficients) are from ALife data. Data to estimate public transfers and labour productivity are sourced from HILDA.

Labour income distribution. The starting point of approximating the market income distribution is estimating the labour income process. Since labour income forms the larger portion of market income, this gives us a suitable approximation of market income quantiles in the data.

To do so, we estimate the labour productivity process from the Household, Income and Labour Dynamics in Australia (HILDA) longitudinal survey for the years 2001-2018. We follow Nishiyama and Smetters (2007) to approximate the dynamics of labour productivity over the life-cycle. We define working ability/labour productivity as the hourly average wage rate, defined as gross labour income divided by total hours worked. We first group individuals aged between 20 and 64 into cohorts of 5 year age groups. We then classify individuals in each of these age groups in 5 quintiles of hourly wage rate. We assume that labour productivity declines linearly for those age 65 and above, reaching 0 at age 80.

The mobility of individuals from quintile to quintile over the life cycle is governed by Markov transition matrices that are skill and age dependent. The following steps outline the estimation procedure for these matrices.

1. For each wave of the HILDA survey, we group individuals by skill type, age and quintile. Let $N_{j,s}^{i=v}$ be the total number of individuals of skill type s and age j in quintile $i = v \in [1, 2, 3, 4, 5]$.

2. Next, we track the movement of individuals in each group from age j to $j+1$. That is, we see whether they have stayed in one quintile or moved to another, and if so, which quintile they moved to. Let $n_{j+1,s}^{i=k}$ be the total number of individuals in the pool $N_{j,s}^{i=v}$ in age j that moved to quintile $i = k \in [1, 2, 3, 4, 5]$ at age $j + 1$.

3. The transition probability from quintile v at age j to quintile k at age $j + 1$ is then calculated as

$$\pi_{j,j+1}\left(e_{j+1}^{i=k} | e_j^{i=v}\right) = \frac{n_{j+1,s}^{i=k}}{N_{j,s}^{i=v}} \tag{16}$$

To make the transition matrix more persistent, we use the average of estimates between 2001 and 2018.

The difference between skill types in our model is thus not directly dependent on a skill specific labour productivity profile over the life cycle. Rather, it depends on the transition probabilities that are different between skill types. For example, at the age of 40-45, both a high skilled individual and a medium skilled individual could be at the top quintile. However, a high skilled individual could be more likely to persist at the top, while a low skilled individual is more likely to descend to a lower quintile.

The main reason for choosing this method to estimate labour productivity is that we approximate welfare transfers below the age of 65 by wage quintile rather than by skill type. This is a better approximation of reality as welfare transfers do not distinguish between skill type, but is highly correlated on labour income regardless of one's educational background.

Income tax. We approximate the Australian income tax code using a parametric tax function discussed in Section 4.3. 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 $\lambda = 0.6557$ and the curvature parameter $\tau^y = 0.15$ so as to match the income tax share of GDP, the distribution of tax liabilities as per Suits and Kakwani indices, the redistributive effect as per the Reynolds-Smolensky index.

Public transfers. Prior to the age of 65, we lump all welfare transfers other than pension such as family benefits, disability support pension and unemployment benefits in to $st(\eta_j, j)$. We estimate the share of other welfare transfers by wage quintile η_j and age j using HILDA data and set the total amount of welfare transfers to match its share of GDP.

At 65 years, individuals are eligible for means-tested pension subject to an income test. 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 $\bar{y}_1$.[5]

4.7.2 Other model parameters

Table 9 present values for key parameters that were determined by standard and their respective sources or benchmark targets.

[5]In order to test whether the asset test binds in our model, we also calibrate a version with the asset test where the asset test taper rate is $\omega^a = 0.0015$ 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. In our benchmark model economy, the income test binds.

Table 9: Key parameters, targets and data sources

Parameter	Value	Source/Target
Demographics		
Population growth rate	$n = 1.3\%$	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	$g = 2.24\%$	WDI
Depreciation	$\delta = 0.055$	Tran and Woodland (2014)
Total factor productivity	$A = 1$	(scaling parameter)
Interest rates	$r = r^w = 1.04\%$	Investment share of GDP
Preferences		
Inter-temporal elasticity of consumption	$\sigma = 2$	
Share parameter for leisure	$\gamma = 0.3$	Labour supply over the life cycle
Discount factor	$\beta = 0.97$	Household savings share of GDP
Fiscal policy		
Consumption tax rate	$\tau^c = 7\%$	Consumption tax share of GDP
Income tax	$\lambda = 0.6557$ $\tau = 0.15$	Income tax share of GDP, Suits index and Tax distribution
Company profits tax rate	$\tau^f = 20\%$	Company tax share of GDP and investment/GDP ratio.
Pension income test taper rate	$\omega^y = 0.5$	Official taper rate
Maximum pension	p^{max}	Pension share of GDP
Pension thresholds	y_1	Pension participation rates

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

Demographics. We set the population growth rate to $n = 1.3\%$. We use Life Tables for the period from the Australian Bureau of Statistics to determine survival probabilities ψ_j.

