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The Redistributive Effect of Direct Taxes: An International Comparison of Six LIS Countries

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Abstract

The Luxembourg Income Study (LIS) is used to estimate Lorenz-type curves that facilitate direct *ordinal* comparisons of two very general measures of progressivity--so called "residual" and "liability" progression. Three often neglected issues in tax progressivity studies are addressed. The ordinal comparisons avoid the multiplicity of index numbers problem that plague many tax progressivity studies. Microdata permit adjustments for tax-induced rerankings of families. Statistical inference procedures allow us to take the sampling variability inherent in the data into account. The analysis is applied to investigate the redistributive effects of direct taxes in six countries, Australia, Canada, Sweden, West Germany, the United States, and the United Kingdom. Two periods are considered and comparisons are made within countries across time and between countries at different points in time.

The Redistributive Effect of Direct Taxes: An International Comparison of Six LIS Countries

John A. Bishop, K. Victor Chow, and John P. Formby

I. Introduction

Recent political events such as major tax reform acts in the US and other Western countries and European integration have stimulated renewed interest in international comparisons of the redistributive effect of taxes. Until the recent development of the Luxembourg Income Study (LIS), cross-country studies of tax progressivity have suffered due to an absence of comparable microdata. The availability of LIS individual family income and tax data allows us to address three often neglected issues, the "multiplicity of index numbers problem," tax-induced rerankings of families, and sampling variability in the data.

The first issue, the multiplicity of index number problem in measuring tax progressivity, is closely related to the more widely-known problem of conflicting summary measures of inequality--conflicts which result from the assignment of alternative weights to the various income quantiles. To address this problem we use the LIS microdata to construct Lorenz-type curves that can be used to make *ordinal* comparisons of two very general classes of progressivity--so called "residual" and "liability" progression (Musgrave and Thin, 1948; Lambert, 1989). While a Lorenz-based analysis cannot "solve" potential conflicts it does bring these problems to the forefront and can uncover those cases where no conflict exists. The second issue, the reranking bias, is addressed in an important contribution by Jenkins (1988). Jenkins contrasts the reranking bias to the well-known grouping bias and shows that the reranking bias can be relatively large. Given the existence of microdata (like the Luxembourg Income Study), the reranking problem can be readily overcome by replacing the post-tax Lorenz curve with the post-tax concentration curve (which maintains the pre-tax ordering). Finally,

newly developed statistical inference procedures (Bishop, Chow, and Formby, 1991) that allow tests for significant differences in tax progressivity across countries. These tests, which require microdata, are (asymptotically) distribution-free and recognize the statistical dependence between income and direct taxes. An important advantage of an inference-based analysis is that it strengthens the Lorenz curve analysis in that many numerical Lorenz crossings have been shown to be the result of sampling noise (Bishop, Formby, and Smith, 1991).

The empirical analysis evaluates the redistributive effects of direct taxes in six countries, Australia, Canada, Sweden, West Germany, the United States, and the United Kingdom. The analysis focuses on both the early and middle 1980's and presents estimates of the distribution of taxes and the net redistributive effects. We use the LIS database and the Lorenz-based progressivity measures to make two types of progressivity comparisons--comparisons of progressivity for each country over time, and comparisons across countries at two different points in time. Such cross-country comparisons are important given the current interest in tax reform and in the development of a single European fiscal system.

II. Analyzing Pre-Tax, Post-Tax, and Tax Lorenz Ordinates

The work of Atkinson (1970) establishes the Lorenz curves and the dominance of one Lorenz curve over another as the most basic indicator of income inequality. We use the LIS dataset to estimate Lorenz curves for pre-tax, post-tax, and for the distribution of direct tax burdens. We refer to this last Lorenz curve as the "tax" Lorenz curve and use it along with the pre and post-tax Lorenz curves to make judgments about income inequality and the comparative distributions of direct tax burdens.

The LIS dataset is the first microdata specifically designed to enhance international comparability. The survey data are adjusted for definitional differences in income and the income recipient unit, and weighted to better represent the underlying

populations. Bishop, Formby and Smith (1991, 1993) discuss some of the limitations of the LIS data. Appendix Table A.1 provides the survey date, original data source, and sample size for each of the two time periods, which we refer to as circa 1980 and circa 1985.[1]

Statistical inferences procedures developed by Beach and Davidson (1983) and Bishop, Formby, and Thistle (1989) are used to draw inferences regarding Lorenz dominance. Bishop, Formby and Smith (1991, 1993) provide a detailed discussion of inequality inference procedure with the LIS data set. In brief, the evaluation of Lorenz curves allows three possible alternatives, one Lorenz curve can lie everywhere above another (Lorenz dominance), the two curves can be coincident (Lorenz equivalence), or one curve can lie above the other along some portion of the curve, while the opposite is true along a different portion of the curve (Lorenz crossing). To make statistical evaluations requires the estimation of standard errors for each Lorenz ordinate in order to construct confidence bands around each of the Lorenz curves. Appendix Tables A.2 to A.4 present the decile Lorenz ordinates and their standard errors used to make comparisons of income inequality and the distribution of the tax burden.[2]

A. Changes in the Distribution of Pre-Tax Income

As we shall demonstrate formally in Section III, the distribution of pre-tax (gross) is a determinant of all residual and liability progressivity measures. To measure pre-tax income we use gross cash income, the most comprehensive income concept available in the LIS dataset, defined as market income plus public and private transfers.

Table 1 uses the information in Table A.2 and applies the Lorenz dominance tests to make cross-country (parts A and B) and intertemporal comparisons (part C).

1. O'Higgins et al (1989) use the LIS data to analyze the income and tax distributions for circa 1980. The LIS data used in our study includes all updates through the end of 1992.

2. It is important to recognize the multivariate nature of a simultaneous test of all nine Lorenz ordinates. Thus, we construct the confidence intervals using the Student Maximum Modulus (SMM) distribution to maintain the nominal size of the test. For deciles, the SSM value for a 90 percent confidence interval is 2.50 (for 95%, SMM = 2.80). For a discussion of the SMM distribution with applications to income distributions, see Beach and Richmond (1985). Also see Bishop, Formby, and Thistle (1989).

Table 1 summarizes a great deal of information and requires some explanation. Consider the comparison of Australia and Canada in part A. The "+" in row 1, column 1 indicates that the Canadian pre-tax Lorenz curve lies everywhere *above* the Australian pre-tax Lorenz curve;in other words, the Canadian pre-tax incomes are more equal than Australian pre-tax incomes. Similarly, the "-" in row 6, column 1, indicates that the US pre-tax Lorenz curve lies everywhere *below* the Australian pre-tax Lorenz curve, which indicates that US pre-tax incomes are less equal than Australian pre-tax incomes. A "0" implies that we cannot reject the hypothesis that the two curves are coincident. Finally, an "X" indicates a Lorenz crossing, suggesting that an unambiguous judgment about the relative degree of inequality between the two countries is not possible without making more restrictive assumptions about the determinants of the inequality ordering.[3] All tests are performed at the ten percent significance level.

