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STOCHASTIC DOMINANCE ANALYSIS OF AUSTRALIAN INCOME DISTRIBUTIONS

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Abstract

We apply stochastic dominance tests to investigate trends in inequality in Australia over the period 1983 to 1998. Results show significant levels of inequalities in the income and expenditure distributions for the population as a whole as well as within population groups. We further find that the impact of the government's tax and transfer redistribution scheme varied greatly among the different demographic groups. After tax and transfers are made, significant gains in welfare levels were observed for migrant and single-parents households compared to their non-migrant and couple-parent counterparts respectively. In contrast, welfare levels of male-headed households continue to dominate those of female households post tax and that there is limited government capacity for closing the existing gap in incomes and expenditures among households without children.

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1. Introduction

Singular measures of income and consumption inequality provide useful though limited views of actual disparities in welfare and living standards in the population. Such indices are instructive in providing complete orderings of distributions as they appear comprehensible and unambiguous in many applications. At the same time, however, singular measures are known to suffer from the lack of universal acceptance of the value judgments of the underlying welfare functions[i]. Contradicting conclusions can thus emerge and present problems for policy analysis and decision making.

An alternative procedure for analysing distributions is to use the stochastic dominance approach which rank welfare situations over very wide classes of welfare functions. The stochastic dominance (SD) approach uses a systematic method for a pairwise comparison of points in two distinct distributions – so it uses more information, presents a fuller picture of existing inequality level (at all possible points of comparison) and as such avoids the overly narrow cardinalisation of welfare functions as is done by indices. Conclusions drawn from SD analysis are thus more robust and more useful in the wider policy sense.

Recent longitudinal studies on inequality among households in Australia indicate a widening of the gap between the rich and the poor in the country. In their study comparing trends in income and consumption inequality, Barrett, et al (2000a) find that that both income and consumption inequality rose by significant amounts between 1975 and 1993, and that consumption inequality rose by much less than. This finding is consistent with earlier findings by Harding (1997), Harding and Szukalska (2000). It is also evident in other countries as well with economic inequality is also seen as rising over time in the US (Cutler & Katz 1992) and in Canada (Pendakur 1998). Pendakur (1998) claims that fluctuations in both income and consumption inequality is countercyclical – they are high in time of recession and low in times of prosperity.

Unlike the US and Canada however, Barrett, et al (2000) analyses show that demographic changes in the population (such as aging of the population and change in family structures) account for only a minor component of the overall growth in economic inequality in Australia. Further, they find that between 1975 and 1993, both income and consumption inequality increased but inequality of incomes rose more than inequality of consumption and conclude that a significant fraction of the changes in income inequality levels represent increases in the variance of transitory income fluctuations which households have some facility to smooth.

In this paper, we examine trends in the distribution of income and consumption among Australian households using stochastic dominance analysis. Using micro-unit records from the Australian Bureau of Statistics, we investigate trends in inequality over the period 1983 to 1999. Over this 15-year period, the Australian government made substantial changes to the social welfare system in an attempt to minimize economic inequality as the economy grows; it would be useful to know whether these policy changes have in fact made a significant positive impact on the overall distribution. The progressivity of current tax policies and the effectiveness of the government's social welfare program can be wholistically assessed and evaluated using this information; appropriate improvements/adjustments can thus follow. Further, for many economic analysts and social scientists, it would also be very useful to know the impact of the government's redistribution policies on particular household types and family groups. This paper thus provides new insights into inequality in Australia as we examine these trends within population groups. We put particular concern to the study of vulnerable households, to include migrant families, families with children, single-parent families and families headed by females. Results from this analysis can provide guidance in designing more effective assistance programs for such economically disadvantaged groups.

The use of the stochastic dominance approach is an important feature of this paper. SD analysis consider the whole distributions of outcomes, and thus can provide crucial details and potential important distinctions between different parts of the distribution. The technique will be applied to compare various incomes and expenditures distributions across various population groups and over time. Conclusions drawn will be compared to those derived from the implementation of singular measure which we also implement here for comparison purposes.

This paper has the following structure. After a brief introduction and overview in Section 1, Section 2 introduces and describes some tests of stochastic dominance (describes theory of SD), their distributional characteristics and the bootstrap technique used. Section 3 presents the data, variable definitions and some summary statistics. Section 4 presents the empirical analysis and Section 5 concludes.

2. Tests for Stochastic Dominance

The term stochastic dominance is generally used in decision theory to refer to situations where one outcome (or a probability distribution over outcomes) can be ranked as superior to another. Testing for stochastic dominance of one distribution over another involves a pair-by-pair comparison of the "distances' at a finite number of points or ordinates on the curves. Ranking results are based on preferences (eg a higher value of an outcome is preferred), but require only limited knowledge of preferences with regard to the distribution of outcomes. Several tests for stochastic dominance (SD) have been proposed in the literature. In this paper, we employ SD test procedures based on a generalized Kolmogorov-Smirnov test discussed in Linton et.al (2005) and Maasoumi and Hestmati (2000). Alternative implementations of this type of tests have also been examined by several authors including MdFadden (1989), Klecan and McFadden (1991) and Barrett and Donald (2003).

To describe the tests, use first set the following notation. Let *X* and *Y* be two outcome variables for any two groups or periods. These variables will either be income or expenditures of households, before or after tax incomes, at different points in time, regions for some given population. For ease of exposition though, we will simply refer to both as income for the moment. We let $X_{(i)}$ and $Y_{(i)}$ denote the i^{th} order statistics, and $F(x)$ and $G(x)$ denote the cumulative distribution functions (cdfs) of X and Y respectively. Assuming general von Neumann-Morgenstern conditions, we let U_1 denote the class of social welfare functions *u* such that welfare is increasing in income (), and U_2 denote the class of all utility functions in U_1 for which $u'' \leq 0$. This strict concavity assumption represents a strong aversion to higher dispersion of incomes across individuals; in other words, a high concentration of incomes (or expenditures) is undesirable. Quantiles $q_x(p)$ and $q_y(p)$ are implicitly defined by $F[X \leq q(p)] = p$.