Preferences. We assume that the period utility function has a form of $u(c,l) = \frac{\left[c_j^{\gamma} l_j^{1-\gamma}\right]^{1-\sigma}}{1-\sigma}$. We set $\sigma = 2$ and $\gamma = 0.3$. The subjective discount factor β is calibrated to match gross household savings to GDP ratio.

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 2.24% which is the average rate for Australia during the period, taken from the World Development Indicators database of the World Bank. We base our model on the small open economy assumption and assume the world interest rate is $r = 4\%$.

Aggregate macro-fiscal variables. Table 10 presents key macroeconomic variables in the benchmark economy and their respective targets.

Table 10: Key variables in the benchmark economy

Variable	Model	Target
Domestic investment	17	25
Consumption	51	58
Average hours per week	30	35
Consumption tax	3	3
Company tax	8	5
Total tax revenue	27	29
Government expenditure	17	17

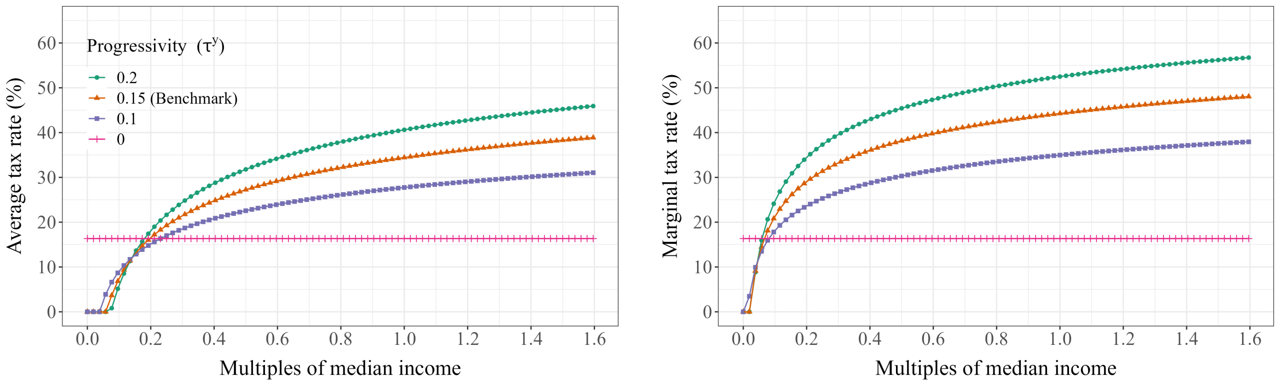
Note: Except for hours worked, all other variables are expressed in percentage share of GDP.

5 Simulation results

In this section, we use our model to study the effects of progressive income tax on income inequality in the long run. To do so, we make the assumption that the economy is on the balanced growth path where the growth rate is around 2000-2004 levels at $g = 2.24\%$. Then we consider counterfactual steady state economies with alternative income tax codes with different levels of progressivity.

To do so, we keep all other fiscal variables fixed in real terms at benchmark levels and vary the progressivity parameter τ^y between 0 (flat income tax) and 0.2 that is higher than the benchmark level of $\tau^y = 0.15$. In each case, we balance the budget by adjusting the average level of taxation $1 - \lambda$.

Figure14a displays the average tax function, while Figure 14b presents the marginal tax function at various levels of τ^y. We notice that as τ^y increases, both tax functions rotate anti-clockwise, leading to an increase in average and marginal tax rates across a significant portion of the income tax scale. This increase is more pronounced for higher income levels. The anti-clockwise rotation also results in a slight decrease in tax rates at very the lower end of the income tax scale. Moreover, the tax-free threshold (represented by $\lambda^{\frac{1}{\tau^y}}$) increases by a small amount.



(a) Average tax rates

(b) Marginal tax rates

Figure 14: Average and marginal tax functions at different levels of τ^y

5.1 Tax progressivity and inequality

Incentive effects and market income inequality. The incentive effects at play determine the effect of changing tax progressivity on market income inequality. The steepening of the tax code shown in Figures 14a and b suggests an increase in the tax burden for those in higher income brackets and a decrease for those in lower income brackets. Furthermore, it indicates a negative incentive effect due to the increase in marginal tax rates for all income groups.