[Insert Table 1 about here]

Figure 1 is a Hesse diagram depicting the cross-country pre-tax income inequality comparison for the circa 1980 and circa 1985 datasets. Circa 1980 provides a complete and unambiguous Lorenz ordering: Sweden Lorenz dominates Germany, Germany Lorenz dominates the UK, the UK Lorenz dominates Canada, Canada Lorenz dominates Australia, and Australia Lorenz dominates the US. For circa 1985 several of the Lorenz comparisons are ambiguous as indicated by xxx's, which denote crossings. For example, the Swedish and German Lorenz curves cross but Lorenz dominate all other countries, the Canadian and British Lorenz curves cross but Lorenz dominate Australia and the US, and Australia Lorenz dominates the US.

[Insert Figure 1 about here]

Table 1, Part C evaluates the changes in pre-tax income over time. Five of the six countries experienced increasing income inequality, Germany being the exception in that there was no statistically significant change in German income inequality between

3. See Davies and Hoy (1992) for one alternative solution to the "crossing" Lorenz curve problem.

the 1981 and 1984 survey dates.

B. Changes in the Distribution of Post-Tax Income

Table 2 uses the data in Table A.3 to make comparisons of the distribution of the post-tax income across countries and over time. Post-tax income is pre-tax (gross) income described above minus direct (income and payroll) taxes. In the absence of reranking the post-tax Lorenz curve can be used together with the pre-tax income Lorenz curve to measure residual progressivity.

[Insert Table 2 about here]

Figure 2 provides the post-tax inequality ordering. Comparing Figures 1 and 2 shows that for circa 1980 the same inequality ordering is obtained with either pre-tax or post-tax income. This is not true for circa 1985, where in contrast to the pre-tax ordering, the post-tax ordering is complete (i.e., there are no Lorenz crossings). For circa 1985, Germany post-tax Lorenz dominates Sweden, Canada Lorenz dominates the UK, and Australia and the US Lorenz curves are not significantly different at the ten percent significance level.

[Insert Figure 2 about here]

Table 2, Part C evaluates changes in post-tax income over time. With the exception of Canada, all of the countries experienced increasing income inequality. At the ten percent significance level, the Canada circa 1985 Lorenz curve crosses the Canada circa 1980 Lorenz curve. In particular, the Canada 1985 Lorenz curve lies above the Canada 1980 Lorenz curve at the first and second deciles, the two curves are not significantly different between deciles three and six, while the Canada 1980 Lorenz curve lies above the Canada 1985 Lorenz curve between deciles seven and ten. These results suggest that Canada after-tax income shares are larger in 1985 at both the top and the bottom of the income distribution.

C. Changes in the Distribution of Taxes

One way to examine changes in the tax burden is to scrutinize tax Lorenz ordinates. If the tax Lorenz curve unambiguously shifts away from the line of equality over time, then we can conclude that the distribution of taxes has become more unequal, with important implications for the allocation of the tax burdens. In the absence of rerankings or a shifting pre-tax income distribution, shifts in the tax Lorenz curve can be used to measure changes in liability tax progression.

Table 3 uses the data in Table A.4 to make comparisons of the distribution of burden of direct taxes across countries and over time. As above, a "-" sign implies that the row country's tax Lorenz curve is less equal than the column country's tax Lorenz curve, while a "+" implies that the row is more equal than the column. An "X" denotes a Lorenz crossing which allows no unambiguous conclusion regarding the degree of inequality. For circa 1980, of the fifteen comparisons, three result in crossing--the US tax Lorenz curve crosses Australia, Canada, and Germany. For circa 1985 there are six crossings, three with Australia (Canada, Germany, and the UK), two crossings with the Germany (the UK and the US), and one additional crossing with the UK (the US). In many of the crossing cases the following interpretation is possible: those countries that impose relatively high tax burdens on the bottom thirty percent of families typically also impose relatively high tax burdens on the wealthiest families.

[Insert Table 3 about here]

Figure 3 summarizes the tax Lorenz curve orderings for circa 1980 and circa 1985. Excluding the US (due to the crossings), we find the following circa 1980 ordering: Germany's tax shares are less equal than Canada's, which are less equal than Australia's, which are less equal than the UK's, which are less equal than Sweden's. For circa 1985, the large number of crossings make it difficult to characterize the degree of tax inequality. However, one conclusion is possible, Sweden's tax shares are more equal than any of the other five countries.

[Insert Figure 3 about here]

Finally, Table 3, part C shows a comparison of the tax Lorenz ordinates across time. Canada's, Germany's, and Sweden's tax shares are becoming more equal, the UK's tax shares are becoming less equal, and the US's tax shares are not significantly different across time. Australia's circa 1980 and circa 1985 tax Lorenz curves cross, implying that no unambiguous statements about tax inequality can be made.

While Tables 1, 2, and 3 provide interesting insights into the distribution of income and personal income taxes, they cannot be used directly to analyze tax progressivity. This follows from the that the comparisons of tax Lorenz curves and differences between the pre and post-tax Lorenz curves neglects two important aspects of tax progressivity. First, it is impossible to tell whether the changes in the Lorenz curves resulted from a change in the *tax structure* or a change in the *pre-tax income distribution*. Second, simple Lorenz curve comparisons neglect tax-induced rerankings, which can have important consequences for the measurement of progressivity.[4] To address these issues, a more complete and rigorous assessment of changes in income tax progressivity is required.

III. Measuring Tax Progressivity

The modern analysis of tax progressivity has its roots in a seminal paper by Richard Musgrave and Tun Thin (1948), which identifies two general classes of tax progressivity measures -- liability progression and residual progression. The basic concepts of liability and residual progression are local or point measures given, respectively, by the elasticity of taxes with respect to before tax income and the elasticity of after tax income with respect to before tax income. However, overall liability and residual progressivity of a tax system can be analyzed using familiar Lorenz and

4. Stephen Jenkins (1988) demonstrates the importance of rerankings in the measurement of income inequality. Atkinson (1980) and Formby, Smith and Thistle (1990) provide similar discussions for tax induced rerankings.

concentration curves. The essential difference between liability and residual type measures is that they differ in the way they treat changes in tax height.[5] Residual progression measures the redistributive effect of the tax system and considers the interaction of pre-tax income with both tax height and the distribution of the tax burden. Liability progression measures the departure of the tax system from proportionality by removing the effect of changes in the tax height and considering the interaction of the pre-tax income with the distribution of taxes only.[6]

Nanak Kakwani (1976) and U. Jakobsson (1976) demonstrate that all summary indices of residual and liability measures are based on a comparison of the pre-tax Lorenz curve (LC_X) and the after-tax concentration curve (CC_Y) and tax concentration curve (CC_T).[7] As noted above, the work of Atkinson (1970) establishes that Lorenz curves and the dominance of one Lorenz curve over another is the most basic indicator of income inequality. In a similar manner, the Kakwani and Jacobssen theorems show that departures of the after-tax concentration curve (CC_Y) and tax concentration curve (CC_T) from the pre-tax Lorenz curve (LC_X) are the most basic indicators of the overall residual and liability progression of a tax system. In particular, *for a given pre-tax income distribution*, Tax A has more residual progression than Tax B if and only if

$$CC_Y^A - LC_X^A \geq CC_Y^B - LC_X^B, \qquad (1)$$

with one strict inequality prevailing. Similarly, *for the same pre-tax income distribution*, Tax A has more liability progression than Tax B if and only if

$$LC_X^A - CC_T^A \geq LC_X^B - CC_T^B, \qquad (2)$$

with one strict inequality prevailing.

