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Tax progressivity in Australia: Facts, measurements and estimates

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Abstract

We study the progressivity of Australia's personal income tax system after the introduction of a New Tax System (Goods and Services Tax) Act 1999. We use two data sets: administrative data from Australian Tax Office (ATO) 2004-16 and survey data from the Household Income and Labour Dynamics in Australia (HILDA) survey 2001-16. We first document the distributions of income and tax liabilities, properties of the joint distributions of taxes paid and income, and discuss how taxes are varied across households and over time. We next provide estimates of tax progressivity using two approaches: one based on tax liability progression and one based on tax liability distribution relative to income distribution. The result obtained from the tax progression approach implies a significant decline in the average level of tax progressivity since 2004. Meanwhile, the result obtained from the tax distribution approach indicates a tax progressivity cycle with a modest decline up to 2006, then a sharp increase until 2010, and a slight decline thereafter. The personal income tax cuts for all taxpayers in early 2000s and the introduction of tax offset for low income earners (LITO) are main driving forces. Moreover, the evolution of income distribution and its interactions with bracket creep strongly affect the overall progressivity level of Australia's income tax system. Hence, our findings provide new insights into the dynamics of income growth and tax progressivity, which has implications for tax policy debates in Australia.

JEL Codes: E62, H24, H31.
Keywords: Taxation, progressiveness, income dynamics, inequality, parametric tax function, Suits index, Kakwani index.

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1 Introduction

Since the introduction of a New Tax System (Goods and Serivces Tax) Act 1999, there have been several reviews and debates on further reforming Australia's income tax system (e.g. see Henry et al. (2010)). The progressivity of the tax system plays a centre role within these reviews as it is directly linked to the equity and efficiency implications of the tax system. Critics usually argue that Australia's income tax system is too progressive, so that high earners are paying too much tax. In response, in 2018 the Australian government proposed tax cuts for low- and middle-income earners from 2019. How progressive is Australia's personal income tax system? There is little evidence/agreement on measuring and estimating tax progressivity in Australia.

In this paper, we provide a comprehensive investigation of progressivity of Australia's personal income tax system. In particular, we focus on the period after the introduction of a New Tax System (Goods and Serivces Tax) Act 1999. Our ultimate goal is to construct a set of tax progressivity measures that can be consistently evaluated and monitored over time.

Our analysis relies on administrative data of individual sample files from tax returns from the Australian Tax Office (ATO) consisting of over 2 million units representative of the entire population of tax payers. Since the sample is not representative of the entire population, we verify our results using survey data from the Household Income and Labour Dynamics in Australia (HILDA) survey. We first document facts on the distributions of tax liabilities, properties of the joint distributions of taxes paid and income, and discuss how taxes are varied across households and over time in Australia. We next estimate the progressivity of Australia's income tax system using two approaches: one based on tax liability progression and one based on the distribution of tax liabilities relative to the income distribution.

The tax progression approach measures tax progressivity in terms of the elasticity of tax liability at a given income level. According to this measure, a more progressive tax system is simply one where the level of tax liabilities progresses with income at a more rapid rate than in a less progressive tax system. We assume a parametric tax function, that is commonly used in the public finance literature (e.g., see Heathcote, Storesletten and Violante (2017)), and estimate the trends in tax progressivity in Australia. Our least squares estimates indicate that the level of tax progressivity, on average, has declined significantly since 2004. However, our quantile regression estimates show that the level of tax progressivity vary significantly across income quantiles and has a hump shape. Yet, the level of tax progressivity increases from the bottom quantile to the mid, and declines with income at quantiles above the middle.

The tax distribution approach measures tax progressivity in terms of tax liability distribution relative to the income distribution. This approach accounts for both the income tax schedule and the underlying income distribution. We specifically use two indices: the Suits (1977) index and Kakwani (1977) index. Intuitively, these two indices measure how tax liabilities are distributed across the income distribution. A more progressive tax system is simply one where the tax liabilities are distributed more unequally toward the higher end of income distribution. Our main results obtained from the tax distribution approach show a tax progressivity cycle with a decline up to 2006, and then followed by a sharp increase until 2010, and a slight decline thereafter.

We identify the main factors that affect progressivity of the tax system comparing the Suits Index values obtained from simulations of various counterfactual cases with the Suits Index from

actual data. We find that the personal income tax cuts for all taxpayers in early 2000s and the increase in the tax offset for low income earners (LITO) are important driving forces. Moreover, the evolution of the income distribution and interactions with braket creep strongly affect the overall progressivivity level of the Australian income tax system. The results generated from the two datasets are fairly consistent with each other.

Finally, we examine various extensions including the link between tax progressivity and redistributive effects, the implications of household heterogeneity for tax progressivity, the progressivity of the tax and transfer system as a whole, and tax progressivity through the lens of wealth distribution. We hightlight the quantitative importance of accounting for household heterogeneity as a large number of tax offsets and transfers depend on family structure. Interestingly, the income tax system is very regressive in wealth space.

Hence, our findings provide new insights in to the dynamics of income growth and tax liability, which has important implications for for public debates on tax reforms in Australia.

Related studies. We are not the first to examine tax progressivity in Australia. However, to the best of our knowledge, the trend in tax progressivity has not been explored since the 2000s in Australia. One of the earliest papers that examined tax progressivity in Australia is Kakwani (1977). He examined income tax statistics for Australia (1962-1972), Canada (1966-1972), Britain (1959-1967) and the United States (1958-1970). He found that there were relatively small differences in the degrees of income inequality before and after tax except in the US. He also found that during the period, Australia had the highest degree of tax progressivity compared to the other countries. Hodgson (2014) explores the relationship between personal income tax rates and means tested transfer payments in Australia from 1970 to 2014. She documents the major reforms in taxes and transfers during that period. She argues that the Australian tax and transfer system shifted from one with highly progressive tax rates coupled with universal benefits to flatter tax rates coupled with more targeted and means tested benefits.