Two critical definitions are now in order. One, *X* First Order Stochastic Dominates (FSD) *Y*, denoted $X \succ_1 Y$, if and only if any one of the following equivalent conditions holds:

(1) $E\left[u(X)\right] \geq E\left[u(Y)\right]$ for all $u \in U_1$, with strict inequality for some *u*.

(2) $F(x) \leq G(x)$ for all *x* in the support of *X*, with strict inequality for some *x*.

(3) $q_x(p) \geq q_y(p)$ for all $0 \leq p \leq 1$.

If $X \succ_1 Y$, then the expected welfare from X is as least as great as that from Y for all increasing welfare functions, with strict inequality holding for some utility function(s) in the class.

Two, X Second Order Stochastic Dominates (SSD) *Y*, denoted $X \succ_2 Y$, if and only if any of the following equivalent conditions holds:

(1) $E\left[u(X)\right] \geq E\left[u(Y)\right]$ for all $u \in U_2$, with strict inequality for some u.

(2) $\int_{-\infty}^{x} F(t)\,dt \leq \int_{-\infty}^{x} G(t)\,dt$ for all *x* in the support of *X* and *Y*, with strict inequality for some *x*.

(3) $\int_0^x q_x(t)dt \geq \int_0^x q_y(t)dt$ for all $0 \leq p \leq 1$ with strict inequality for some value(s) *p*.

If $X \succ_2 Y$, then the expected welfare from X is as least as great as that from Y for all increasing and concave utility functions in the class U_2, with strict inequality holding for some utility function(s) in the class.

The tests of FSD and SSD are based on empirical evaluations of conditions (2) or (3) in the above definitions. Mounting tests on conditions (2) requires empirical cdfs and comparisons at a finite number of observed ordinates. Mounting tests on conditions (3) rely on the fact that quantiles are consistently estimated by the corresponding order statistics at a finite number of sample points. FSD implies SSD and higher orders[ii].

Following Maasoumi and Heshmati (2000), proceed with the KS type tests analysis by first defining a "maximal" sets (originally due to McFadden) as follows. We let $\Re = \{X_1, X_2, ..., X_K\}$ be a set of K distinct random variables, and let F_K denote the cdf of the k^{th} variable. We define the set $\Re$ as first (second) order maximal if no variable in $\Re$ is first (second) order weakly dominated by another. Further, we let $X_{.n} = (x_{1n}, x_{2n}, ..., x_{Kn}), n = 1, 2, ..., N$ be the observed data. Assume $X_{.n}$ is strictly stationary and $\alpha-$mixing. We assume $F_i(X_i),\ i = 1,2,\ldots,K$ are exchangeable random variables, so that our resampling of the test statistics converge appropriately. This is a less stringent assumption than independence of income distributions, particularly in our paper, as it will be more often the case that one distribution can be derived from the other (eg before and after tax scenarios). We also assume that F_K is unknown and estimated by the empirical distribution fundtion $F_{kN}(X_k)$. Finally, we adopt the mathematical regularity conditions pertaining to von Neumann-Morgenstern (VNM) utility functions that generally underlie the expected utility maximization paradigm. We also assume that all the expectations involved are finite.

Given the mathematical regularity conditions due to VNM, the first-order stochastically maximal variables in $\Re$ imply that a statistic d exists defined by

(1) $d = \min_{i \neq j} \max_x \left[F_i(x) - F_j(x) \right] > 0$ if and only if for each i and j, there exists a continuous increasing function u such that $E\left[u(X_i)\right] > E\left[u(X_j)\right]$.

Similarly, the second order stochastically maximal variables in $\Re$ implies that a statistic s exists such that

(2) $s = \min_{i \neq j} \max_x \int_{-\infty}^{x} \left[F_i(\mu) - F_j(\mu) \right] d\mu > 0$ if and only if for each i and j, there exists a continuous increasing and strictly concave function u such that $E\left[u(X_i)\right] > E\left[u(X_j)\right]$.

Now, assuming the stochastic process $X_{.n}$, $n = 1, 2, \ldots, N$ to be strictly stationary and $\alpha-$mixing with $\alpha(j) = O(j^{-\delta})$ for some $\delta > 1$, we have $d_{2N} \to d$ and $s_{2N} \to s$ where d_{2N} and s_{2N} are the empirical versions of the test statistics defined as :

(3) $d_{2N} = \min_{i \neq j} \max_x \left[F_{iN}(x) - F_{jN}(x) \right]$ and

(4) $s_{2N} = \min_{i \neq j} \max_{x} \int_{-\infty}^{x} \left[F_{iN}(\mu) - F_{jN}(\mu) \right] d\mu$.

The null hypothesis tested by these two statistics is that $\Re$ is not first (second) order maximal, i.e., X_i FSD (SSD) X_j for some *i* and *j*. We do not reject the null when the statistics are negative to a statistical degree of confidence. Kaur (1994) and Klecan et al (1991) show that when X and Y are independent, tests based on d_{2N} and s_{2N} are consistent. Furthermore, the asymptotic distributions of these statistics are non-degenerate in the least favourable case, being Gaussian.

In this paper, we estimate the empirical distributions by bootstrap methods. We compute d_{2N} and s_{2N} for a finite number q of the income (expenditure) ordinates. Bootstrap samples (typically 1000) are generated from which empirical distributions of the differences of the d_{2N} and s_{2N} statistics, and their bootstrap confidence intervals are determined. The bootstrap probability of these statistics being negative and/or falling in these intervals leads to an inference of dominance to a degree of statistical confidence.

3. The Data

The empirical analysis presented in this paper is based on the series of four household expenditure surveys collected by the Australian Bureau of Statistics (ABS) over the period 1983 to 1998. The stochastic dominance tests and procedures described in Section 2 are applied to household unit record data from the 1983-84, 1988/89, 1993/94 and, 1998/99 Household Expenditure Survey (HES) of the Australian Bureau of Statistics (ABS). These are the latest body of data conducted of a series of surveys designed to obtain details of expenditure, income and a wide range of demographic characteristics of Australian private households on a nationwide basis. The information on demographic characteristics, income and infrequent expenditure items (eg vehicle and property purchases, household bills) were recorded by personal interview and details of all other expenditures made by each household member, 15 years or more, during a two-week period were recorded in personal diaries[iii]. The public-use files were representative of the Australian population and the sample of households enumerated evenly over the respective 12-month period[iv].