The critical question, of course, is whether one country's, direct taxes are more or

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5. For an excellent summary of these measures see Lambert (1989).

6. Given the large differences in tax height and fiscal policy between such countries as the US and Sweden, the liability progression measure may be the most appropriate measure of direct tax progression to use when making cross country comparisons.

7. The after-tax concentration curve is constructed by arranging after-tax incomes in order of ascending pre-tax income. A tax concentration curve orders taxes by pre-tax income. In the absence of tax induced reranking the after-tax Lorenz and after-tax concentration curves are coincident.

less residual and liability progressive than anothers, *given their existing pre-tax income distributions.* Differences in pre-tax income distributions are equally troublesome when making single country comparisons across time. Suppose that Canada's pre-tax incomes are becoming more unequal while at the same time revisions to Canada's tax code changes the structure of tax rates. Peter Lambert and Wilhelm Pfhäler (1992) explore the behavior of overall tax progression under these conditions concluding that changes in progressivity is essentially an empirical question. To analyze overall progressivity when both the pre-tax income distribution and the structure of taxes are changing, we treat the before tax distribution in each country and in each time period as exogenous and measure the size of the residual and liability progression *given the prevailing pre-tax income distribution.*

IV. Evaluating Direct Tax Progressivity In Six LIS Countries

It is convenient to have a simple geometrical construct for evaluating and presenting the results of the progressivity comparisons. We define a residual progression curve or R curve, which is determined for a given year and for the prevailing pre-tax income distribution by simply adding the value of $CC_Y - LC_X$ at particular quantile points to the ordinate of the 45^o line. Deviations of the R curve from the 45^o line show the redistributive effect of residual tax progression given the prevailing pre-tax income distribution. Progressive tax systems like the those in Western countries will have R curves that lie everywhere above the 45^o line, with the size of the deviation at a particular quantile reflecting residual progression at that point in the income distribution. The R curves of regressive tax systems will lie everywhere below the 45^o line.[8] Unambiguously more residual progression is revealed by dominance, which means that one R curve lies above and to the left of another.

8. The R curve of a tax system that is proportional throughout its range will precisely coincide with the 45^o line. A mixed system in which taxes are progressive over one part of the distribution and regressive over another part will have an R curve that crosses the 45^o line. Such a mixed system will be characterized by proportional residual progression at the crossing point.

In a fashion analogous to the R curve we define an L curve (liability progression curve), which measures deviations of CC_T away from LC_X at particular quantile points relative to the 45^O line. The L curve shows the effects of liability progression in terms of deviations from proportionality. A strictly proportional tax system would be characterized by an L curve that coincides with the 45^O line. Since the tax concentration curve of a progressive tax system lies everywhere to the right of the before tax Lorenz curve, equation 2 insures that the L curve lies above and to the left of the 45^O reference line. As with R curves, unambiguously more liability progression is revealed by dominance of one L curve over another, i.e.; there is more liability progression in Country A than in Country B if A's L curve lies above and to the left of B's L curve.

A. An Illustration of R and L Curve Comparisons Using US and Swedish Data

Table 4 illustrates the construction and interpretation of residual progression (R) and liability progression (L) curves using American and Swedish data. Table 4a and 4b show the 1985 R curve and L curve ordinates at deciles and their corresponding standard errors and tests for differences.[9] Table 4c provides similar information for the 1980 L curves. Consider Table 4a first. As explained above, an ordinate of the R curve is simply the difference between the pre-tax Lorenz ordinate (col. 1) and after-tax concentration ordinate, (col. 2), $CC_Y - LC_X$, added to the ordinate of the 45^O line. For both the US and Sweden the deviations of the R curve away from the 45^O line are statistically significant (test statistics are not shown), which means simply that in both cases direct taxes are residually progressive. Now consider Table 4b, which provides the necessary data to evaluate US and Swedish liability progression in 1985. While columns 1 and 4 are the same pre-tax Lorenz ordinates as in Table 4a, the after-tax concentration

9. The standard errors are constructed by a procedure developed by Bishop, Chow, and Formby (1993). Essentially, this procedure addresses the dependence between the two vectors by recognizing the matched pair nature of the test. Given the usual set of regularity conditions, the asymptotic distribution of the difference between the empirical LC and the corresponding CC is multivariate normal. The test procedure is similar to that discussed in footnote 2 above.

ordinates (CC_Y in Table 4a) are replaced by the tax concentration ordinates (CC_T). As with residual progression in Table 4a, the deviations of the R curve away from the 45^o line are statistically significant in both cases implying that direct taxes are liability progressive in both countries.

[Insert Table 4 about here]

If simple, zero variance comparisons are made using the R and L curve ordinates in Table 4 then the Swedish and American curves cross in each comparison. The R curves appear to cross between the fourth and fifth deciles, the 1985 L curves cross between the first and second deciles and the 1980 L curves cross at the third decile. Thus, reliance on zero variance comparison leads to a conclusion that the curves cross, which suggests that no unambiguous progressivity comparison is possible. However, the test statistics in Column 7 of Table 4 can be used to test for differences in the US and Swedish tax progressivity. When statistical comparisons are made, as with ordinary Lorenz curves, two R (or L) curves can cross, be coincident or a dominance relation can exist. The size of test statistics in Column 7 of Table 4a suggests that there are no significant differences in the Swedish and American R curves; the apparent crossing is a statistical illusion. Thus, rather than no conclusions about comparative residual progression when we account for sampling variability in the data, we can conclude that the degree of residual progressivity does not differ between these two countries and that the US and Swedish direct tax systems are no different in terms of residual progression.