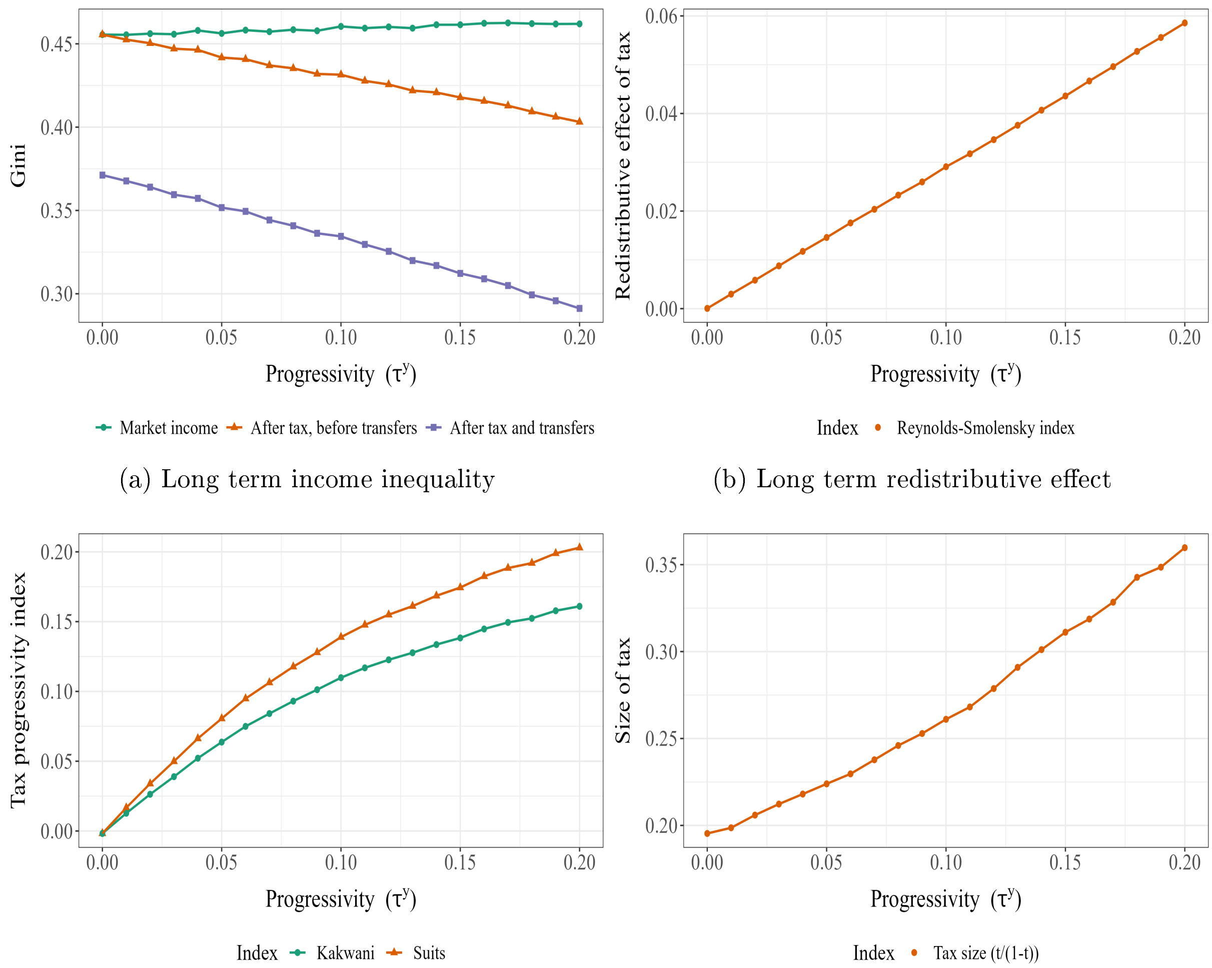
Table 11 shows the percentage change in labour hours and savings by different income types. In our benchmark economy, increasing tax progressivity results in a reduction in labour hours across the income distribution. Further, the percentage change in hours relative to the benchmark is fairly uniform between the skill types. For instance when τ^y is raised from 0.15 to 0.2, all skill types experience a 5-6% reduction in work hours on average. This has minimal impact on labour income inequality with its Gini coefficient at all levels of τ^y around 0.52.

Table 11 further reveals that savings consistently drop by approximately 17-18% for all income categories when progressivity rises. Consequently, capital income inequality remains stable, with a Gini coefficient of around 0.63. Therefore, in our benchmark economy, altering the levels of tax progressivity between 0 and 0.2 has a minimal effect on market income inequality. This observation is also supported by the stable, flat trend of the Gini coefficient for market income inequality depicted in Figure 15a.