The household is the basic unit of our analysis and consists of a person or group of people living together having common provision for food and other essentials of living. They will include both adults and children where children are those aged from the very young to 24; those over 18 are considered children as long as they are fully financially dependent on the parent(s) defined in the survey. We include all types of households in the total HES sample, but also need to define groups of households when we test hypotheses concerning particular groups. The population subgroups we consider are migrant v non-migrant, households with and without children, male-headed v female headed households,

In this study, we analyse the distribution of household incomes and expenditures. For each year of the survey, we analyse four basic distributions:

a) **Gross or Pre-Tax Income (GROSS)** – defined as total household income from all sources. This includes all earned income from employment, own business or self-employment plus unearned income from interest on accounts and financial investments, property rent, worker's compensation, child support and maintenance, superannuation, and scholarships; and,

b) **Disposable or Post-Tax Income (DISP) –** which is total household income less taxes plus all government benefits. These include all family allowances and parenting payments, and age, carer and disability pensions.

c) **Total Expenditure (EXP1) -** includes all expenditures on Current Housing, Fuel and Power, Food, Alcohol and Tobacco, Clothing and Footwear, Household Furnishings and Equipment, Medical and Health Care, Transport, Recreation and Entertainment and Personal Care. Total expenditures also include expenditures on Income Tax, Superannuation and Life Insurance, Mortgage Repayments and Other Capital Housing Costs.

d) **Total Non-Durable Expenditure (EXP2)** is used to measure non-durable consumption. This is EXP1 less expenditures on all household furnishings and equipment.

Family income and expenditure data were divided by an adult equivalent scale to adjust for differences in family economies of scale in consumption. The adult equivalent scale (AES) used was the square-root of family size[v]. HES provides data for each year in nominal terms so it is imperative that we also adjust these values for changes in prices over time. Thus, all nominal values are converted to 2003 dollars using the national consumer price index[vi]. Summary statistics in Table 1 shows that average incomes in real terms declined considerably in 1998 compared to 1993, but this level was still a significant improvement over average income levels in 1983 and 1988. Correspondingly, *real* mean household expenditures were highest in 1993, dropped slightly in 1998; total expenditure levels were relatively lower in 1983 and 1988. Overall though, we note that the average household income across the population had increased only slightly over time, with the statistics also indicating wider dispersion of incomes in the later years. Average total expenditures of households tended to be higher than average incomes, and is also seen to have greater fluctuations over time.

The changing structure of Australian households are evident from Table 1. First, it is seen that the proportion of female-headed households in the population have doubled in the last 15 years, increasing from under 20 percent in 1983 to 40 percent in 1998/99. In 1983, only 2 in 10 households were found to be headed by females; in 1998, we find the 4 out of every 10 households surveyed are now headed by females. The summary statistics show that relative to male-headed households, particularly in the earlier survey years. Corresponding to this observation is the change in relative income levels: in 1983 female-headed households tended to have lower incomes; over time however, average income levels of female-headed households have risen much more than those of households headed by men. Further, it appears that the disposable incomes of female headed households are also more equally indicating greater net transfers accruing to them than their male counterparts.

The proportion of single parent households have dramatically risen between 1983 and 1998. In 1983, only 13 percent of household with children have 1 parent; in 1998 this figure has risen to 21 percent of all households with children. Average pre tax income levels of single parent households were clearly less than couple households, only 50 percent in 1998, under 40 percent in the earlier years. But the table also shows that the gap in incomes is not as great as when disposable incomes are compared. Using this measure, disposable incomes of single parent families is about 60 percent that of couple parent families. This implies that the tax and transfer system does have an equalizing effect on household incomes with greater benefits provided to single parents; and that the average equalizing outcome is in fact comparable to what is required by single parent – their expenditures are about 60 percent that of couple parent households.

With regards to households with and without children, no significant changes were noted in terms of the population shares - they remain around 48 percent and 52 percent respectively over that span of 15 years. We also find that across the survey years, migrant households comprised about 29 percent of total households in the sample. On average, the incomes and expenditures of migrant households compared favourably with those of non-migrant households.

4. <u>Empirical Analysis</u>

The tables in this section present the results of our stochastic dominance analysis for pairwise income and expenditure distributions across households in Australia. All of these are from 1000 bootstrap samples. Given distributions X and Y, the expression $X >_1 Y$ denotes "X first order stochastic dominance of X over Y" and $X >_2 Y$ denotes "X second order stochastic dominance of X over Y". Where evidence of stochastic dominance appears, the number in brackets show probability of the test being negative.

All Households

The first row of Table 2a tabulates the results for a pairwise comparison of gross or income tax distributions across the 4 years of the survey and sheds light on the movement of the overall income distributions over the time period in our sample frame. It shows that pretax income distribution in 1993 first and second order dominated both the 1983 and 1998 distributions, while the 1998 distribution first and second order dominated the 1988 pretax distributions. SD tests applied to 1983 and 1988 showed only second order dominance of the former over the latter year. The 1983 and 1998 pretax distributions were not rankable.

In terms of disposable or post tax incomes, the SD analysis indicated first and second order dominance of the 1993 distribution over the 1988 and 1998 distributions (same as in pretax income results). Taxes and transfers are seen to eliminate any dominance that the 1993 pre-tax distribution had over the 1983 distribution; the strong dominance results of the 1998 over 1988 pretax distributions were also eliminated by the tax and transfers during those years.

In terms of total expenditures, first and second order stochastic dominance were observed for 1983 over 1988, and for 1993 over 1988 distributions of total expenditures (EXP1). Further, the 1993 EXP1 distributions showed second order stochastic dominance over the 1998 EXP1 distributions, while the latter second order stochastically dominated the 1988 EXP1 distribution. The 1983 and 1993 distributions were unrankable, as are the 1983 and 1998. If non-durable consumption EXP2 distributions are considered, the above dominance results hold with the addition of stronger evidence observed for the 1993 EXP2 distribution first order dominating the 1998 EXP2 distribution, which in turns first order dominates the 1988 EXP2 distribution.