The most comprehensive study on the progressivity of the Australian personal income tax to date is by Smith (2001). She estimates the degree of income tax progressivity in Australia from 1917 to 1997 from official income taxation statistics using 3 indices of tax progressivity - the Kakwani (1977) index, Suits (1977) index and Musgrave and Thin (1948) index. She finds a peak in tax progressivity in the early 1950s on the Kakwani and Suits indices and a strong decline till the late 1970s followed by a relatively steady trend till 1997. She also finds that only a slight temporary increase in progressivity was associated with tax reforms in the 1970s and 1980s. The results with Musgrave and Thin index were ambiguous in direction with occasional peaks. Smith (2001) only use taxation statistics and does not extend beyond 1997.

There are very few related empirical studies on the redistributive effects of the Australian tax and transfer system. Whiteford (2010; 2014), Wilkins (2014*b*) and Herault and Azpitarte (2015) are notable studies that examined trends in the redistribution and progressivity of both taxes and transfers in Australia. Whiteford (2010) provides a detailed examination of the progressivity of the Australian transfer system together with taxes by examining the ratio of transfers paid to the poorest quintile to those paid to the richest quintile between the mid 1990s to 2005. Australia had the highest ratio among all OECD countries. He also examined the concentration coefficients of taxes and transfers ranking households by equivalised disposable income during the mid 2000s. He analysed trends in the concentration coefficient for transfers

from 1980 to 2000 and found that Australia has always had the highest concentration coefficient and progressivity has also increased over time. He concludes that Australia has one of the most progressive systems of direct taxes of any OECD country. Wilkins (2014*b*) uses the Survey of Income and Housing (SIH) and the Household Income and Labour Dynamics in Australia (HILDA) survey to analyse income inequality between 2001 and 2010. He analyses the effect of income taxes on inequality using decomposition analysis. He showed that during the decade, the effect of taxes on reducing income inequality declined in all income series used in the analysis. Wilkins (2014*b*) and Whiteford (2010; 2014) are descriptive in essence and focus more on summary statistics of redistribution at various income levels rather than on examining measures of progressivity

Herault and Azpitarte (2015) examine trends in the redistributive impact and progressivity of the tax and transfer system between 1994 and 2009 using the Australian Survey of Income and Housing Costs (SIHC). They measure the redistributive effect as per Reynolds and Smolensky (1977) by comparing the Gini index of pre-fiscal income (before tax and transfers) to post-fiscal income (after tax and transfers) and find that after reaching a peak value in the late 1990s, the redistributive effect of the tax and transfer system declined sharply. They also measure the progressivity of the system following Kakwani (1977) and show that the progressivity of benefits barely changed over that period. Tax progressivity tended to decline from a peak value of 0.27 in 1997 to 0.23 in 2005, and increased in 2007 and 2009.

There is a growing recent literature on inequality in Australia. For example, Wilkins (2015) documents trends in income inequality in Australia using household survey data. They find that there has been a slight increase in income inequality over recent years. Chatterjee, Singh and Stone (2016) examine the rise in labour income inequality over the past decade using HILDA. They also document an increase in inequality in labour earnings and find that it is due to residual factors reflecting idiosyncratic risk and unexpected labour market outcomes. Kaplan, Cava and Stone (2018) document facts about consumption and income inequality among households in Australia, emphasising the role of the rents imputed to home owners for conclusions about inequality. Differently, we document the joint distribution of income and tax liability using HILDA and ATO data. Our focus is to estimate the progressivity level of the Australian personal income tax system and redistributive effects.

We proceed as follows. We begin with an overview of Australia's personal income tax system and briefly discuss the important changes to the tax schedule between 2004 and 2016. Next, we explain the different methods to measures tax progressivity. In section 4, we provide a description of datasets and descriptive statistics of income and tax dynamics. In section 5, we present the main results and examine the various factors that affected the trends in tax progressivity. In section 6, we examine the link between progressivity and redistributive effect of income tax as well as the overall tax-transfer system. We conclude in section 7. We provide additional results and explanation in Appendix.

2 Australia's personal income tax system

The introduction of A New Tax System (Goods and Serivces Tax) Act 1999 was a comprehensive tax reform aimed at enhancing the efficiency and effectiveness of Australia's tax system.

Fundamentally, the reform introduced a new tax called Goods and Services Tax (GST), so that it shifts the tax base away from income more towards consumption.

Australia ranks among those countries with the lowest overall tax burden (as measured by total tax revenue as a percentage of GDP). The personal income taxes are the most important revenue source of the Australian tax system. The tax revenue collected from personal income as a percentage of GDP has been considerably higher than the OECD average since 1972. Compared to the OECD average of around 33 per cent for the years 2004 - 2016, tax revenue as a percentage of GDP for Australia was around 28 per cent for the period. However, taxes paid on personal income as a percentage of GDP has been around 12 per cent on average compared to the OECD average of around 8 percent between 2004 - 2016. The personal income tax accounts for nearly 40 per cent of all tax revenue, which is the second highest among the OECD countries after Denmark (OECD 2018).