In contrast to the finding of coincident R curves, the test statistics in Tables 4b and 4c show that the L curves are different in both the circa 1980 and 1985 comparisons. Figure 4 depicts L curves for each year and careful inspection reveals that they appear to cross. In fact, Table 4b and 4c show that one of the L curves in Figure 4 illustrates dominance, while the other represents a statistically significant crossing. For 1985 the test statistics in Table 4b are not significantly different from zero at deciles 1, 2 and 3 but reveal that the US L curve lies significantly above the Swedish L curve at deciles 4

through 9. Thus, in the circa 1985 comparison the US L curve dominates and we conclude that the direct tax system in the US has more liability progression than does direct taxation in Sweden. For 1980, however, the L curves are characterized by a statistically significant crossing and no conclusions can be drawn. This is apparent from the test statistics in Column 7 of Table 4c. The negative test statistic for the first decile is larger than the critical value and indicates that Sweden's L curve exhibits greater liability progression than the US at the bottom of the income distribution; there is no difference in the degree of liability progression in the two countries at deciles 2 through 4; and the positive and test statistics are positive and significant at deciles 5 through 9, which indicates that the American L curve lies above the Swedish L curve in this range. Thus, there is a significant crossing between the first and fifth deciles.

[Insert Figure 4 about here]

It should be noted that the data in Table 4 could be used to construct summary measures of the overall degree of direct tax progression in the US and Sweden. There are, of course, a plethora of such measures. For residual progression Musgrave and Thin's (1948) index of effective progression and the Reynolds and Smolensky (1977) index are leading examples. However, in a manner analogous to Lorenz curves and the measurement of inequality, comparisons of R curves is the most general indicator of residual progression. The statistical inference tests in Table 4 reveal that the null hypothesis of no difference in R curves cannot be rejected. Under these conditions, calculating seemingly precise summary indexes of residual progressivity from sample data whose differences are within the range of sampling error is an undertaking that should be avoided. The information in Table 4b and 4c could also be used to construct liability progression summary measures such as those suggested by Kakwani (1976) and Daniel Suits (1977). However, these calculations may also be misleading. For 1985 a zero variance comparison suggests that the L curves cross, which implies that one could always find an index of liability progression that ranks the comparative degree of

progression differently. But in fact the US direct tax system is more progressive than the Swedish, and the use of an index number is potentially misleading. Of course, popular index numbers may be consistent with the actual ordinal ranking shown in Table 4b, but there is no guarantee that this will *always* be the case. For 1980 the index number problem is more severe; the dominance tests reveal that the direct tax systems of the US and Sweden cannot be ranked. The indexes, of course always yield a ranking even when the L curves cross as they do in 1980. Consequently, the use of a summary index will *always* be misleading. Thus, the problem of multiple indexes of tax progressivity is closely related to the better known problem of conflicting indexes of income inequality. It is now well established that the existence of sampling variability and crossing Lorenz curves create serious problems in analyzing income inequality with index numbers. It is equally true that sampling variability and crossing R and L curves restrict the usefulness of summary measures of tax progression.

B. Cross-Country Tax Progressivity Comparisons

Table 5 presents the results of the cross-country tax progressivity comparisons.[10] The information in Table 5 is limited to the liability progression tests (L curve) only. We do not report the results of the R curve tests in Table 5 due to the fact that of the thirty possible cross-country comparisons there are only two cases where the R curves of the countries are significantly different at the ten percent level.[11] Similarly, from circa 1980 to circa 1985 we find that none of the countries experienced a significant change in the degree of residual progression.[12] Appendix B provides detailed tables for both R

10. Rosenberg (1989) and Zandvakili (1990) use the LIS data (circa 1980) to evaluate residual progressivity. Rosenberg considers transfers along with taxes and Zandvakili's focus is on decomposing the changes in the income distribution due to direct taxes. However, neither author discusses intersecting Lorenz and concentration curves, tax-induced reranking, or statistical inference problems.

11. The US exhibits greater residual progressivity than either Canada or the UK in the circa 1980 comparisons.

12. The apparent explanation of these findings regarding residual progression is as follows. For the cross country comparisons it appears that countries with greater tax heights also tend to have more equal pre-tax income distributions so that the effect of progressive tax rates on the overall residual progression is muted. In the comparisons of residual progression across time the combination of less progressive tax rates

and L curve ordinates and standard errors for each country and both time periods.

[Insert Table 5 about here]

The notation in Table 5 is equivalent to that of earlier tables, with the "0" in row 1, column 1 indicating that there is no significant difference (at the ten percent level) between the degree of liability progressivity in Canada and Australia, *given their pre-tax distributions*. In addition, a "+" (-) indicates the row country's direct taxes are more (less) liability progressive than the column country, while an "X" indicates that the L curves cross and an unambiguous liability progressivity ranking is not possible.

Figure 5 provides the ordering of liability progression for circa 1980 and circa 1985, excluding the US. We exclude the US for two reasons. First, the U.S. L curves crosses a large number countries and attempting to depict all of these crossings would greatly complicate the diagram and make it difficult to interpret. Second, there is a weak intransitivity between the statistical rankings involving the US, circa 1985 and this too would complicate the diagram.[13] However, it is interesting to note that the US has unambiguously less liability progression in only two of the thirty comparisons (Canada circa 1985 and Germany circa 1980). In addition, Australia and Sweden circa 1985 both exhibit a smaller degree of liability progressivity than the US. Examining Figure 5 we observe that, for both time periods, Germany has the greatest degree of liability progression and Sweden the least. Between circa 1980 and 1985, Australia's relative liability progressivity ranking falls; having dominated the UK in 1980 Australia is dominated by the UK in terms of liability progression.

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and rising pre-tax inequality leads to no change in residual progressivity. On this point see Tables 1-, 2 and 3.

13. Two types of intransitivities can be distinguished. A strong intransitivity takes the form of $A \underset{D}{>} B$, $B \underset{D}{>} C$ and $C \underset{D}{>} A$. A weak intransitivity involves the rejection of the null hypothesis of no difference between two countries. A partial order is said to be weakly intransitive if $A \underset{D}{>} B$, $B \underset{D}{>} C$ and $A = C$ or $A \underset{D}{>} B$, $B = C$ and $A = C$. Thus, weak intransitivities involve pairwise comparisons where the null hypothesis cannot be rejected; whereas, strong intransitivities do not. We find no evidence of a strong intransitivity in the statistical comparisons of tax systems across countries. However, the comparisons of the liability progression of the US, Canada and UK direct tax systems in 1985 involve a weak intransitivity. See Bishop, Formby, and Smith (1993) for a discussion of statistical inference and intransitive rankings.

[Insert Figure 5 about here]

Finally, Table 5, part C shows the results of L curve tests across time. Canada, Germany, and the US experienced no change in the degree of liability progression, while Australia, Sweden, and the UK all experienced declines in liability progression.