It thus appears that the 1993 income and expenditure distributions are consistently significantly more equal compared to the other years' distributions, with strong first order results showing in all pairwise comparisons except perhaps for 3 cases when no stochastic dominance were observed for the 1993 and 1983 posttax and expenditure distributions. This indicates that over the 15 years of the study period, level of inequality in the distribution of incomes and expenditures either improved significantly (as in pretax income) or remained steady during the first ten years, but that it grew worse in the course of the following 5 years.

In Table 2b, results for comparison of pre and post tax income distributions are tabulated; it also includes results for the comparison of posttax income distribution and expenditure distributions. Some surprisingly simple results arise: no stochastic dominance is observed for all pairwise comparisons made except for 1 case. This result broadly indicates that for all years, pre and post tax distributions are deemed unrankable (ie no one is better than the other) - implying that relative welfare in the population was not any better after government tax and transfers were made. The results also generally exhibited no stochastic dominance in the pairings when the test were applied to the post tax and expenditure distributions. Except in 1998/99 when total expenditure and posttax incomes are compared: results show first and second order stochastic dominance of the former over the latter. Overall though, the indication is that taxes and transfers were not effective in equalizing income distributions – there were no discernable improvements in the distribution of incomes after tax and transfers were made in each year of the survey.

Male-Headed v Female-Headed Households.

We now break up the population into various groups and apply the tests to determine relative inequality levels existing within each group. Strong differences in the inequality levels are observed when households are grouped by gender of the household head. Pretax income distributions for male-headed households are shown to first-order stochastically dominate those of female-headed households for each year of the survey except for 1988, where no ranking can be inferred ie no SD. For 1983 and 1993, the tests show strong (first-order) stochastic dominance of the pre-tax income distribution of male-headed households (MHH) over that for female-headed households (FHH), with p-values of 0.024 and 0.09 respectively. Results further show that any evidence of stochastic dominance in the distributions disappeared after tax and transfers were made for the years 1983-84, 1988-89 and 1993-94. Strong evidence of stochastic dominance however appears again in 1998; in fact, the larger p-values found for the SD tests on post income distributions showed that the tax and transfers favoured more the MHH compared to the FHH, and thus they have come out with a more equal income post tax distribution 1998 compared to their female counterparts.

In terms of expenditure, it appears that the distributions for male-headed and female-headed households were comparable in the earlier years. First order stochastic dominance were strong in 1993 and 1998 (where MHH distribution SD dominated FHH distribution) where none was found in 1983 and 1988. We also find that the gap in welfare levels appeared stronger when non-durables expenditure distributions (EXP2) were considered, compared to when all/total expenditures (EXP1) were compared.

We then compare the income and expenditure distribution of households with and without children using the stochastic dominance tests above. From Table 4 looking at the 1983-84 results, we find second-order stochastic dominance of pre-tax incomes of households with children over those without children. Taxes and transfers appear to have corrected this imbalance, while expenditure distributions do not show any evidence of either year's distributions stochastically dominating the other – for both total and non-durable expenditure distributions. In 1988, pre-tax distributions for households with and without children appeared to be equally well off, but post tax distributions show greater equality among households with children than those without.

In 1993-94, the income and expenditure distributions of households with children show very strong welfare dominance over those without children. First-order stochastic dominance is shown throughout – smaller p-values are observed for post tax incomes comparisons (indicating some but not a whole lot of improvement in welfare levels) while larger p-values are observed for non-durables expenditures compared to total expenditure (indicating greater degree of inequity). The same strong results apply to the 1998-99 data, though the strength of the dominance is less pronounced (second-order only) compared to the 1993-94 results.

Overall, strong dominance results are found for most pairwise SD test applications comparing household with and without children. In particular, households with children are shown to have a much more equal distribution of welfare than those of households without children. This is not surprising though. Families with children tend to be a more homogenous group – with similar income and expenditure patterns and constraints. In contrast, families without children are a more diverse group with more variant lifestyles indicating greater degrees of income and expenditure levels. Disparities in their distributions are therefore bound to be greater. In this light, taxes and transfers will have limited capacity to close the gap between the inequities that are evident in the distributions.

Single parent vs Couple Parent Families

We now consider distributions for single-parent (S) v couple-parent (C) families. Single parent families tend to struggle more in terms of meeting ends meet. They also tend to have less income but also get more government benefits. In comparing the income and expenditure distributions for these types of families, we want to know if single parent families have more highly unequal incomes or expenditures compared to couple family households. We also want to know the impact of the government redistribution program on the relative welfare levels of these groups.

Results here are from Table 5. In 1983, pre-tax incomes of couple-parent families show greater equality levels compared to single parent families as evidenced by strong first-order stochastic dominance effects. These differences however disappear after taxes and transfers are made; further, the expenditure distributions of these groups also do not show any dominance effects over the other. For 1988, the pretax income distribution of couple-parent households showed no evidence of being better than the distribution of pretax income of single-parent households. Comparison of post-tax incomes and the two types of expenditures show no change in this result. For 1993, pretax income distribution for couple parent families stochastically dominated the distribution for single parent households. This imbalance appears to have been corrected by the tax and transfer scheme of the government ie stochastic dominance of former over latter disappeared when applying the tests to compare post tax income distributions for the two household types. For 1998, we find no evidence of stochastic dominance in all the distributions that were compared and tested.

Overall, the evidence gathered on the comparison of single-parent v couple-parent households show some evidence of significant relative disparities in welfare levels but that tax and transfers impact significantly so as to make the distributions unrankable. This means taxes worked to equalize that distributions of single-parent households much more than couple-parent households so that it improves this distributions to levels that are at least as good as those found in couple-parent households.

Migrant & Non-Migrant Subgroups:

The final comparison group we have are between migrant and non-migrant households. Comparisons of welfare across migrant and non-migrant groups are important – migrant households are known to incur significant settling-in costs and it is important to know how well government transfers are able to assist them over time relative to the mainstream non-migrant household.