2.1 Personal income tax components

The major components of the Australian personal income tax system includes: regular personal income taxes, levies, concessions and offets

Income tax. Regular income tax is paid on an individual's total income less any expenses (deductions) incurred in generating that income. Individual tax payment/liability is determined by a schedule of marginal tax rates and thresholds. The tax schedule is progressive with a tax-free income threshold followed by increasing marginal tax rates at subsequent thresholds. While the primary tax schedule is fairly simplistic, a large array of levies, concessions and offsets which are often subject to different rates, thresholds, taper rates and means tests add a layer of complexity to the income tax system.

Levies. Levies that are generally linked to funding a particular government expenditure increases an individual's tax liability on top of the amount of tax from the standard tax schedule. The main permanent levy is the Medicare levy, which is applied at a flat rate on the entire taxable income beyond a certain income threshold. The threshold and related taper rates are subject to demographic characteristics such as relationship status and the number of dependents. In addition to the Medicare levy, a surcharge applies on those individuals above a specified income threshold without private health insurance.

Concessions. The tax system also includes a variety of concessions and offsets. Primarily, concessional treatment applies for certain income from saving such as superannuation or capital gains and from certain types of business income such as capital gains tax concessions targeted to small business.

Offsets. The main tax offset is the low-income tax offset (LITO). The LITO is available in full for individuals below a specified low income threshold, and then gradually tapered above that till a specified high income threshold. In addition to the LITO, there are a number of tax offsets that apply to specific demographic groups such as the seniors and pensioners tax offset (SAPTO) and the employment termination payments tax offset Hodgson (2014).

2.2 Major changes since 2000

There have been significant changes to Australia's personal income tax system since the tax reforms entitled 'A New Tax System (Goods and Services Tax) Act 1999'. Within each complex

component of the income tax schedule, rates, thresholds and taxable income have gone through changes often on an yearly basis. In this section, we summarise the major changes that have impacted on the progressivity of the tax system and focus on changes to the tax schedule (in nominal terms) and the low income tax offset (LITO). [1]

Income tax. Since the introduction of 'A New Tax System' effectively from July 2000, there were tax cuts for all taxpayers, with reductions in marginal tax rates for about 95 per cent of all individual taxpayers. There were a number of significant changes to the income tax system through to 2013. It was followed by three years of fairly little change from 2013 to 2016. Between 2004 and 2016, the most significant change to the tax schedule were the changes in the income thresholds (see Table 1 for comparison). The top threshold in 2004 was at $62,500 compared to $180,000 in 2016. This threshold was raised each year from 2005 to 2007, with the steepest rise in 2007 from $95,000 to $150,000 (e.g., see Figure 1). Although the marginal tax rates were relatively constant, the change in the income thresholds indirectly reduced the marginal tax rates for the top income earners. Comparatively, middle income earners faced relatively little change in their tax burdens. This is explained in more detail in section 4. Table 1 highlight changes in the income tax thresholds and rates between 2004 and 2016.

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

3 Measurement

There is no consensus on how to measure the progressivity of an income tax system. The variety of measures can be classified into two main approaches. The first approach measures tax progressivity in terms of tax progression at different income levels (tax progression-based measure). The second approach measures tax progressivity in terms of tax liability distribution relative to income distribution (tax distribution-based measure).

3.1 Tax progression-based measure

In a progressive tax system, tax liability rises with income. The progressive level of a tax system can be measured in terms of tax progression at a given income level, which has a long standing in public finance going back to Pigou (1929) and Slitor (1948). Musgrave and Thin (1948) summarise three common measures of the tax progression approach in Table 2.

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

Liability progression. The tax progression approach measures tax progressivity in terms of the elasticity of tax liability at a given income level. According to this measure, a more progressive tax system is simply one where the level of tax liabilities progresses with income at

[1] We summarize the major changes in the income tax schedule, LITO and SAPTO in Appendix C.3.

a more rapid rate than in a less progressive tax system. Consider an individual i at an income level y_i. The elasticity of tax liability with respect to income is

$$\varepsilon_i = \frac{\partial T_i}{\partial y_i} \frac{y_i}{T_i} \tag{1}$$

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

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

$$\frac{m(y_i)}{t(y_i)} > 1 \quad \text{or } m(y_i) - t(y_i) > 0 \tag{2}$$

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

A parametric tax function. The elasticity of tax liability can be calculated by assuming a parametric tax function. We consider a parametric tax function that maps pre-tax income to post-tax income as

$$\tilde{y_i} = \lambda y_i^{(1-\tau)}, \qquad \lambda > 0, \qquad 0 \leq (1-\tau) \leq 1 \tag{3}$$

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

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

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

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

$$\frac{m(y_i) - t(y_i)}{1 - t(y_i)} = \tau \tag{4}$$

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

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

$$\frac{1-m\left(y_i\right)}{1-t\left(y_i\right)}=1-\tau. \tag{5}$$

According to the interpretation of residual income progression in Musgrave and Thin (1948), $(1-\tau)$ is the measure of residual income progression (see the third row of Table 2). An increase in the elasticity implies a reduction in progressivity and vice-versa. A tax system with a lower $(1-\tau)$ is more progressive than one with a higher $(1-\tau)$.

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

3.2 Tax distribution-based measure

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

We specfically consider a more general index that takes into account both the income tax schedule and the underlying distribution of income (e.g. see Pfahler (1987)). There are two common global measures that take this perspective: Kakwani index (Kakwani (1977)) and Suits index (Suits (1977)). Both indices examine the extent to which the tax system deviates from proportionality by comparing the distribution of pre-tax income with the distribution of tax liabilities ordered by pre-tax income. Intuitively, these two indices measure how tax liabilities are distributed across the income distribution. A more progressive tax system is simply one where the tax liabilities are distributed more unequally toward the higher end of the income distribution.