Table 11: Higher or lower levels of tax progressivity τ^y

	$\tau^y = 0.15$ (Bench.)	$\tau^y = 0.2$ (Higher)	$\tau^y = 0.1$ (Lower)	$\tau^y = 0$ (Flat tax)
Output ($\%\triangle^{Bench}$)	0.0	-5.16	6.51	17.61
Labour hours ($\%\triangle^{Bench}$)				
Aggregate	0.0	-5.44	6.67	18.2
Low skilled	0.0	-6.11	8.2	20.85
Medium skilled	0.0	-5.56	6.35	18.22
High skilled	0.0	-4.97	6.42	16.95
Savings ($\%\triangle^{Bench}$)				
Aggregate	0.0	-17.95	25.89	83.71
Low skilled	0.0	-16.86	21.08	67.25
Medium skilled	0.0	-17.85	27.18	80.87
High skilled	0.0	-18.87	27.11	99.48
Income inequality (Gini)				
Labour income	0.52	0.52	0.52	0.51
Capital income	0.63	0.63	0.63	0.64
After tax income	0.42	0.4	0.43	0.46
Net income	0.34	0.32	0.35	0.39
Redistribution				
Suits index	0.17	0.2	0.14	0
Kakwani index	0.14	0.16	0.11	0
Tax size	0.31	0.36	0.26	0.2
Redistributive effect	0.04	0.06	0.03	0

Note: $\%\Delta^{bench}$ refers to the percentage change in the respective variable relative to its value in the benchmark. Redistributive effect is measured by the Reynolds-Smolensky index. Net redistributive effect is the effect after tax and transfers.



(a) Long term income inequality

(b) Long term redistributive effect

(c) Long term tax progressivity

(d) Long term tax size

Figure 15: Income distribution and redistribution at different levels of tax progressivity τ^y

Redistributive effect of progressive income tax. Although market inequality remains stable, there is a notable decline in after-tax income inequality, as depicted in 15a. This is because increasing tax progressivity makes the tax system increasingly redistributive. Figure 15b illustrates the Reynolds-Smolensky index of redistributive effect, which shows an increase as tax progressivity (τ^y) rises. This index can be decomposed into two components - tax progressivity presented in Figure 15c and average size of tax in Figure 15d. We observe that both progressivity indices and tax size increase as τ^y increases.

5.2 The importance of the public transfer system

A notable trend in Figure 15a is that at any given level of tax progressivity, post-government income inequality (after tax and transfers) is considerably below that of after tax income inequality. While a detailed investigation of the full array of public transfers is beyond the scope of this paper (and our general equilibrium model), we briefly investigate the role of the public transfer system in mitigating income inequality.

To do so, we briefly examine a counterfactual economy with the benchmark income tax system, but alternative levels of public transfer generosity. In this regard, the we examine an economy where all public transfers are 150% of the benchmark, 50% and 0% (no public transfer system). This allows us to quantify the contribution of public transfers to mitigating market income inequality. In order to generate the same tax function and tax distribution, we adjust general government purchases to offset the increase or decrease in public transfer expenditure.

Table 12: The effect of more or less generosity of public transfer

	Bench. (Δ^{bench})	150% Δ^{bench}	50% Δ^{bench}	0% Δ^{bench}
Income inequality (Gini)				
Labour income	0.52	0.54	0.47	0.45
Capital income	0.63	0.66	0.55	0.44
Market income	0.46	0.45	0.44	0.41
After tax income	0.42	0.41	0.40	0.37
Net income	0.31	0.26	0.35	0.37
Redistributive effect				
Tax	0.04	0.05	0.04	0.04
Net	0.11	0.13	0.06	0.04
Hours worked (% Δ^{bench})				
- Aggregate		-8.08	16.08	29.63
- Low		-10.41	21.09	38.67
- Medium		-8.90	17.86	32.99
- High		-5.85	11.25	20.75
Savings (% Δ^{bench})				
- Aggregate		-16.77	39.79	107.83
- Low		-19.68	43.09	116.85
- Medium		-18.35	43.90	119.05
- High		-12.25	30.95	83.65

Note: % Δ^{bench} refers to the percentage change in the respective variable relative to its value in the benchmark. Redistributive effect is measured by the Reynolds-Smolensky index. Net redistributive effect is the effect after tax and transfers. The tax progressivity parameter is kept unchanged at the benchmark level.

Table 12 presents crucial findings regarding the impact of the transfer system on income inequality and its potential unintended consequences. Firstly, the transfer system plays a significant role in reducing inequality, as evidenced by the Reynolds-Smolensky index for tax (0.04) and the overall tax and transfer system (0.11). Naturally, a 150% more generous public transfer system increases the redistributive effect (0.13) and lowers net income inequality from 0.31 in the benchmark to 0.26.

However, the transfer system also generates substantial disincentives for low and medium skill workers. When public transfers are 150% more generous, work hours reduce across all types of households. Conversely, when transfers are reduced, it results in a substantial increase in hours and an even greater increase in savings. In this regard, eliminating public transfers altogether results in a 39% and 33% increase in hours worked when transfers are eliminated. This change also leads to a considerable rise in savings (117% for low skill and 119% for medium skill, compared to 84% for high skill).

These distortions from the public transfer system affects market income inequality. As evident, a more generous public transfer system results in large decline in savings for low skill types (20%) relative to the high skilled (12%). This increases capital income inequality. Less generous public transfers incentivises low income types to save. Hence we observe a significant reduction in the Gini coefficient of capital income inequality from 0.66 in the economy with public transfers at 150% of benchmark to 0.44 in the economy with no public transfers.