From Table 6, it is seen that the 1983 income and expenditure distributions of non-migrant households (NM) clearly stochastically dominated those of migrant households (Mig). First order stochastic dominance was observed for pre-tax incomes and also non-durable consumption; results on the SD analysis for posttax income distributions indicate a marked improvement in the distribution of migrant households in each of the survey years particularly, in 1983 and 1993. In 1983, the income distribution of non-migrant households still dominated that of migrant households but significantly less so compared to that of pretax incomes. Specifically, evidence of first order dominance has disappeared completely post tax; and p-value for 2nd order dominance is significantly smaller than in the pre-tax comparisons.

In 1988, the income and expenditure distributions of migrant households showed no significant difference (no better; no worse) compared to those for non-migrant households - with test p-values of only .005 and .006 for comparison of pretax and post tax incomes, respectively. In 1993, however, the dominance relationship between the income distributions before and after tax were reversed. For this year, the results show that before tax, the income distribution for non-migrant household were more equitable compared to that of migrant households [with a 2nd SD p-value of 16.7 percent]; post tax comparisons for these two groups reversed this trend and showed an even stronger stochastic dominance effect of migrant income distribution over that of the non-migrant

– with a p-value of 47.4 percent. This means that, in 1993, the redistribution of incomes through tax and transfers did serve to close the gap in incomes among migrant households much more than it did incomes for non-migrant households. In 1998 meanwhile, application of SD test comparing pretax incomes for migrant and non-migrant households showed that the distribution for the migrant group stochastically dominated that of the non-migrant group by 1.6%. This 2^{nd} order dominance persisted in the comparison of post tax income although the resulting p-value is now greatly diminished to .04 percent.

With expenditure distributions, migrant expenditure distributions were generally found more equally dispersed compared to those of non-migrants. Total expenditure distribution for 1988, 1993 and 1998 for migrant households all stochastically dominated their counterpart distributions for non-migrant households, except for year 1983 which showed the reverse relationship and therefore defied the general trend. It is nonetheless noted that the strength of the dominance results seem to have diminished over time with p-values dropping from 48% in 1988-89 to 28% in 1993-94 and down to 2% in 1998-99. We also applied the test to compare non-durable distributions and we find that the dominance relationships observed above are shown to hold, perhaps even more strongly, as evidenced by first-order stochastic dominance results.

In summary, for the migrant and non-migrant group comparisons, we find that first order stochastic dominance was observed for pre-tax incomes and also non-durable expenditures; the disappearance of this first order dominance in the analysis of posttax income indicates a clear positive impact of the government's tax and transfer scheme in improving the inequality levels in the population in 1983. In the subsequent years, however, the opposite dominance relationship is observed ie the income and expenditure distribution of migrant households now stochastically dominate those of non-migrant households. The results show that the impact of the government tax and transfer program resulted in a strong reversal of the dominance relationship in 1993-94 pre and post tax distributions in favour of migrant households.

5. **Conclusion**

The term stochastic dominance is generally used in decision theory to refer to situations where one outcome (or a probability distribution over outcomes) can be ranked as superior to another. Testing for stochastic dominance of one distribution over another involves a pair-by-pair comparison of the “distances’ at a finite number of points or ordinates on the curves. Ranking results are based on preferences (eg a higher value of an outcome is preferred), but require only limited knowledge of preferences with regard to the distribution of outcomes. In this paper, we employ statistical test procedures for first and second order statistic dominance (FSD and SSD, respectively) of Lorenz and Generalised Lorenz curves. This involves comparing the “distances” at finite points or ordinates on the curves, where these points/ordinates are represented by quantiles. The tests used are multivariate generalizations of the Kolmogorov-Smirnov statistics when weak dependence is permitted in the processes.

We apply these tests to investigate trends in inequality and relative welfare levels in Australia over the period 1983 to 1998. We find that that when the SD tests are applied to income and expenditure distributions for the entire population, results show that net transfers to households do not make any significant improvement on the level of inequality existing for each year. However, when analysis is applied to particular population subgroups in the economy, the SD tests show that taxes and transfers do improve gross imbalances in the distribution of welfare within and between the groups.

We find strong evidence of disparities in the relative welfare levels across a number of demographic groups in Australia. Application of stochastic dominance tests show greater levels of inequalities in the pretax distributions of male-headed over female headed households, of households with children over those without, and of couple parents families over their single-parent counterparts, and of migrant v non-migrant households. We then find that the impact of the government’s tax and transfer redistribution scheme varied greatly among the different demographic groups. For migrant and non-migrant households, tax and transfers appear to favour migrant households more so that they end up having a more equal income and expenditure level post tax. More favourable welfare outcomes also result for single-parents households compared to their couple-parent counterparts. On the other hand, we find that the welfare levels of male-headed households continue to dominate those of female households post tax and that there is limited government capacity for closing the existing gap in incomes and expenditures among households without children.

Table 1. Summary Statistics

Year: 1983-84	All Households	Male Head	Female Head	Without children	With children	Couple Parents	Single parent	Non-Migrant	Migrant
Sample Size n	4492	79%	21%	53%	47%	87%	13%	72%	28%
Taxable Income	566	624	348	559	543	594	214	570	557
	(489)	(486)	(435)	(548)	(393)	(386)	(255)	(468)	(495)
Disposable Income	528	557	416	539	484	508	328	528	528
	(331)	(338)	(277)	(364)	(393)	(278)	(169)	(325)	(347)
Total Expenditure	672	714	513	667	645	678	434	671	676
	(469)	(467)	(442)	(498)	(408)	(411)	(317)	(465)	(478)
Year: 1988-89	**All Households**	**Male Head**	**Female Head**	**Without children**	**With children**	**Couple Parents**	**Single parent**	**Non-Migrant**	**Migrant**
Sample Size n	7225	77%	23%	57%	43%	85%	15%	71%	29%
Taxable Income	555	611	371	531	549	604	232	563	534
	(503)	(498)	(475)	(529)	(455)	(458)	(268)	(516)	(470)
Disposable Income	500	528	409	501	470	497	313	505	490
	(350)	(357)	(305)	(358)	(323)	(336)	(160)	(356)	(332)
Total Expenditure	654	696	514	638	644	684	412	651	659
	(512)	(510)	(492)	(549)	(458)	(466)	(320)	(527)	(470)
Year: 1993-94	**All Households**	**Male Head**	**Female Head**	**Without children**	**With children**	**Couple Parents**	**Single parent**	**Non-Migrant**	**Migrant**
Sample Size n	8389	61%	39%	52%	48%	81%	19%	71%	29%
Taxable Income	912	1045	701	688	1092	1212	574	902	938
	(826)	(880)	(682)	(652)	(930)	(968)	(478)	(772)	(946)
Disposable Income	781	874	634	581	939	1019	597	772	805
	(564)	(586)	(492)	(451)	(601)	(623)	(323)	(537)	(624)
Total Expenditure	789	853	686	593	956	1030	638	781	808
	(537)	(553)	(493)	(437)	(562)	(569)	(402)	(533)	(545)
Year: 1998-99	**All Households**	**Male Head**	**Female Head**	**Without children**	**With children**	**Couple Parents**	**Single parent**	**Non-Migrant**	**Migrant**
Sample Size n	6892	60%	40%	52%	48%	79%	21%	72%	28%
Taxable Income	622	703	500	606	628	701	355	627	611
	(512)	(537)	(445)	(551)	(472)	(480)	(311)	(498)	(546)
Disposable Income	526	584	439	499	535	574	390	530	515
	(345)	(337)	(338)	(375)	(304)	(312)	(218)	(346)	(343)
Total Expenditure	723	799	608	684	745	811	495	728	708
	(568)	(601)	(493)	(631)	(504)	(513)	(375)	(576)	(545)