To formally define these two indices, we first define the cumulative distribution function and the associated concentration curves. Let Y represent pre-tax income and T represent tax liabilities where both are non-negative and continuous random variables where $T=f\left(y\right)$. Let μ_Y and μ_T be the means of the pre-tax income and tax liabilities respectively. The cumulative distribution function (c.d.f.) is $p=F_Y\left(y\right),0\leq p\leq 1$. Thus, the Lorenz curve of pre-tax income is defined as $L_Y\left(p\right)=\mu_Y^{-1}\int_0^p y\left(x\right)dx$ where $y\left(p\right)$ is the pth-quantile of the pre-tax income distribution. The tax concentration curve is defined as $L_T\left(p\right)=\mu_T^{-1}\int_0^p t\left(x\right)dx$ where $t\left(p\right)=f\left[y\left(p\right)\right]$. Figure 3(a) illustrates the Lorenz curve and the tax concentration curves. The areas under the curves give the concentration index for each respective curve. As such, the concentration index (Gini coefficient) for pre-tax income is

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

and the concentration index for tax liabilities is

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

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

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

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

Suits index takes a different approach but uses the same concept of tax shares relative to income shares. Instead of relying on two concentration curves, the index relies on the relative concentration curve of taxes as shown in Figure 3(b). The curve plots the cumulative proportion of tax liabilities ordered by pre-tax income against the cumulative proportion of pre-tax income. The 45 degree line indicates proportionality where tax shares equal income shares. A curve below the line indicates a progressive system where tax shares increase with rising income shares and vice-versa. The Suits index is the area between the 45-degree line and the relative concentration curve. The index ranges from -1 for the most regressive tax possible to +1 for the most progressive tax possible, and takes the value zero for a proportional tax. This is expressed as

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

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

4 Data and descriptive statistics

4.1 Data

We use two datasets for our analyses. Our main dataset consists of confidentialised unit records of individual income tax returns from the Australian Tax Office (ATO). For comparison, we also use unconfidentialised unit record data from the Household, Income and Labour Dynamics in Australia Survey (HILDA).

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

The ATO sample used in this paper contains 2,071,348 units in total and includes 49 variables that provide useful information on demographics and individual components of net income. The

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

large size of the sample enables more precise estimations of mean values and distributions for total income and its respective income components.

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

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

HILDA data. HILDA used in this paper contains 247,863 units in total. In each year, the HILDA survey collects detailed information on respondent's annual income that allows for an estimation of total personal and household incomes. Public transfers, income tax and after tax net income is estimated.

We used unconfidentialised data from HILDA and hence, in contrast to the ATO data, relevant variables are neither top nor bottom coded. In addition, the rich set of information included in the survey allows for more accurate estimations of tax payments. In addition to individual level records, the availability of household level data enables us to obtain more accurate estimates of tax payments and rates by family type and the number of children using the HILDA sample. Further, the sample is not dependent on individuals lodging tax returns. In this manner, it could be deemed more representative of the Australian population compared to ATO. In addition, HILDA is relatively stable in its survey methods and income measures and there is a strong emphasis on preserving longitudinal consistency (Wilkins, 2015).

Although the initial sampling frame was designed to be nationally representative in 2001, immigrants arriving in Australia after 2001 have little chance of entering the sample. It is possible that this affects the representation of the distribution of income and tax payments. In 2011, a general sample top-up was conducted to address the declining representativeness of the survey.

From both datasets, we restrict our sample to those individuals with non-negative income and tax liability. Also, we drop any observations where the average tax rate exceeds the top marginal tax rate for a given year. 8% of the ATO data and 5% of the HILDA data were excluded. For comparison, we restrict the HILDA sample to the period 2004 to 2016 in our

main analysis.

4.2 Income and tax liabilities

In order to understand progressivity measures, it is important to understand the income distribution and and how tax liabilities are allocated. For this purpose, we document stylized facts on income share and tax liabilities by quantiles of nominal pre-tax income. For brevity, we only report the results from our ATO sample within this section[3]. The notion of income we use throughout the paper encompasses all income flows accruing to the sampling unit: labor income, asset income from different sources, private transfers and public transfers. Unless explicitly mentioned, all income, tax liabilities and transfers are expressed in nominal terms.

Table 3 and 4 presents income and tax descriptive statistics by decile and for the top 1% of the nominal pre-tax income distribution from 2004 to 2016, respectively. It highlights the substantial degree of concentration of both pre-tax income as well as tax liabilities at the top. The richest 10% of individuals earned around 31-32% of total pre-tax income and were liable for 44-46% of total tax payments. Meanwhile, the bottom 10% earned around 0.9% of total income. With a mean pre-tax income less than the tax free threshold, they were not liable for any tax payments. The top 1% stands out from the rest of the income distribution with 7.82% of total income and 13% of total tax payment

As seen, share of tax payments increases for higher income group; however, it is not clear whether a tax system is progressive. In fact, proportional and regressive tax systems could result in top incomes liable for a larger share of total taxes depending on the distribution of pre-tax income. Column 7 in Tables 3 and 4 shows the share of taxes relative to the share of income earned by each quantile. In 2004, the share of total tax paid by the top 1% was 1.61 times their share of total income. The share of total taxes relative to the share of income increases with increasing incomes indicating a progressive tax system. Comparing 2016 with 2004 reveals that the relative tax liabilities at the bottom had declined significantly with very small changes at the top. This is also reflected in the marginal tax rates (column 8) and average tax rates (column 9). There has been a decline in average tax rates for the bottom 4 deciles.