Hence, within the general equilibrium framework where the tax and transfer system influences incentives, the public transfer system exert minimal effect on net income inequality. The Gini coefficient is only marginally higher at 0.37 without public transfers, compared to 0.31 with public transfers in place. Similarly, increasing the generosity of public transfers by 150% results in only a small decline in net income inequality (Gini of 0.26) due to the increase in capital income inequality. These results highlight the complex interplay between public transfer systems, labor market incentives, and income inequality in a macroeconomic context.

6 Conclusion

We examine to what extent a progressive tax and transfer system can moderate the distributional impact of uneven growth. We use Australia as a case study as it has two salient features: three decades of uninterrupted economic growth and a higly progressive tax and transfer system. We first use the point-in-time records of income and tax payments of million Australian taxpayers from 1991 to 2019 to document how the benefits of economic growth have been shared across groups and overtime.

Our main results based on a point-in-time approach indicate that majority of Australians are beneficial from uninterrupted growth. However, the benefits of market income growth have not been unevenly shared across age and income groups over time. Having used progressive tax and targeted transfer plolicies, the Australian government has successfully alleviated some of the inequality and ensured a more equitable distribution of economic gains. The gap between rich and poor is substantially reduced after accounting for the redistributive effects of taxes and transfers. Furthermore, when examining the income inequality of nine cohorts over a span of 20 years, we show that lifetime income inequality is relatively lower and more stable. This finding highlights the biased conclusion and policy recommendations based on a point-in-time statistics to assess inequality. Finally, we construct a dynamic general equilibrium model to explore the potential impact of higher tax-transfer progressivity on reducing inequality in Australia. Our simulation results demonstrate that different tax designs have varying implications for individual behaviors, aggregate outcomes and inequality a dynamic general equilibrium framework.

Our paper underscores the important facts that income growth is slowing down and that the importance of a progressive tax and transfer system in moderating the distributional effects of uneven growth in Australia.

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Technical appendix

Our technical appendix contains supplementary material that provides further details to the main paper.

A Measuring redistributive effect of taxes and transfers

This appendix presents a comprehensive overview of our measures of income inequality and redistribution, as well as our decomposition method, which is based on the work of Lambert (2001).

A.1 Definitions

In the following exposition, we provide clear definitions for our income distribution concepts, which apply to both the point-in-time and lifetime approaches. To simplify notation, we abstract from indexing time or cohort.

Market income distribution. Let N be the number of income units (population) and x_i define the market income level of unit i. Assume that income is continously distributed along the income scale $[x_1, x_N]$ such that $x_1 < x_2 < ...x_{N-1} < x_N$ (ranked by ascending order). For convenience, let $x_1 = 0$. Total income in the economy be given by

$$X = \int_{0}^{x_N} h(x)\, dx \tag{17}$$

where $h(x)$ is the income density function such that $h(x)\, dx$ gives the amount of income held by income units in the range $[x, x + dx]$.

Let $f(x)$ define the frequency density function that gives the proportion of N at each income level x. As such $f(x)\, dx$ gives the proportion of the population whose incomes lie in the range $[x, x + dx]$. Given that the income distribution is continuous,

$$h(x) = Nxf(x) \tag{18}$$

$$X = \int_{0}^{x_N} xf(x)\, dx \tag{19}$$

The cumulative density function is given by

$$F(x) = \int_{0}^{x} f(t)\, dt \tag{20}$$

Let $p \in (0, 1)$ represent the first $100p$ percent of income units. For each $p \in (0, 1)$, there is only one income level z with rank p. The Lorenz curve is given by

$$L_X(p) = \int_0^z \frac{x f(x)\, dx}{\mu_x} \qquad 0 < p < 1 \tag{21}$$

The Gini coefficient of pre-tax income is

$$G_X = 1 - 2\int_0^1 L_X(p)\, dp \tag{22}$$

Income tax. Let $t(x)$ represent the tax liability at income level x. Total tax revenue is given by

$$T = N\int_0^{x_N} t(x) f(x)\, dx \tag{23}$$

The overall average tax rate is

$$t = \frac{T}{X} \tag{24}$$

Let L_{X-T} and L_T denote the concentration curves for post-tax income, and tax respectively, their concentration coefficients are

$$C_{X-T} = 1 - 2\int_0^1 L_{X-T}(p)\, dp \tag{25}$$

and

$$C_T = 1 - 2\int_0^1 L_T(p)\, dp \tag{26}$$

Note that, both concentration curves are plotted against percentiles of pre-tax income. Thus they both have the same argument p as L_X.