Note: Standard errors are in parentheses.

Table 2a : Stochastic Dominance Results for all households (comparison over the years)

	83 vs. 88	83 vs. 93	83 vs. 98	88 vs. 93	88 vs. 98	93 vs. 98
Gross Income	83 $>_2$ 88 (0.61)	93 $>_1$ 83 (0.363) 93 $>_2$ 83 (1.000)	No SD	93 $>_1$ 88 (0.236) 93 $>_2$ 88 (0.657)	98 $>_1$ 88 (0.003) 98 $>_2$ 88 (0.403)	93 $>_1$ 98 (0.434) 93 $>_2$ 98 (0.993)
Disp Income	83 $>_2$ 88 (0.649)	No SD	83 $>_1$ 98 (0.014) 83 $>_2$ 98 (0.221)	93 $>_1$ 88 (0.035) 93 $>_2$ 88 (0.305)	No SD	93 $>_1$ 98 (0.059) 93 $>_2$ 98 (0.485)
Total Exp	83 $>_1$ 88 (0.001) 83 $>_2$ 88 (0.643)	No SD	No SD	93 $>_1$ 88 (0.001) 93 $>_2$ 88 (0.615)	98 $>_2$ 88 (0.188)	93 $>_2$ 98 (0.621)
Non Durable Exp	83 $>_1$ 88 (0.003) 83 $>_2$ 88 (0.644)	No SD	No SD	93 $>_1$ 88 (0.006) 93 $>_2$ 88 (0.615)	98 $>_1$ 88 (0.001) 98 $>_2$ 88 (0.193)	93 $>_1$ 98 (0.001) 93 $>_2$ 98 (0.607)

Table 2b. Stochastic Dominance Results for all households
(comparison of pretax, post tax and expenditure distributions)

	Gross vs. Disposable	**Disposable vs. Total Expenditure (EXP1)**	**Disposable vs. Non Durable Expenditure (EXP2)**
83/84	No SD	No SD	No SD
88/89	No SD	No SD	No SD
93/94	No SD	No SD	No SD
98/99	No SD	Exp1 $>_1$ Pos (0.02) Exp1 $>_2$ Pos (0.11)	No SD

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y; No SD means no stochastic dominance between X and Y. The number in parentheses is the probability of SD statistics being negative.

Table 3: SD Results by Male v Female Headed Households

	Gross Income	Disposable Income	Total Expenditure (EXP1)	Non Durable Expenditure (EXP2)
83-84	M $>_1$ F (0.239) M $>_2$ F (1.000)	No SD	No SD	No SD
88-89	No SD	No SD	No SD	No SD
93-94	M $>_1$ F (0.09) M $>_2$ F (0.999)	No SD	M $>_1$ F (0.084) M $>_2$ F (0.603)	M $>_1$ F (0.116) M $>_2$ F (0.596)
98-99	M $>_1$ F(0.006) M $>_2$ F(0.142)	M $>_1$ F (0.478) M $>_2$ F (0.632)	M $>_1$ F (0.134) M $>_2$ F (0.461)	M $>_1$ F (0.122) M $>_2$ F (0.446)

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y;
No SD means no stochastic dominance between X and Y. The number in parentheses is the probability of SD statistics being negative.

Table 4: SD Results by households with v without children

	Gross Income	Disposable Income	Total Expenditure (EXP1)	Non Durable Expenditure (EXP2)
83-84	w/ child $>_2$ no child (0.089)	NO SD	No SD	No SD
88-89	NO SD	w/ child $>_2$ no child (0.055)	w/ child $>_2$ no child (0.692)	w/ child $>_2$ no child (0.63)
93-94	w/ child $>_1$ no child (0.194) w/ child $>_2$ no child (1.000)	w/ child $>_1$ no child (0.023) w/ child $>_2$ no child (0.248)	w/ child $>_1$ no child (0.039) w/ child $>_2$ no child (0.496)	w/ child $>_1$ no child (0.125) w/ child $>_2$ no child (0.534)
98-99	w/ child $>_2$ no child (0.54)	w/ child $>_2$ no child (0.596)	w/ child $>_2$ no child (0.667)	w/ child $>_2$ no child (0.667)

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y;
No SD means no stochastic dominance between X and Y. The number in parentheses is the probability of SD statistics being negative.

Table 5: SD Results by Single-Parent (S) v Couple-Parent (C) Households

	Gross Income	Disposable Income	Total Expenditure (EXP1)	Non Durable Expenditure (EXP2)
83-84	C $>_1$ S (0.166) C $>_2$ S (1.000)	NO SD	No SD	No SD
88-89	NO SD	NO SD	No SD	No SD
93-94	C $>_1$ S (0.041) C $>_2$ S (0.278)	NO SD	C $>_1$ S (0.068) C $>_2$ S (0.642)	C $>_1$ S (0.317) C $>_2$ S (0.642)
98-99	NO SD	NO SD	No SD	No SD

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y;
No SD means no stochastic dominance between X and Y. The number in parentheses is the probability of SD statistics being negative.