4.3 Income growth relative to the tax schedule

In Australia, income brackets in the tax schedule are not indexed annually to CPI or wage growth. This fiscal lagging feature has important implications for understanding changes in tax progressivity. We report the growth in pre-tax incomes in relation to changes in income tax brackets.

Figure 4a displays the trend in average pre-tax nominal income for each decile. The solid lines track changes to income tax thresholds.

As seen in panel (a) of Figure 4, incomes at the bottom have been relatively stagnant compared to the top. The steepest rise in income is seen in the top 10%. Figure 4b shows this steep trend in the top 10% is actually driven by the top 1%. The trends also reveals that the top 1% experienced a decline in average income from $527,000 to around $400,000 between

[3]A more complete summary statistics from the ATO sample and the HILDA sample are included in Appendix C.

2007 and 2011 following the aftermath of the 2008 Global Financial Crisis. All other quantiles do not show any decline.

One very important indication from Figure 4a is that income thresholds do not seem to track trends in incomes across deciles. This is one symptom of the absence of inflation indexed tax brackets. Prior to 2009, the top 10% was above the top threshold. With the steep increase in the top threshold, a large number of those at the top were pushed down to the second top tax bracket. Throughout the period, the middle bracket applied to those in deciles 5 to 8. The result of the absence of inflation indexation of tax brackets can be seen when tax thresholds are juxtaposed against trends in real income. When nominal income is adjusted for inflation and expressed in 2004$, the only quantile that is above the top income threshold since 2007 is the top 1%. Only the top 10% lies within the second top income bracket. Decile 5 which falls within the middle income bracket in nominal terms falls into the first income bracket. This is one sign of the presence of bracket creeping where individual incomes fall into higher income brackets as nominal incomes increase without much increase in real terms. As evident from Figures 5a and 5b there has been relatively little growth in real incomes except for the top 1%.

4.4 Tax rates and liabilities over time

We document changes in tax rates and tax liabilities since 2004.

Figure 6 shows the trends in marginal and average tax rates between 2004 and 2016 by decile. The left panel of Figure 6 reports the marginal tax rate averaged within each decile. There has been a steep decline in the marginal tax rate for the top 2 deciles from 2004 to 2007. This corresponds with the increase in the top income tax threshold such that the majority of individuals in the top decile falls below the highest threshold. The most significant reduction in the marginal tax rate was for decile 4 (20 - 30 percentile) from 2006 to 2009. This corresponds with the gradual raising of the second income tax threshold from $21,600 in 2006 to $34,000 in 2009 such that decile 4 went from the second tax bracket to the lowest bracket as evident from Figure 4a. The other major change was for the lowest 2 deciles from 2012 to 2013 when the tax free threshold was raised from $6,000 to $18,200. The right panel of Figure 6 shows trends in the average tax rate.

For all years, the average tax rate for each respective decile is below the marginal tax rate. A decline in the marginal tax rate corresponds with a decline in average tax rates. However, impact of declining marginal tax rates on the average tax rate is counter balanced by rising nominal incomes. This is evident in the fact that trends in average tax liability by quantiles as shown in Figure 7 reflect trends in nominal income in Figure 4a and 4b.

The change in average tax rates and tax liabilities with income can be seen even more clearly from Figure 8. Panel (a) shows a scatter plot of pre-tax income averaged within 100 quantiles against the average tax rate and panel (b) plots income and against average tax liability. Compared to all other years, 2004 shows higher average tax rates at all income levels. Since then, there has been a a downward and rightward shift. This is due to the increase in the tax free threshold as well as the decline in the mean average tax rate. Further, since 2004, the rate at which the average tax rate increases with income has slowed down.

4.5 Relative tax liabilities

How are tax liabilities distributed? Another way to gauge progressivity is by comparing the share of total tax liabilities for each quantile relative to its respective share of total pre-tax income.

Figure 6 provides evidence of the progressive structure of the income tax where the marginal tax rate exceeds the average tax rate at each quantile. Examining share of tax and share of income in isolation does not reveal much about trends in progressivity. As evident from Figures 9a and 9b the individual trends in income shares and tax shares have been fairly stable throughout the period except for the top 1% (Figure 9c) . A clearer picture of the trend in progressivity emerges from Figure 9d when we examine the share of tax relative to the income share of each quantile.

From 2004 to 2006, there were no significant changes in the relative tax liabilities for any quantile. The relative tax liability of the bottom deciles 2006 to 2009 saw a decline in the relative tax liabilities of the bottom deciles. This corresponds with increases in the maximum amount of the Low Income Tax Offset (LITO) from $235 in 2006 to $1,200 in 2009. In 2006, those who earned an income below $27,475 were eligible for the LITO. This threshold was raised between 2006 and 2009 such that in 2009, the threshold was at $60,000. Deciles 1 - 7 were eligible for the LITO in 2009 compared to only deciles 1 - 4 in 2006.

2007 to 2010 saw a rise in the relative tax liability of the top 1% and a decline from 2010 to 2014. The threshold and marginal tax rate that applied to the top 1% were was constant at 45% at the top threshold of $180,000 during this period. Hence, the trend in relative tax liabilities can be attributed mainly to changes in income earned by the top 1% during this period. As seen from Figure 4b, there was a steep decline in average pre-tax income earned by the quantile. Figure 9a also shows a corresponding decline in the share of income during the period. From 2010, the top 1% saw a steep increase in income. However, while the share of income rose over 25% from 2010 to 2014, the share of tax at the top only rose by around 21%.