IV. Conclusions

Until the recent development of the Luxembourg Income Study (LIS), cross-country studies of tax progressivity have suffered due to an absence of comparable microdata. We use the LIS microdata to construct Lorenz-type curves that can be used to make *ordinal* comparisons of two very general classes of progressivity--so called "residual" and "liability" progression. The importance of LIS microdata is that it allows us to address three often neglected issues in international comparisons of tax progressivity, the "multiplicity of index numbers problem," tax-induced rerankings of families, and sampling variability in the data. First, we point out that a Lorenz-based analysis of the sort carried out in this study cannot "solve" potential conflicts among index numbers, but it does bring these problems to the forefront and can uncover those cases where no conflict exists. Second, given the existence of microdata, the reranking problem can be readily overcome by replacing the post-tax Lorenz curve with the post-tax concentration curve (which maintains the pre-tax ordering). Finally, newly developed statistical inference procedures allow tests for significant differences in tax progressivity across countries. These tests, which require microdata, are (asymptotically) distribution-free and recognize the statistical dependence between income and taxes. An important advantage of an inference-based analysis is that it strengthens the Lorenz curve analysis in that many numerical Lorenz crossings have been shown to be the result of sampling noise.

The empirical analysis evaluates the redistributive effects of direct taxes in six countries, Australia, Canada, Sweden, West Germany, the United States, and the United Kingdom. The analysis focuses on both the early and middle 1980's and presents

comparisons of progressivity for each country over time, as well as comparisons across countries at two different points in time. We present a graphical method of analyzing tax progressivity which we call R (residual progression) and L (liability progression) curves.

The analysis provides three important findings. First, there is little evidence of variation in residual progression between these countries or within these countries across time. One possible explanation for the cross country is that countries with greater tax heights also tend to have more equal pre-tax distribution so that the effect of progressive tax rates on the overall residual progressivity is muted. Across time the combination of less progressive tax rates and greater pre-tax inequality leads to no change in residual progressivity. Second, Germany and Canada are found to have the most, and Sweden the least liability progression in their direct tax systems. Third, Canada, Germany, and the US show no change in liability progression across time, while Australia, Sweden, and the UK all show declines in liability progressivity. We point out that a shortcoming of the analysis is the necessity of measuring progressivity given the prevailing pre-tax distributions.

References

Atkinson, Anthony B. (1970), "On the Measurement of Inequality," Journal of Economic Theory, 2, 244-263.

_____, (1980). "Horizontal Equity and the Distribution of the Tax Burden," in Henry J. Aaron and Michael J. Boskin (eds.) The Economics of Taxation, Washington, Brookings.

Beach, Charles M. and Davidson, Russell (1983), "Distribution-free Statistical Inference with Lorenz Curves and Income Shares," Review of Economic Studies, 50,722-735.

_____ **and Richmond, James** (1985), "Joint Confidence Intervals for Income Shares and Lorenz Curves," International Economic Review, 26, 439-450.

Bishop, John A., Formby, John P. and Smith, W. James (1991), "International Comparisons of Income Inequality: Tests For Lorenz Dominance Across Nine Countries," Economica, 58, 461-477.

_____, _____ **and** _____ (1993), "International Comparisons of Welfare and Poverty: Stochastic Dominance Orderings for Ten Countries, Canadian Journal of Economics, forthcoming.

_____, _____ **and Thistle, Paul D.** (1989), "Statistical Inference, Income Distributions, and Social Welfare," in Daniel J. Slottje ed., Research in Economic Inequality, 1, JAI Press: Greenwich, CT.

_____, **Chow, K. Victor,** and **Formby, John P.** (1991), "A Large Sample Test for Differences Between Lorenz and Concentration Curves," University of Alabama, Department of Economics and Finance, Working Paper No. 205.

Davies, James and Hoy, Michael (1991), "Making Inequality Comparisons When Lorenz Curves Intersect," Working Paper, Department of Economics, Western Ontario University.

Formby, John, Thistle, Paul, and W. James Smith (1990), "The Average Tax Burden and the Welfare Implications of Global Tax Progressivity," Public Finance Quarterly, 19, 3-24.

Jakobsson, U. (1976), "On the Measurement of the Degree of Progression," Journal of Public Economics, 5, 161-168.

Jenkins, Stephen (1988), "Reranking and the Analysis of Income Redistribution," Scottish Journal of Political Economy, 35, 161-168.

Kakwani, Nanak C. (1976), "Measurement of Tax Progressivity: An International Comparison," Economic Journal, 87, 71-80.

Lambert, Peter J. (1989), The Distribution and Redistribution of Income, Basil Blackwell: Oxford.

_____ **and Pfähler, Wilhelm** (1992), "Income Tax Progression and Redistributive Effect: The Influence of Changes in the Pre-tax Income

Distribution," Public Finance, 47, 1-16.

Musgrave, Richard A. and Thin, Tun (1948), "Income Tax Progression: 1929-1948," Journal of Political Economy, 56, 498-514.

O'Higgins, M. Schmaus, G. and Stephenson, G. (1989), "Income Distribution and Redistribution: A Microdata Analysis for Seven Countries," Review of Income and Wealth, 35, 107-131.

Reynolds. M. and Smolensky, E. (1977), "Postfisc Distributions of Income in 1950, 1961, and 1970", Public Finance Quarterly, 5, 109-120.

Rosenberg, C. B. (1989), "The Redistributive Effect of the Tax System in West Germany, Sweden, and the United States," LIS-CPS Working Paper #36.

Suits, Daniel B. (1977), "Measurement of Tax Progressivity," American Economic Review, 67, pp. 747-752.

Zandavakili, S. (1990), "Redistribution Through Taxation: An International Comparison," LIS-CPS Working Paper #44.

Table 1. Pairwise Comparison of Pre-tax Income Lorenz Curves

A. Circa 1980					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	+	*			
Germany	+	+	*		
Sweden	+	+	+	*	
UK	+	+	-	-	*
US	-	-	-	-	-

B. Circa 1985					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	+	*			
Germany	+	+	*		
Sweden	+	+	x	*	
UK	+	x	-	-	*
US	-	-	-	-	-

C. Changes in Pre-tax Income Lorenz Curves Over Time	
Australia	Less equal
Canada	Less equal
Germany	No change
Sweden	Less equal
UK	Less equal
US	Less equal

Note: A "-" denotes row country's Lorenz curve is less equal than column country's, while a "+" indicates row more equal than column. An "x" denotes Lorenz crossing and "0" denotes Lorenz equivalence.

Table 2. Pairwise Comparison of Post-tax Lorenz Curves

A. Circa 1980					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	+	*			
Germany	+	+	*		
Sweden	+	+	+	*	
UK	+	+	-	-	*
US	-	-	-	-	-

B. Circa 1985					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	+	*			
Germany	+	+	*		
Sweden	+	+	-	*	
UK	+	-	-	-	*
US	0	-	-	-	-

C. Changes in Post-tax Income Lorenz Curves Over Time	
Australia	Less equal
Canada	Crossing
Germany	Less equal
Sweden	Less equal
UK	Less equal
US	Less equal

Note: A "-" denotes row country's Lorenz curve is less equal than column country's, while a "+" indicates row more equal than column. An "x" denotes Lorenz crossing and "0" denotes Lorenz equivalence.