A.2 Progressivity and redistributive effect

Tax progressivity. The Kakwani index of tax progressivity is given by the difference between the tax concentration index (C_T) and the Gini index for pre-tax income.

$$K_T = C_T - G_X \tag{27}$$

The limits of the Kakwani index depends on the degree of pre-tax income inequality. The range is $[-(1+G_X), (1-G_X)]$. The closer to the latter the more progressive is the tax system.

The Suits index S_T is calculated by plotting the cumulative proportion of tax liability ordered by pre-tax income against the cumulative proportion of pre-tax income. The indexed is measured as twice the area between the 45° line and this relative concentration curve. The range of the Suits index is $[-1, 1]$.

In the case of both indices, an index value of 0 indicate a proportional tax.

Redistributive effect. We measure the redistributive effect using the Reynold-Smolensky index of redistributive effect.

$$RS = G_X - G_{X-T} \tag{28}$$

The range of the Reynolds-Smolensky index is $[G_X - 1, G_X]$

Reranking. Whenever nonincome characteristics (such as marital status, age, and dependents) determine tax liabilities, the post-tax income rank of an income unit may not be the same as their pre-tax rank. Such reversals of rank that occur in the transition from pre-tax to post-tax income would mean that the Lorenz curve for post-tax income will not be the same as the concentration curve for post-tax income. This would imply that $C_{X-T} \neq G_{X-T}$. The reranking correction is computed as

$$RC = C_{X-T} - G_{X-T} \tag{29}$$

Note that when there is no reranking such that $C_{X-T} = G_{X-T}$, $RS = G_X - C_{X-T}$. (This is relevant for practical purposes. For instance, in computations, if there is no reranking inherent in the tax system, one can compute RS without having to re-order data by post-tax income and computing G_{X-T}).

Decomposing the redistributive effect. The RS index can be decomposed as follows.

$$RS = \overbrace{\frac{t}{1-t}}^{\text{Average rate of tax on } \textbf{net} \text{ income}} \times \underbrace{K_T}_{\text{Kakwani index}} + \overbrace{(C_{X-T} - G_{X-T})}^{\text{Reranking correction}} \tag{30}$$

Following a similar approach we can construct the distributions of public transfer, post-transfer income and post-government income, concentration curves, and transfer progressivity and redistributive effects of public transfer.

A.3 The parametric tax function

Australia's income tax code consists of multiple income thresholds and statutory marginal tax rates that rise as we progress to higher thresholds. Further, those on lower income thresholds receive various credits and offsets. We approximate this complex tax code using a parsimonious tax function commonly used in the public finance literature (e.g., see Jakobsson (1976), Persson (1983), Benabou (2002) and more recently Heathcote, Storesletten and Violante (2017)). Specifically, the total tax liability $t(y)$, average tax rate atr and marginal tax rate mtr take the functional form:

$$t(y) = y - \lambda y^{(1-\tau^y)} \tag{31}$$

$$atr = 1 - \lambda y^{-\tau^y} \tag{32}$$

$$mtr = 1 - \lambda(1-\tau^y) y^{-\tau^y} \tag{33}$$

y is taxable income, λ is a scale parameter that controls the level of the average taxation and τ^y is a curvature parameter that controls the curvature of the function. When $\tau^y = 0$, the tax code is proportional with an average tax rate of $1-\lambda$. The higher the value of τ^y, the more progressive is the income tax schedule.[6]

B Empirical facts: Additional results

B.1 Estimation of the tax function

We estimate the tax function using taxable income and tax liability from ALife data via 2 methods - ordinary least squares estimation of the logarithmic transformation of the function, and non-linear least squares. Both methods yield the similar estimates and exactly the same trend. Table 13 summarizes the OLS estimates of τ^y, their 95% confidence intervals and the adjusted R-squares of the estimations for some selected years. As evident from the table, we can obtain a very precise estimate of τ^y. This confirms that the tax function is a fair approximation of the income tax code in Australia.

Table 13: OLS estimates of τ^y

Year	1991	2000	2010	2019
τ^y	0.152	0.150	0.129	0.165
95% Confidence interval	(0.151,0.152)	(0.150,0.151)	(0.129,0.129)	(0.165,0.166)
Adjusted R^2	0.97	0.98	0.99	0.99

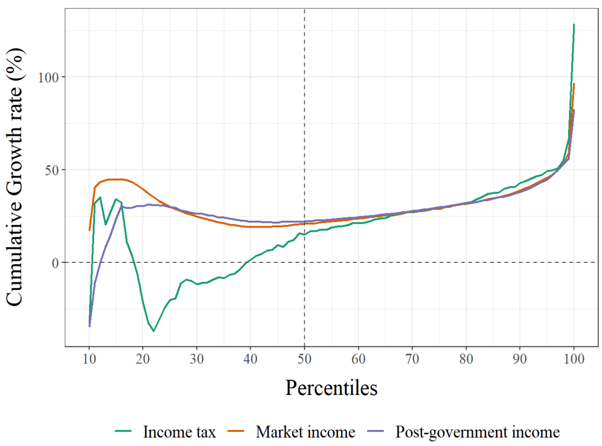
[6] This tax function is fairly general and captures the common cases:

$$\begin{cases} \text{(1) Full redistribution: } t(y) = y - \lambda \text{ and } t'(y) = 1 & \text{if } \tau^y = 1, \\ \text{(2) Progressive: } t'(y) = 1 - \overbrace{(1-\tau)}^{<1}\lambda y^{(-\tau^y)} \text{ and } t'(y) > \frac{t(y)}{y} & \text{if } 0 < \tau^y < 1, \\ \text{(3) No redistribution (proportional): } t(y) = y - \lambda y \text{ and } t'(y) = 1-\lambda & \text{if } \tau^y = 0, \\ \text{(4) Regressive: } t'(y) = 1 - \overbrace{(1-\tau)}^{>1}\lambda y^{(-\tau^y)} \text{ and } t'(y) < \frac{t(y)}{y} & \text{if } \tau^y < 0. \end{cases}$$

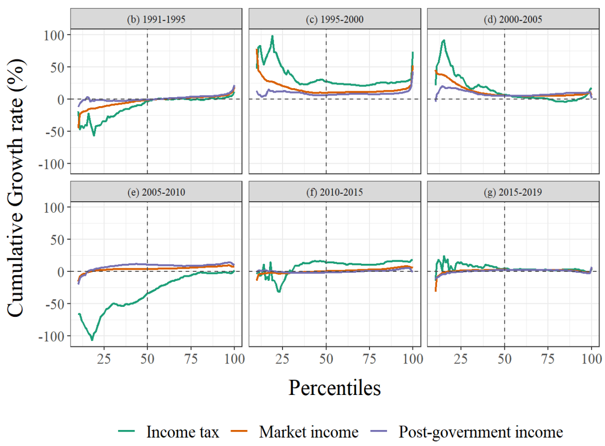
The curvature parameter τ^y is a closed-form expression of tax elasticity given by $\frac{mtr(y)-atr(y)}{1-atr(y)} = \tau^y$. If the elasticity is larger than unity, $\varepsilon > 1$, additional tax liability on an additional unit of income (marginal rate) exceeds average tax liability at that income level (average rate), i.e., $mtr(y) - atr(y) > 0$.

B.2 Point-in-time measures

Cumulative growth. Figure 16a displays the cumulative income growth for the period from 1991 to 2019. In order to provide more insights into cumulative growth over time, we report the cumulative income growth for 6 sub-periods (Figure 5b). There are few key facts. First, there has been a variation in the cumulative market income growth across income groups over time. However, the tax and transfer system has smoothed these income fluctuations out, especially 1991-2005. The cumulative post-government income growth is more stable. Second, the bottom half of the distribution have much higher income growth between 1995 and 2005. The cumulative growth is generally lower since 2005. Importantly, the cumulative growth for both market and post-government income is negative for the bottom end of the distribution (P10) since 2005. This implies that the poor have been falling behind and gains less over time.