It is difficult to decipher trends in progressivity by examining summary statistics. The only conclusion that could be drawn is that the Australian income tax system has maintained a progressive structure from 2004 to 2016. This motivates the need for constructing measures of progressivity that would pick up subtle changes in the dynamics of the tax and income distribution.

5 Result

5.1 The tax progression-based measure

We estimate the scale of the tax system measured by λ and the progressivity measured by τ, using the logarithmic transformation of the parametric tax function specification given in equation 3

$$\ln \tilde{y}_i = \ln \lambda + (1 - \tau) \ln y_i + u_i \tag{10}$$

We use the ordinary least squares method to estimate the parameters of the tax function for each year. Table 5 reports OLS estimates of the parametric tax function for all years. Our

estimated parameters are a good fit for the data, 99 percent of the variation in the data is explained by the tax function and with very low robust standard errors on both the coefficient $(1-\tau)$ and constant $\ln\lambda$. Both ATO and HILDA estimates are relatively similar. Estimates from the HILDA sample are however lower than the ATO sample indicating that average difference between marginal tax rates and average tax rates are higher from the ATO data.

The intuitive interpretation for the parameter τ obtained from OLS estimations is that it tracks how the effective marginal tax rate increases on average more than the average tax rate. As discussed before, $\tau > 0$ implies a progressive income tax system. Figure 10 displays a time series of progressivity parameter τ. There is a declining trend in τ since 2004. This implies that the marginal tax rates increase, on average, less than the increase in average tax rates. One reason for this is that while the marginal tax rate at the very top of the distribution has not increased by much over the period, the rates at lower quantiles (particularly at the middle) have increased. The steepest decline in τ is observed between 2005 and 2008 during which the top income threshold was increased substantially resulting in only the top 1 percent paying the top marginal tax rate. Thus, according to this local measure the progressivity level of Australia's personal income tax system, on average, has declined since 2004.

As documented in the summary statistics in section 4, both marginal and average tax rates vary considerably across the income distribution. To check robustness, we estimate the parameters at different quantiles using quantile regression. Panel (b) of Figure 11 show that the estimated value of τ at different quantiles are significantly different from the OLS estimates for each year. For all years, the rate of progression increases from the bottom quantile to the mid and declines with income at quantiles above the middle. The steep decline in progressivity between 2004 and 2010 observed from the OLS estimation is confirmed by an unambiguous downward shift in the estimates from the quantile regression for these years. The quantile estimates for 2016 are less progressive below the 40^{th} percentile compared to 2004. The estimates for 2016 indicate that average tax rates increase at a faster rate with income at this quantiles. Moreover, there is a significant increase in progressivity at the middle compared to 2004 while the rate of increase at the top is fairly similar in both years. This results in lower progressivity on average in 2016 compared to 2004.[4]

5.2 The tax distribution-based measure

Figure 3 reports the estimates of Kakwani and Suits indices of progressivity for both ATO and HILDA samples from 2004 - 2016. The trends for both samples show declines from 2004 - 2006. The major change that happens to the tax schedule between 2004 and 2006 was the increase in the top income threshold. This significantly reduced the tax liability of those in the $90^{th} - 99^{th}$ percentile. From 2006 - 2010 there is an increase in progressivity. Among a variety of changes to the tax schedule, the maximum LITO was increased from $455 to $1,350 between 2006 and 2010. The indices show a relatively stable trend between 2010 and 2013 and a slight decline thereafter. [5]

The trends from ATO data are more pronounced than from HILDA. This is mostly due

[4] Appendix D reports the estimation results using the HILDA data from 2001 to 2016.

[5] We report more information on the tax progressivity cycle since 2001, using the HILDA data, in Appendix D

to differences in the availability of demographic information between the two samples. Tax liabilities for ATO are estimated ignoring the effect of family structure, while tax liabilities in the HILDA sample take in to account a whole range of demographic information such as the number of dependents enables us to examine the impact of the changes in the income distribution for the subsequent years if a given tax schedule is left unchanged since the first year that indents, age of dependents and marital status. These information are crucial in the calculation of various offsets that reduce tax liabilities.

5.3 The role of tax policy and economic factors

In this section we study the quantitative importance of tax policy and economic factors that drive the change in the overall level of tax progressivity in Australia.

5.3.1 The role of different tax components

We examine the contribution of the major components of the tax schedule to progressivity. For clarity and conciseness, we present results on only those components that were found to have a relatively large impact on progressivity. These were, (i) tax applied using the standard tax schedule, (ii) LITO, (iii) the sum of all offsets that applied to senior Australians and (iv) medicare levy. On average, component (i) makes up 87 percent of total tax liability per year, while LITO and offsets to seniors make up 2-3 percent and the medicare levy makes up 5 percent. Tax on superannuation benefits and the medicare levy surcharge were found to have very little to no impact on the trends in progressivity. Further, they consist of less than 0.5 percent of annual total tax liabilities. Hence, we exclude these two components from this section.

We first calculate the Suits index for the following constructs: (i) Tax liability calculated using standard tax rates exclusive of all other components ("Standard tax"); (ii) Standard tax - LITO, (iii) Standard tax - Offsets to seniors and (iv) Standard tax + Medicare levy. We then compare the Suit index for standard tax with each of the other constructs. This gives the contribution of LITO, Offsets to seniors and medicare levy. However, it is important to note that the Suits index is a global measure.