Table 3. Pairwise Comparison of Tax Lorenz Curves

A. Circa 1980					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	-	*			
Germany	-	-	*		
Sweden	+	+	+	*	
UK	+	+	+	-	*
US	x	x	x	-	-

B. Circa 1985					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	x	*			
Germany	x	-	*		
Sweden	+	+	+	*	
UK	x	-	x	-	*
US	-	-	x	-	x

C. Changes in Tax Income Lorenz Curves Over Time	
Australia	Crossing
Canada	More equal
Germany	More equal
Sweden	More equal
UK	Less equal
US	No change

Note: A "-" denotes row country's Lorenz curve is less equal than column country's, while a "+" indicates row more equal than column. An "x" denotes Lorenz crossing and "0" denotes Lorenz equivalence.

Table 4. Direct Tax Progressivity in the U.S. and Sweden, Circa 1980 and Circa 1985

A. Residual Progression (R) Curves							
Decile	**US**			**Sweden**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LC	**CC**	**R**	**LC**	**CC**	**R**	**TEST STATISTICS**
1	0.011	0.014	0.103 (0.001)	0.018	0.024	0.106 (0.002)	-1.46
2	0.038	0.046	0.208 (0.002)	0.056	0.070	0.214 (0.003)	-1.67
3	0.078	0.093	0.315 (0.003)	0.108	0.127	0.320 (0.004)	-0.90
4	0.133	0.155	0.422 (0.004)	0.173	0.197	0.423 (0.005)	-0.24
5	0.205	0.233	0.528 (0.005)	0.253	0.279	0.526 (0.006)	0.30
6	0.295	0.327	0.632 (0.006)	0.344	0.370	0.626 (0.007)	0.69
7	0.404	0.441	0.737 (0.007)	0.457	0.484	0.727 (0.008)	0.89
8	0.539	0.577	0.838 (0.009)	0.596	0.624	0.829 (0.010)	0.70
9	0.712	0.747	0.935 (0.006)	0.761	0.789	0.928 (0.007)	0.75

Note: At each ordinate the R curves of both countries are significantly different from the 45° line. The test statistics in column 7 compare the R curves of the US and Sweden to each other. Given the five percent critical SMM Value of 2.77, we conclude no signficance difference between the two R curves.

Table 4 *continued*

B. Liability Progression (L) Curves, Circa 1985							
Decile	**US**			**Sweden**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LC	**CC**	**L**	**LC**	**CC**	**L**	**TEST STATISTICS**
1	0.011	0.001	0.110 (0.001)	0.018	0.007	0.111 (.002)	-0.89
2	0.038	0.007	0.230 (0.001)	0.056	0.027	0.229 (.002)	0.78
3	0.078	0.022	0.356 (0.002)	0.108	0.068	0.340 (.004)	3.89*
4	0.133	0.052	0.481 (0.003)	0.173	0.126	0.448 (.005)	5.77*
5	0.205	0.100	0.605 (0.004)	0.253	0.200	0.553 (.006)	7.02*
6	0.295	0.174	0.721 (0.005)	0.344	0.291	0.653 (.007)	7.38*
7	0.404	0.270	0.835 (0.007)	0.457	0.403	0.754 (.009)	7.30*
8	0.539	0.400	0.939 (0.008)	0.596	0.537	0.858 (.010)	6.18*
9	0.712	0.584	1.029 (0.010)	0.761	0.705	0.957 (.010)	4.87*

Note: At each ordinate the US and Swedish L curves are significantly different from the 45° line. The test statistics in column 7 compare the US and Swedish L curves to each other and we conclude that Swedish direct taxes are less liability progressive than the U.S. ("*" denotes significance at five percent level).

Table 4 ***continued***

C. Liability Progression (L) Curves, Circa 1980							
Decile	**US**			**Sweden**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
	LC	**CC**	**L**	**LC**	**CC**	**L**	**TEST STATISTIC**
1	.012	.001	.111 (.0004)	.023	.007	.116 (.002)	-2.81*
2	.039	.006	.233 (.001)	.066	.026	.240 (.003)	-2.13
3	.081	.021	.360 (.002)	.122	.062	.360 (.004)	0.16
4	.138	.049	.489 (.003)	.189	.115	.474 (.005)	2.74
5	.213	.098	.615 (.004)	.268	.187	.581 (.006)	4.75*
6	.305	.171	.734 (.005)	.361	.283	.678 (.007)	6.28*
7	.418	.269	.848 (.006)	.473	.400	.774 (.009)	6.94*
8	.556	.403	.9526 (.008)	.610	.538	.872 (.010)	6.27*
9	.728	.587	1.041 (.010)	.774	.711	.923 (.011)	5.33*

Note: At each ordinate the US and Swedish L curves are significantly different from the 45° line. The test statistics in column 7 compare the US and Swedish L curves to each other and we conclude that the two L curves cross ("*" denotes significance at five percent level).

Table 5. Pairwise Comparison of Liability Progression (L) Curves

A. Circa 1980					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	0	*			
Germany	+	+	*		
Sweden	-	-	-	*	
UK	x	-	-	+	*
US	x	x	-	x	x

B. Circa 1985					
	Australia	**Canada**	**Germany**	**Sweden**	**UK**
Australia	*				
Canada	+	*			
Germany	+	+	*		
Sweden	-	-	-	*	
UK	+	-	-	+	*
US	+	-	x	+	x

C. Changes in L Curves Over Time	
Australia	Less progressive
Canada	No change
Germany	No change
Sweden	Less progressive
UK	Less progressive
US	No change

Note: A "-" denotes row country's Lorenz curve is less equal than column country's, while a "+" indicates row more equal than column. An "x" denotes crossing and "0" denotes L curve equivalence.