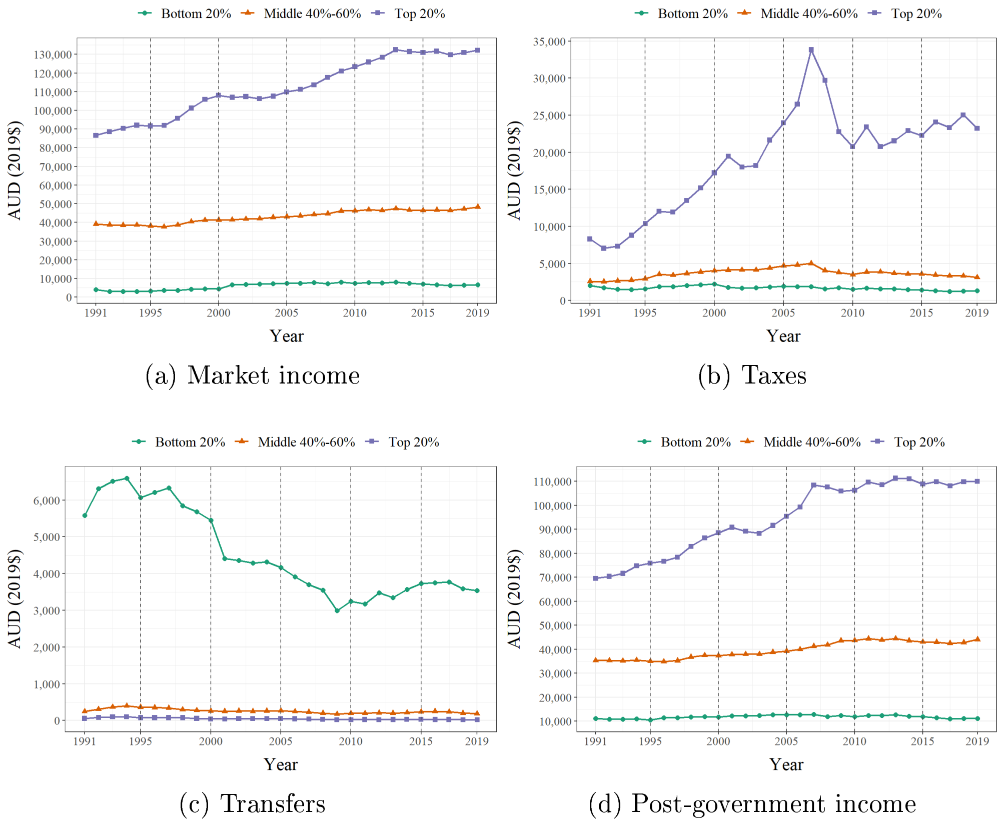
(a) 1991-2019



(b) Sub-periods

Figure 16: Cumulative growth incidence curves.

Figure 17 document how market income, income, tax, transfer and post-government income have changed in the past three decades.



(a) Market income (b) Taxes

(c) Transfers (d) Post-government income

Figure 17: Market income, tax, transfer and post-government income.

Growth by production factors.

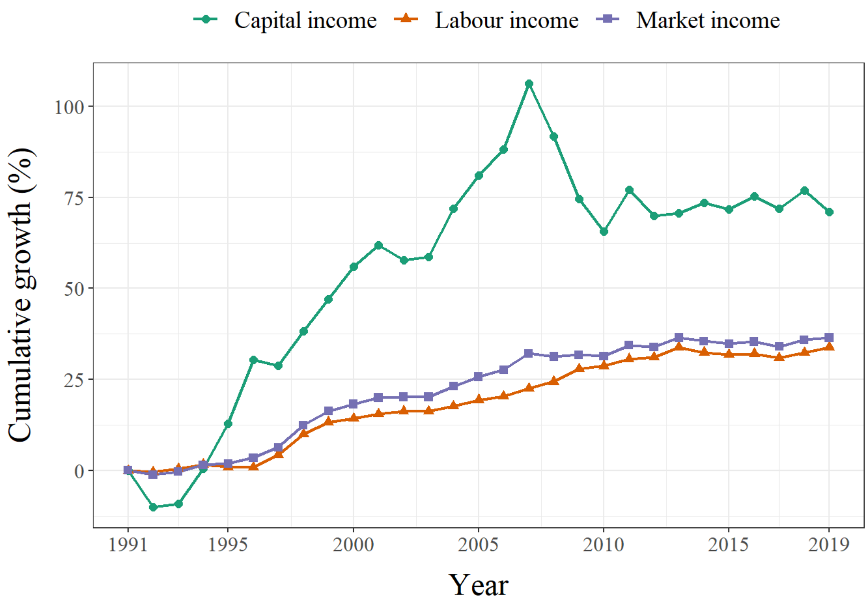


Figure 18: Cumulative growth in labour and capital income.

(a) Mean market income

(b) Net income

(c) Median market income

(d) Median net income

Figure 19: Market income and net income by gender

Growth by gender.

B.3 Lifetime measures

Lifetime income and tax shares. As Table 14 shows, shares of lifetime income and tax shares for c1999 are almost the same as those for c1991. We observe a slight increase in tax shares at the top for c1999. This is not surprising since this cohort is active from 1999 to 2019, where point-in-time tax progressivity was sharply increasing. Yet, in terms of lifetime tax liability, we observe lower progressivity as they entered the sample in 1999 when progressivity was relatively low.

Table 14: Lifetime income and tax shares by quantiles of lifetime market income

	Quintiles					Top quantiles		
	Q1	Q2	Q3	Q4	Q5	Top 10%	Top 1%	Top 0.1%
					Market income			
1991	6.88	12.67	17.05	22.37	41.03	26.67	7.03	1.96
1995	6.84	12.41	16.87	22.32	41.56	27.06	7.24	1.72
1999	6.74	12.23	16.77	22.49	41.77	27.17	6.89	1.46
					Post-government income			
1991	7.95	13.88	17.92	22.57	37.69	23.77	5.96	1.64
1995	7.93	13.62	17.8	22.64	38.01	23.88	5.8	1.27
1999	7.85	13.54	17.76	22.85	38	23.68	5.23	0.98
					Income tax			
1991	4.68	9.27	14.27	21.31	50.48	35.05	10.2	2.93
1995	4.62	9	13.92	20.94	51.52	36.21	11.5	3.07
1999	4.47	8.58	13.76	21.05	52.14	37.01	11.65	2.87
					Public transfers			
1991	49.02	26.87	15.06	6.81	2.24	0.87	0.02	0
1995	54.92	24.58	12.78	5.84	1.88	0.56	0	0
1999	57.88	23.7	11.51	5.25	1.66	0.59	0	0