To examine the impact on the various quantiles of the income distribution, we calculate the share of tax relative to the share of income (RST) by decile for each of the constructs. This is given by

$$\text{RST}_i = \frac{\text{Percent of total tax paid by quantile } i}{\text{Percent of total income earned by quantile } i} \tag{11}$$

To demonstrate this exercise, consider the Suits index and the RST by decile for the ATO sample for 2004 (Table 6a). Income and tax shares are in percentages and the RST is the ratio as per equation 11. The first component is tax calculated using the standard tax schedule (Standard tax). Component [2] subtracts LITO from standard tax. Component [3] subtracts all offsets to seniors. The final two columns gives the total tax liability. A reduction in the RST at the bottom and an increase in the RST at the top results in greater progressivity (a higher value for the Suits index). This is seen in the fact that subtracting the LITO from standard tax reduces RST for all deciles below the median and increases RST for those above the median.

Tables 6b and 6c provide the same statistics for 2010 and 2016. Comparing differences in

the Suits index for total tax liabilities with that of standard tax reveals the extent to which the standard tax schedule itself affects overall progressivity. In 2004, there is little difference in the progressivity of the total tax liabilities [5] and the standard tax [1]. In comparison, there is a large difference between [5] and [1] in 2010. This implies that in 2004, overall progressivity was largely driven by standard tax while in 2010, overall progressivity depended more on other components. For example, subtracting LITO from the standard tax increases the Suits index from 0.21 to 0.30 which is closer to the Suits index of 0.27 for total tax liabilities. The mechanics behind the index can be observed by examining the RST for the components for the different deciles. The RST at deciles 1 and 2 is significantly higher for the standard tax compared to total tax liabilities in 2010. When LITO is subtracted from standard tax, the RST for the bottom 2 deciles shows a large decline. This decline is more pronounced in 2010 and 2016 compared to 2004. Adding the medicare levy to standard tax leads to an interesting change in progressivity. Including the medicare levy results in an increase in RST in deciles 5 to 9 and a decrease for the bottom 30 percent enables us to examine the impact of the changes in the income distribution for the subsequent years if a given tax schedule is left unchanged since the first year that i. Compared to the two offsets, the medicare levy thus contributes less towards overall progressivity.

5.3.2 The role of policy change

To understand the role of changes in tax policy in the overall progressivity of the tax system, we examine the trend in Suits index for each of the above constructs between 2004 - 2016 in comparison with the trend in the index for total tax liabilities (Figure 13). Comparing the trend in standard tax rates with that of total liabilities leads us to the conclusion that the overall progressivity of the tax system is less driven by changes to the standard tax schedule. The trend for the Suits index for tax using standard tax rates show fairly small increases from 2004 to 2012. This is despite the steady increase in the top threshold from $62,500 in 2004 to $150,000 in 2007. The most significant change in the progressivity of the standard tax schedule is from 2012 to 2013. This corresponds to the raising of the tax free threshold from $6,000 to $18,200.

Adding the medicare levy to the standard tax results in a very small decrease in progressivity. Thus, the contribution of the medicare levy on overall progressivity is fairly small. The largest contribution to progressivity of the tax schedule comes from offsets. Both the LITO and total senior offsets makes the tax schedule more progressive. Deducting offsets to seniors from standard tax leads to an parallel upward shift in the trend in standard tax. This implies that there have been no major structural changes to the offset schedule for seniors. In contrast, when LITO is deducted from the standard tax, the pattern in trends in progressivity match fairly well with those of the total tax liability. In particular, the increase in 2007 to 2010 is evident. This shows that changes in the LITO had a large positive effect on progressivity.

The large effect of LITO on progressivity warrants a further examination. Figure 14a provides a breakdown of how LITO affects relative tax shares for different quantiles. The relative tax liability using standard tax rates remain stable for all deciles till 2012. When LITO is applied, the relative tax liability of the bottom 20% decline significantly from 2006 to 2012. The threshold for LITO as well as the maximum LITO amount increased from 2007 to 2011.

This effectively reduces the share of tax relative to the share of income for more quantiles at the lower end of the income distribution, leading to and increase in overall progressivity.

5.3.3 The role of income growth

When income tax brackets are not indexed to income growth, changes in income can make an income come tax system more or less progressive. This phenomenon is known as "fiscal drag" or "bracket creep". In this section, we investigate implications of income growth for tax progressivity. It is important to note that despite the absence of any statutory indexation built in to the tax system, income tax brackets as well as the thresholds and rates for individual tax components do change on a regular basis. In order to examine bracket creep, we conduct a counterfactual analysis where we hold a given tax schedule constant and examine the effect of changes in the income distribution on progressivity. We do this by applying the tax schedule for each year on the respective year and the years that follow. For instance, we apply the 2004 schedule to all years, the 2005 schedule from 2005 to 2016 and so on till 2015. This enables us to examine the impact of the changes in the income distribution for the subsequent years if a given tax schedule is left unchanged since the first year that it was implemented.

For example, consider the extreme case where the 2004 tax schedule was left unchanged till 2016. Figure 15a compares the income distribution in 2004 with the income distribution in 2016. Bracket creep is more evident from Figure 15b which shows the reverse cumulative distribution functions for 2004 and 2016. The vertical lines gives the 2004 income tax brackets. Compared to 2004, a larger portion of taxpayers in 2016 were above the tax free threshold. Overall a smaller proportion of individuals were in the low tax brackets compared to 2004. Although comparing income distributions provide a general picture, it does not indicate how bracket creep affects tax burdens across the income distribution.