Table 6: SD Results by Migrant (Mig) v Non-Migrant (NM) Households

	Gross Income	Disposable Income	Total Expenditure (EXP1)	Non Durable Expenditure (EXP2)
83-84	NM $>_1$ Mig. (0.01) NM $>_2$ Mig. (0.771)	NM $>_2$ Mig. (0.223)	NM $>_2$ Mig. (0.156)	NM. $>_1$ Mig. (0.001) NM. $>_2$ Mig. (0.208)
88-89	Mig. $>_2$ NM (0.005)	Mig. $>_2$ NM (0.006)	Mig. $>_2$ NM (0.478)	Mig. $>_1$ NM (0.001) Mig. $>_2$ NM (0.394)
93-94	NM $>_2$ mig. (0.167)	Mig. $>_2$ NM (0.474)	Mig. $>_1$ NM (0.002) Mig. $>_2$ NM (0.284)	Mig. $>_1$ NM (0.001) Mig. $>_2$ NM (0.355)
98-99	Mig. $>_2$ NM (0.016)	Mig. $>_2$ NM (0.004)	Mig. $>_2$ NM (0.021)	Mig. $>_2$ NM (0.017)

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y;
No SD means no stochastic dominance between X and Y. The number in parentheses is the probability of SD statistics being negative.

Appendix

Definition of Household Groups:

Migrant households are identified from the country of birth of the household head. Migrant households are those with heads born overseas; otherwise they are *non-migrant households*. *Male-headed* and *female-headed households* are identified by the survey respondent him/herself as it appears in the datafiles (sex of household reference person). In most cases – the nuclear family setting - this is either the husband or wife. In extended family settings, this person can be the oldest person (grandparent) in the household or the person which provides the greatest financial contribution to the household. *Households with and without children:* children here are defined as those aged from the very young to 24 as long as they are financially dependent on the family for board and lodging. They can be *single-parent* and *couple-parent households*. Households with children can also have multiple adults – and so this definition would accommodate extended family type households (ie including grandparents). Households without children can be can consist of single-member households, couple only households or other multiple adults living together and sharing common board.

Expenditure Variable Definitions:

EXP1 includes all expenditures on Current Housing, Fuel and Power, Food, Alcohol and Tobacco, Clothing and Footwear, Household Furnishings and Equipment, Medical and Health Care, Transport, Recreation and Entertainment and Personal Care. Total expenditures also include expenditures on Income Tax, Superannuation and Life Insurance, Mortgage Repayments and Other Capital Housing Costs.

EXP2 is used to measure non-durable consumption. This is TotExp1 less expenditures on all household furnishings and equipment.

EXP3 is TotExp1 less expenditures jointly labeled as Special Other Payments (SOP) which are expenditures on income tax, mortgage payments, other capital housing costs and superannuation and life insurance.

EXP4 is another measure for non-durable consumption. This is TotExp2 less expenditures on all household furnishings and equipment.

More Complete Table of Results [includes SD results for EXP3 and EXP4]

Note: X $>_1$ Y means X first-order stochastic dominance Y; X $>_2$ Y means X second-order stochastic dominance Y; No SD means no stochastic dominance between X and Y.The number in parentheses is the probability of SD statistics being negative.

Table A.2a Stochastic Dominance Results for all households

	83 vs. 88	83 vs. 93	83 vs. 98	88 vs. 93	88 vs. 98	93 vs. 98
Gross Income	83 $>_2$ 88 (0.61)	93 $>_1$ 83 (0.363) 93 $>_2$ 83 (1.000)	No SD	93 $>_1$ 88 (0.236) 93 $>_2$ 88 (0.657)	98 $>_1$ 88 (0.003) 98 $>_2$ 88 (0.403)	93 $>_1$ 98 (0.434) 93 $>_2$ 98 (0.993)
Disposable Income	83 $>_2$ 88 (0.649)	No SD	83 $>_1$ 98 (0.014) 83 $>_2$ 98 (0.221)	93 $>_1$ 88 (0.035) 93 $>_2$ 88 (0.305)	No SD	93 $>_1$ 98 (0.059) 93 $>_2$ 98 (0.485)
Total Consumption EXP1	83 $>_1$ 88 (0.001) 83 $>_2$ 88 (0.643)	No SD	No SD	93 $>_1$ 88 (0.001) 93 $>_2$ 88 (0.615)	98 $>_2$ 88 (0.188)	93 $>_2$ 98 (0.621)
Non Durable Consumption EXP2	83 $>_1$ 88 (0.003) 83 $>_2$ 88 (0.645)	No SD	No SD	93 $>_1$ 88 (0.006) 93 $>_2$ 88 (0.615)	98 $>_1$ 88 (0.001) 98 $>_2$ 88 (0.193)	93 $>_1$ 98 (0.001) 93 $>_2$ 98 (0.607)
Exp3	83 $>_1$ 88 (0.02) 83 $>_2$ 88 (0.641)	No SD	98 $>_1$ 83 (0.037) 98 $>_2$ 83 (0.621)	No SD	98 $>_1$ 88 (0.011) 98 $>_2$ 88 (0.632)	98 $>_2$ 93 (0.002)
Exp4	83 $>_2$ 88 (0.644)	83 $>_2$ 93 (0.659)	98 $>_1$ 83 (0.018) 98 $>_2$ 83 (0.613)	88 $>_2$ 93 (0.662)	98 $>_1$ 88 (0.02) 98 $>_2$ 88 (0.623)	98 $>_2$ 93 (0.647)