Table A.1. LIS Data Sets

Country	Year	Data Source	Sample Size
Australia	1981	Income and Housing Survey	15985
Australia	1985	Income and Housing Survey	8014
Canada	1981	Survey of Consumer Finances	15136
Canada	1987	Survey of Consumer Finances	11418
Sweden	1981	Income Distribution Survey	9625
Sweden	1987	Income Distribution Survey	9421
Germany	1981	Transfer Survey	2727
Germany	1984	Panel Survey: Wave II	5174
United Kingdom	1979	Family Expenditure Survey	6888
United Kingdom	1986	Family Expenditure Survey	7178
United States	1979	Current Population Survey	15225
United States	1986	Current Population Survey	12158

Table A.2. Pre-tax Income Lorenz Ordinates and Standard Errors

A. Circa 1980

Decile	Australia	Canada	Germany	Sweden	UK	US
1	0.0151	0.0153	0.0206	0.0235	0.0207	0.0115
	(0.0002)	(0.0004)	(0.0006)	(0.0024)	(0.0003)	(0.0003)
2	0.0437	0.0467	0.0567	0.0658	0.0518	0.0388
	(0.0005)	(0.0006)	(0.0013)	(0.0023)	(0.0006)	(0.0005)
3	0.0857	0.0938	0.1075	0.1212	0.0961	0.0810
	(0.0008)	(0.0009)	(0.0020)	(0.0023)	(0.0011)	(0.0009)
4	0.1459	0.1574	0.1726	0.1884	0.1595	0.1385
	(0.0012)	(0.0012)	(0.0027)	(0.0023)	(0.0017)	(0.0012)
5	0.2235	0.2376	0.2528	0.2677	0.2415	0.2120
	(0.0015)	(0.0015)	(0.0033)	(0.0023)	(0.0022)	(0.0015)
6	0.3179	0.3350	0.3489	0.3605	0.3397	0.3046
	(0.0017)	(0.0017)	(0.0038)	(0.0023)	(0.0024)	(0.0018)
7	0.4312	0.4506	0.4618	0.4733	0.4554	0.4178
	(0.0019)	(0.0018)	(0.0042)	(0.0023)	(0.0026)	(0.0019)
8	0.5682	0.5876	0.5962	0.6104	0.5913	0.5558
	(0.0020)	(0.0018)	(0.0044)	(0.0022)	(0.0026)	(0.0020)
9	0.7380	0.7543	0.7577	0.7735	0.7571	0.7280
	(0.0019)	(0.0017)	(0.0044)	(0.0019)	(0.0023)	(0.0019)

B. Circa 1985

Decile	Australia	Canada	Germany	Sweden	UK	US
1	0.0157	0.0165	0.0218	0.0187	0.0190	0.0114
	(0.0004)	(0.0003)	(0.0004)	(0.0010)	(0.0009)	(0.0003)
2	0.0437	0.0481	0.0567	0.0560	0.0516	0.0378
	(0.0007)	(0.0006)	(0.0008)	(0.0013)	(0.0010)	(0.0006)
3	0.0840	0.0940	0.1054	0.1075	0.0941	0.0777
	(0.0011)	(0.0010)	(0.0014)	(0.0018)	(0.0013)	(0.0009)
4	0.1401	0.1548	0.1687	0.1735	0.1491	0.1329
	(0.0017)	(0.0013)	(0.0019)	(0.0023)	(0.0016)	(0.0013)
5	0.2147	0.2318	0.2470	0.2519	0.2214	0.2048
	(0.0022)	(0.0016)	(0.0024)	(0.0027)	(0.0021)	(0.0017)
6	0.3077	0.3262	0.3411	0.3440	0.3124	0.2945
	(0.0027)	(0.0019)	(0.0029)	(0.0031)	(0.0025)	(0.0020)
7	0.4201	0.4395	0.4520	0.4567	0.4244	0.4046
	(0.0032)	(0.0021)	(0.0033)	(0.0035)	(0.0028)	(0.0023)
8	0.5559	0.5754	0.5844	0.5957	0.5605	0.5395
	(0.0037)	(0.0022)	(0.0036)	(0.0039)	(0.0030)	(0.0025)
9	0.7243	0.7428	0.7468	0.7614	0.7318	0.7121
	(0.0041)	(0.0021)	(0.0037)	(0.0042)	(0.0029)	(0.0024)

Table A.3. Post-tax Income Lorenz Ordinates and Standard Errors

A. Circa 1980						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.0192 (0.0003)	0.0179 (0.0004)	0.0260 (0.0007)	0.0287 (0.0035)	0.0244 (0.0004)	0.0142 (0.0004)
2	0.0544 (0.0006)	0.0539 (0.0007)	0.0700 (0.0014)	0.0800 (0.0034)	0.0617 (0.0007)	0.0472 (0.0006)
3	0.1047 (0.0008)	0.1059 (0.0009)	0.1289 (0.0020)	0.1412 (0.0032)	0.1120 (0.0011)	0.0962 (0.0009)
4	0.1708 (0.0011)	0.1736 (0.0012)	0.2000 (0.0025)	0.2124 (0.0032)	0.1785 (0.0016)	0.1604 (0.0012)
5	0.2526 (0.0014)	0.2567 (0.0014)	0.2824 (0.0030)	0.2942 (0.0028)	0.2616 (0.0020)	0.2405 (0.0014)
6	0.3503 (0.0015)	0.3558 (0.0016)	0.3772 (0.0033)	0.3866 (0.0026)	0.3596 (0.0023)	0.3380 (0.0016)
7	0.4644 (0.0016)	0.4713 (0.0016)	0.4884 (0.0037)	0.4964 (0.0023)	0.4738 (0.0025)	0.4542 (0.0017)
8	0.5998 (0.0016)	0.6058 (0.0016)	0.6190 (0.0039)	0.6311 (0.0020)	0.6070 (0.0025)	0.5928 (0.0016)
9	0.7642 (0.0014)	0.7675 (0.0015)	0.7730 (0.0038)	0.7921 (0.0015)	0.7676 (0.0024)	0.7603 (0.0013)

B. Circa 1985						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.0167 (0.0003)	0.0195 (0.0005)	0.0281 (0.0004)	0.0184 (0.0015)	0.0200 (0.0014)	0.0137 (0.0004)
2	0.0450 (0.0007)	0.0563 (0.0007)	0.0720 (0.0010)	0.0623 (0.0015)	0.0602 (0.0015)	0.0454 (0.0007)
3	0.0857 (0.0011)	0.1080 (0.0010)	0.1292 (0.0015)	0.1176 (0.0017)	0.1114 (0.0016)	0.0917 (0.0010)
4	0.1422 (0.0017)	0.1738 (0.0013)	0.1986 (0.0019)	0.1861 (0.0019)	0.1744 (0.0019)	0.1530 (0.0013)
5	0.2168 (0.0022)	0.2546 (0.0016)	0.2802 (0.0024)	0.2657 (0.0020)	0.2519 (0.0022)	0.2306 (0.0016)
6	0.3098 (0.0027)	0.3509 (0.0018)	0.3758 (0.0029)	0.3590 (0.0022)	0.3452 (0.0024)	0.3248 (0.0019)
7	0.4220 (0.0032)	0.4642 (0.0019)	0.4869 (0.0033)	0.4735 (0.0024)	0.4560 (0.0027)	0.4381 (0.0020)
8	0.5573 (0.0037)	0.5982 (0.0019)	0.6152 (0.0037)	0.6144 (0.0027)	0.5879 (0.0028)	0.5739 (0.0021)
9	0.7251 (0.0041)	0.7602 (0.0018)	0.7680 (0.0040)	0.7800 (0.0029)	0.7495 (0.0027)	0.7431 (0.0019)