Table 7 compares the distribution of tax liabilities across deciles in 2004 and 2016 under the 2004 tax schedule. On average, the bottom 10 percent fell under the tax free threshold of \$6,000 in 2004. In 2016 the average income at the bottom was \$5,856 indicating that a large number of individuals in the decile would be above the tax free threshold. The same pattern is seen in at the top. In 2004, only the top 10 percent was in the top tax bracket compared to the top 30 percent in 2016. The tax liability is higher for all deciles in 2016 compared to 2004. This provides evidence that bracket creep impacts everyone across the income distribution. However, this impact is not shared equally between the different quantiles. This is seen in the relative tax shares shown in the last two columns. Relative shares in 2016 are significantly higher than those for 2004 around and below the median, while it is the same or slightly lower above the median.

6 Extensions and futher considerations

6.1 Tax progressivity and redistribution

It is important to note that tax progressivity is not the same as redistribution. A tax system with a given level of progressivity, could have different redistributive effects depending on the scale of the tax system. The larger the scale of the tax system (in terms of average tax rates)

the larger the redistributive effect. Kakwani (1977) shows that comparing the inequality of pre-tax and post-tax incomes make the index of progressivity highly sensitive to average tax rates. For instance, doubling tax rates at all income levels leads to an increase in the redistributive effect by twice. Further, taxes may in fact re-rank individuals. This also affects redistribution. Both the Suits and Kakwani indices rank individuals by pre-tax income. Atkinson (1980) and Plotnick (1981) proposes a measure of this re-ranking effect that computes the difference in the difference between the post-tax Gini coefficient (which uses the post-tax rankings) and the concentration coefficient for post-tax income which using the pre-tax rankings.

In order to examine the redistributive effect of the Australian progressive income tax system we use two indices that compare pre-tax income inequality with post-tax income inequality: Musgrave-Thin index and Reynolds-Smolensky index. Technically, the Musgrave-Thin index is the ratio of the pre- and post-tax Gini coefficient $\frac{G_Y}{G_{Y-T}}$ Musgrave and Thin (1948) and the Reynolds-Smolensky index is the difference between the pre- and post-tax Gini coefficient $G_Y - G_{Y-T}$ (Reynolds and Smolensky, 1977)

Figure 17a show the trend in pre-tax and post-tax income inequality from 2004 to 2016.[6] Apart from the increase prior to 2007 and the subsequent decline till 2009, trends in Gini coefficients for both pre- and post-tax income have been fairly stable. The distance between the two trend lines track the redistributive effect of the income tax. The effect can be measured by the difference between pre-tax Gini and the post-tax Gini as per Reynolds and Smolensky (1977). The y-axis on the left of Figure 17b tracks the Reynolds-Smolensky index of redistributive effect. The trend shows a decline prior to 2007 and an increase from 2007 to 2013.

Figure 17b also shows the link between redistribution, progressivity and the scale of the tax system (measured by the average tax rate). The fact that redistribution does not only depend on progressivity is most evident in the diverging trends in the Reynolds-Smolensky index and the Suits index from 2011 to 2016. Since 2010, although there has been a slight decline in progressivity, the redistributive effect of the tax system has been relatively stable due to the increasing scale. From 2004 to 2006, there was decrease in both the size and the progressivity of the tax system. This results in a steep decline in the redistributive effect. 2007 to 2009 showed a decline in the size of the tax system. However, changes to the tax schedule as well as the income distribution made the tax system more progressive during that period. This is indicated by the steep increase in the Suits index, and a similar increase in the redistributive effect.

6.2 Household heterogeneity and tax progressivity

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

[6]The additional results from 2001 to 2016 are reported in Appendix D.

household characteristic is not present in the ATO sample, we rely solely on the HILDA sample in this section.

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

$$\ln \tilde{y}_i = \ln \lambda + \beta \mathrm{H}_i + (1 - \tau) \times \mathrm{H}_i \times \ln y_i + u_i \tag{12}$$

where H is a vector of dummy variables indicating a specific household type and $\tilde{y}_i$and y_i are post and pre-tax incomes of household i. We examine single and couple households, both with children ranging from 0,1,2 and 3 or more children. We present the details of the regression results in the Appendix and focus on illustrating the average tax rates for different household types in 2016.

Figure 18 shows the average tax rate by multiples of median income for different household compositions for 2016. For both singles and couples, the effective tax free threshold increases with the number of children. Further, the average tax rate at lower income levels decline with the number of children. For couples, the average tax rate converges at higher incomes as benefits associated with children are reduced. Households with 1 adult and dependent children (single parents) have lower average tax rates than couples. This holds true even at higher income levels.

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

Figure 19a compares the trend in Suits index from our HILDA individual sample with that from the household sample. Although the pattern in trends are similar, the index generated from the household sample is much lower. It also plots the trend for households equivalised using three equivalence scales used by the Organisation of Economic Cooperation and Development (OECD) Organisation for Economic Co-operation and Development (2013). The first, OECD square root scale divides total household income by the square root of the household size. The second, OECD modified scale assigns a value of 1 to the first adult, of 0.7 to each additional adult and of 0.5 to each child below 15 years of age. The third is the old OECD scale which assigns a value of 1 to the first adult, of 0.5 to each additional adult and of 0.3 to each child below 15 years of age . As seen from the Figure, the square root scale and the modified scale is quite close to unequivalised household data. Yet neither scale matches well with the trends from individual data.

Figure 19b compares the Suits index trends for the individual sample with trends generated from an alternative specification of the equivalence scale commonly used in the literature on inequality and redistribution (Cutler and Katz, 1992). The scale is defined as

$$s = (a + \theta c)^{\delta} \tag{13}$$

where s is the number of adult equivalents that depend on the number of adults a and