Table A.2b Table A.2a Stochastic Dominance Results for all households

	Gross vs. Disposable	Disposable vs. Exp1	Disposable vs. Exp2	Disposable vs. Exp3	Disposable vs. Exp4
83/84	No SD	No SD	No SD	No SD	Pos $>_1$ Exp (0.011) Pos $>_2$ Exp (0.249)
88/89	No SD	No SD	No SD	No SD	Pos $>_2$ Exp (0.021)
93/94	No SD	No SD	No SD	Pos $>_1$ Exp (0.027) Pos $>_2$ Exp (0.64)	Pos $>_1$ Exp (0.032) Pos $>_2$ Exp (0.64)
98/99	No SD	Exp $>_1$ Pos (0.02) Exp $>_2$ Pos (0.11)	Exp $>_2$ Pos (0.006)	Exp $>_2$ Pos (0.425)	No SD

Table A3: SD Results by Migrant (Mig) v Non-Migrant (NM) Households

	Gross Income (PreTax)	Disposable Income (PostTax)	EXP 1 Total Expenditure	EXP2 Non Durable Expenditure	EXP3	EXP4
83-84	NM $>_1$ Mig. (0.01) NM $>_2$ Mig. (0.771)	NM. $>_2$ mig. (0.223)	NM. $>_2$ mig. (0.156)	NM $>_1$ mig. (0.001) NM $>_2$ mig. (0.208)	NM $>_2$ mig. (0.085)	NM $>_1$ mig. (0.001) NM $>_2$ mig. (0.067)
88-89	Mig. $>_2$ NM (0.005)	Mig. $>_2$ NM. (0.006)	Mig. $>_2$ NM (0.478)	Mig. $>_1$ NM. (0.001) Mig. $>_2$ NM (0.394)	Mig. $>_1$ NM (0.009) Mig. $>_2$ NM (0.635)	Mig. $>_1$ NM (0.011) Mig. $>_2$ NM (0.592)
93-94	NM $>_2$ mig. (0.167)	Mig. $>_2$ NM (0.474)	Mig. $>_1$ NM (0.002) Mig. $>_2$ NM (0.284)	Mig. $>_1$ NM (0.001) Mig. $>_2$ NM (0.355)	Mig. $>_2$ NM (0.116)	Mig. $>_2$ NM (0.164)
98-99	Mig. $>_2$ NM (0.016)	Mig. $>_2$ NM (0.004)	Mig. $>_2$ NM (0.021)	Mig. $>_2$ NM. (0.017)	Mig. $>_2$ NM. (0.032)	No SD

Table A4: SD Results by Male (M) v Female (F) Headed Households

	Gross Income (PreTax)	Disposable Income (PostTax)	EXP 1 Total Expenditure	EXP2 Non Durable Expenditure	EXP3	EXP4
83-84	M $>_1$ F (0.239) M $>_2$ F (1.000)	No SD	No SD	No SD	No SD	No SD
88-89	No SD	No SD	No SD	No SD	No SD	No SD
93-94	M $>_1$ F (0.09) M $>_2$ F (0.999)	No SD	M $>_1$ F (0.084) M $>_2$ F (0.603)	M $>_1$ F (0.116) M $>_2$ F (0.596)	F $>_2$ M (0.52)	F $>_1$ M (0.024) F $>_2$ M (0.652)
98-99	M $>_1$ F (0.006) M $>_2$ F (0.142)	M $>_1$ F (0.478) M $>_2$ F (0.632)	M $>_1$ F (0.134) M $>_2$ F (0.461)	M $>_1$ F (0.122) M $>_2$ F (0.446)	M$>_1$ F (0.077) M $>_2$ F (0.627)	M $>_1$ F (0.123) M $>_2$ F (0.632)

Table A5: SD Results by households with (With Child) v without children (No Child)

	Gross Income (PreTax)	Disposable Income (PostTax)	EXP 1 Total Expenditure	EXP2 Non Durable Expenditure	EXP3	EXP4
83-84	With child $>_2$ no child (0.089)	NO SD	No SD	No SD	No SD	With child $>_2$ no child (0.014)
88-89	NO SD	With child $>_2$ no child (0.055)	With child $>_2$ no child (0.692)	With child $>_2$ no child (0.63)	With child $>_2$ no child (0.624)	With child $>_2$ no child (0.616)
93-94	With child $>_1$ no child (0.194) With child $>_2$ no child (1.000)	With child $>_1$ no child (0.023) With child $>_2$ no child (0.248)	With child $>_1$ no child (0.039) With child $>_2$ no child (0.496)	With child $>_1$ no child (0.125) With child $>_2$ no child (0.534)	No SD	No SD
98-99	With child $>_2$ no child (0.54)	With child $>_2$ no child (0.596)	With child $>_2$ no child (0.667)	With child $>_2$ no child (0.667)	With child $>_2$ no child (0.664)	With child $>_2$ no child (0.644)

Table A6: SD Results by Single-Parent (S) v Couple-Parent (C) Households

	Gross Income (PreTax)	Disposable Income (PostTax)	EXP 1 Total Expenditure	EXP2 Non Durable Expenditure	EXP3	EXP4
83-84	C $>_1$ S (0.166) C $>_2$ S (1.000)	NO SD	No SD	No SD	No SD	No SD
88-89	NO SD	NO SD	No SD	No SD	No SD	No SD
93-94	C $>_1$ S (0.041) C $>_2$ S (0.278)	NO SD	C $>_1$ S (0.068) C $>_2$ S (0.642)	C $>_1$ S (0.317) C $>_2$ S (0.642)	No SD	S $>_2$ C (0.575)
98-99	NO SD	NO SD	No SD	No SD	No SD	No SD

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[i] See Maasoumi (2000) for an extended discussion.

[ii] Higher order dominance rankings (eg third or fourth order) are based on more restricted classes of utility functions which reflect aversion to asymmetry, kurtosis and higher order moments.

[iii] Regular but infrequent bills are prorated and the expenditure items correspond to average weekly amounts.

[iv] Sample of households for each year of the survey are: 4492 for the 1983-84 HES, 7225 for the 1988-89 HES, 8389 for the 1993-94 HES and 6892 for the 1998-99 HES. These households represent around 5 million Australian households from all over the country for each year the surveys were conducted.

[v] This AES is widely used in empirical studies on inequality and lies near the middles of the range of AES surveyed in Buhmann, et al (1987).

[vi] Barrett et al (2000) notes that using a single price index to deflate expenditures of all households, irrespective of the actual consumption bundle is appropriate only if preferences are homothetic.