Table A.4. Tax Lorenz Shares and Standard Errors

A. Circa 1980						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0013 (0.0001)	0.0000 (0.0015)	0.0000 (0.0000)
2	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0139 (0.0006)	0.0001 (0.0015)	0.0006 (0.0001)
3	0.0081 (0.0006)	0.0057 (0.0005)	0.0000 (0.0000)	0.0452 (0.0013)	0.0074 (0.0017)	0.0088 (0.0005)
4	0.0431 (0.0015)	0.0340 (0.0890)	0.0185 (0.0035)	0.0963 (0.0018)	0.0402 (0.0027)	0.0346 (0.0011)
5	0.1049 (0.0020)	0.0890 (0.0020)	0.0786 (0.0057)	0.1663 (0.0024)	0.1071 (0.0037)	0.0823 (0.0018)
6	0.1876 (0.0024)	0.1726 (0.0025)	0.1657 (0.0067)	0.2564 (0.0029)	0.2015 (0.0042)	0.1545 (0.0025)
7	0.2953 (0.0029)	0.2866 (0.0029)	0.2754 (0.0076)	0.3682 (0.0033)	0.3241 (0.0043)	0.2544 (0.0032)
8	0.4368 (0.0034)	0.4369 (0.0033)	0.4175 (0.0090)	0.5073 (0.0038)	0.4768 (0.0043)	0.3904 (0.0042)
9	0.6282 (0.0039)	0.6388 (0.0034)	0.6109 (0.0105)	0.6872 (0.0043	0.6749 (0.0040)	0.5779 (0.0052

B. Circa 1985						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0013 (0.0006)	0.0000 (0.0003)	0.0000 (0.0000)
2	0.0015 (0.0001)	0.0006 (0.0001)	0.0000 (0.0000)	0.0203 (0.0010)	0.0001 (0.0003)	0.0007 (0.0001)
3	0.0105 (0.0007)	0.0136 (0.0008)	0.0003 (0.0002)	0.0579 (0.0015)	0.0037 (0.0005)	0.0104 (0.0006)
4	0.0413 (0.0018)	0.0482 (0.0016)	0.0202 (0.0027)	0.1133 (0.0020)	0.0225 (0.0015)	0.0370 (0.0012)
5	0.0963 (0.0027)	0.1057 (0.0022)	0.0856 (0.0043)	0.1849 (0.0025)	0.0714 (0.0029)	0.0848 (0.0020)
6	0.1734 (0.0036)	0.1882 (0.0029)	0.1785 (0.0048)	0.2733 (0.0030)	0.1535 (0.0038)	0.1567 (0.0027)
7	0.2788 (0.0046)	0.2989 (0.0036)	0.2988 (0.0052)	0.3826 (0.0036)	0.2695 (0.0044)	0.2541 (0.0035)
8	0.4166 (0.0059)	0.4451 (0.0042)	0.4518 (0.0053)	0.5174 (0.0042)	0.4261 (0.0048)	0.3870 (0.0044)
9	0.6019 (0.0073)	0.6402 (0.0050)	0.6531 (0.0050)	0.6884 (0.0049)	0.6382 (0.0048)	0.5753 (0.0055)

Table B.1. Residual Progression Ordinates and Standard Errors

A. Circa 1980						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.1040 (0.0009)	0.1027 (0.0010)	0.1060 (0.0028)	0.1071 (0.0062)	0.1040 (0.0009)	0.1028 (0.0008)
2	0.2109 (0.0017)	0.2074 (0.0019)	0.2168 (0.0055)	0.2165 (0.0068)	0.2109 (0.0017)	0.2087 (0.0016)
3	0.3195 (0.0026)	0.3128 (0.0028)	0.3283 (0.0080)	0.3251 (0.0076)	0.3195 (0.0026)	0.3160 (0.0026)
4	0.4260 (0.0036)	0.4172 (0.0039)	0.4348 (0.0100)	0.4310 (0.0084)	0.4260 (0.0036)	0.4236 (0.0036)
5	0.5302 (0.0046)	0.5204 (0.0049)	0.5373 (0.0121)	0.5340 (0.0091)	0.5302 (0.0046)	0.5304 (0.0046)
6	0.6336 (0.0056)	0.6224 (0.0059)	0.6359 (0.0140)	0.6330 (0.0098)	0.6336 (0.0056)	0.6355 (0.0057)
7	0.7346 (0.0065)	0.7226 (0.0068)	0.7371 (0.0160)	0.7311 (0.0105)	0.7346 (0.0065)	0.7393 (0.0068)
8	0.8330 (0.0074)	0.8206 (0.0076)	0.8346 (0.0177)	0.8304 (0.0114)	0.8330 (0.0074)	0.8405 (0.0079)
9	0.9276 (0.0049)	0.9152 (0.0054)	0.9288 (0.0109)	0.9265 (0.0091)	0.9276 (0.0049)	0.9375 (0.0055)

B. Circa 1985						
Decile	**Australia**	**Canada**	**Germany**	**Sweden**	**UK**	**US**
1	0.1019 (0.0015)	0.1035 (0.0011)	0.1065 (0.0021)	0.1056 (0.0018)	0.1039 (0.0017)	0.1027 (0.0008)
2	0.2077 (0.0025)	0.2092 (0.0021)	0.2162 (0.0038)	0.2141 (0.0030)	0.2110 (0.0029)	0.2083 (0.0017)
3	0.3160 (0.0036)	0.3153 (0.0032)	0.3273 (0.0054)	0.3196 (0.0042)	0.3181 (0.0044)	0.3151 (0.0027)
4	0.4222 (0.0050)	0.4207 (0.0043)	0.4350 (0.0071)	0.4234 (0.0054)	0.4220 (0.0061)	0.4218 (0.0038)
5	0.5257 (0.0064)	0.5247 (0.0055)	0.5394 (0.0086)	0.5259 (0.0064)	0.5238 (0.0077)	0.5283 (0.0049)
6	0.6282 (0.0079)	0.6271 (0.0066)	0.6424 (0.0101)	0.6260 (0.0074)	0.6231 (0.0091)	0.6327 (0.0061)
7	0.7294 (0.0093)	0.7270 (0.0076)	0.7403 (0.0113)	0.7265 (0.0084)	0.7217 (0.0104)	0.7364 (0.0073)
8	0.8266 (0.0108)	0.8253 (0.0086)	0.8352 (0.0124)	0.8286 (0.0097)	0.8182 (0.0113)	0.8377 (0.0085)
9	0.9212 (0.0081)	0.9219 (0.0042)	0.9248 (0.0072)	0.9278 (0.0071)	0.9122 (0.0084)	0.9347 (0.0059)