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## THE RURAL / URBAN DIVIDE IS NOT CHANGING: INCOME DISPARITIES PERSIST

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### HIGHLIGHTS

- ◆ Sub-provincial territorial income disparity increased between 1992 and 1999; income divergence was associated with the economic expansion during the second half of the 1990s.
- ◆ The income disparity due to between-provinces disparity declined in relative terms, while within-provinces disparity became more important in explaining total territorial disparity.
- ◆ Provincial income disparity remained relevant, but income disparities shifted slowly but steadily from a provincial to a rural / urban divide. In consequence, a focus on provincial trends could overlook some of the emerging patterns of territorial disparity across Canada.
- ◆ Income is becoming increasingly concentrated in a small number of census divisions (CDs). Rural CDs, particularly rural northern and rural non-metro-adjacent CDs, represent a declining share of aggregate income, meaning they are becoming relatively smaller in aggregate terms.
- ◆ There are clusters of rich CDs whose relative income conditions further improved during the 1990s; these are typically core urban areas. In contrast, some clusters of low-income CDs, typically in peripheral areas, saw their income levels further deteriorate in relative terms. Some of these clusters cross provincial borders.

### Introduction

Reducing territorial<sup>1</sup> disparities is a policy priority for most OECD member countries. In Canada, there is an

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<sup>1</sup> "Territorial development" is the term used by the OECD to draw attention to the fact that economic development has sub-national or local dimensions. In this report, "territorial" refers to Canada's census divisions as sub-provincial units.

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abundant literature on the topic of regional disparity. However, most of this literature has addressed differences between provinces. The economy's ongoing movement from natural resource production to "new economy" activities increasingly exposed to a globally competitive environment has highlighted the importance of generating territorial-based, rather than provincially-based, policies (OECD, 2002). To date, few studies have used small geographic area data such as census division data and to our knowledge, no research has used annual time series data for small geographic units with a national coverage. It has also been recognized that in order to generate a broad understanding of territorial trends and patterns of spatial change, a wide range of measures and indicators should be employed (OECD, 2001).

This paper applies a broad set of disparity measures to sub-provincial income data in Canada. The data used in this research comes from income tax returns from 1992 to 1999, for about 280 census divisions covering the entire country. This approach provides an understanding of the spatial structure of income disparity with a high level of geographical resolution, which also highlights the evolution of the rural / urban divide. Nevertheless, the period of study is short, therefore, the results are particularly relevant to understand the spatial characteristics of the growth that occurred over the 1990s.

Three major dimensions of territorial disparity will be examined:

- *the disparity in per capita income across territorial units*

Changes in per capita income over time refer to the process of regional convergence / divergence. This addresses the question of whether the standard of living differential across areas increases or decreases over time;

- *the disparity in aggregate income across territorial units*

Changes in aggregate income over time refer to the process of concentration. This addresses the question of whether economic activities tend to locate in a restricted space; and

- *the persistence of disparity*

This dimension shifts the focus toward the performance of each individual territorial unit relative to national trends.

Each of these dimensions of disparity bears specific implications for territorial policies, and provides valuable information for policy design and analysis. While the analysis of per capita income indicators is important from an equity perspective, assessing the changes in the aggregate economic dimension of localities provides insights into potential development opportunities and options for each area. Increasing disparity in aggregate territorial dimensions might restrict territorial development options by reducing the regional size below the critical mass required to support local activities and basic services (health, education, transportation and municipal services). This, in turn, could reduce the opportunities for per capita income growth. Finally, besides having indicators about the behavior of the entire system, it is also important to know how likely *each* region is to improve its conditions, how many did so, and their characteristics. Analysis of the persistence of conditions, therefore, shifts the focus to the performance of the individual unit.

A comprehensive analysis of territorial disparity for policy purposes should take into account these various processes of spatial change. A full explanation of these three dimensions, as well as a comprehensive review of measures and indicators associated with them, will be presented in Alasia (2003 to follow).

## **Data and methods**

All the data used in this analysis are from the Neighbourhood Income and Demographics database of the Small Area and Administrative Data Division (SAAD), Statistics Canada. The data is derived from income tax returns and is updated annually. Details on the characteristics of the data are provided by Statistics Canada (2001), but it should be mentioned that in 1999, about 71 percent of Canadians filed tax returns and the coverage of income was over 90 percent. The analysis was done at the census division (CD) level. Of



The analysis applies a set of standard indices of dispersion, which include the coefficient of variation, the variance of logarithms, Theil's index and the Gini coefficient. These indices are used in their weighted and un-weighted formulation, where the weights refer to the share of the national population found within the CD. Trends in between and within group disparity are assessed by decomposing Theil's index. Details about the characteristics of these indices are presented in Alasia (2003, to follow). Appendix B shows the mathematical specification of these indices.

## **Economic context**

Any discussion of income disparity patterns should take account of the economic context in which the analysis is carried out. In the present case, 1993 was the last year of a severe economic recession. Between 1992 and 1993, the data used in the analysis indicate a decline of the average income of approximately 4 percent in real terms, for the country as a whole (see Appendix A). This recession particularly impacted the manufacturing and construction sectors (Rutherford, 1996) and as such it affected primarily eastern Canada and in particular, the region surrounding Toronto. The mid-1990s saw recovery followed by sustained growth until the end of the decade. Despite the economic slowdown in 1998, the average total income grew about 1.5 percent annually in real terms from 1994 to 1999.

### **Results 1. Convergence / divergence of average income**

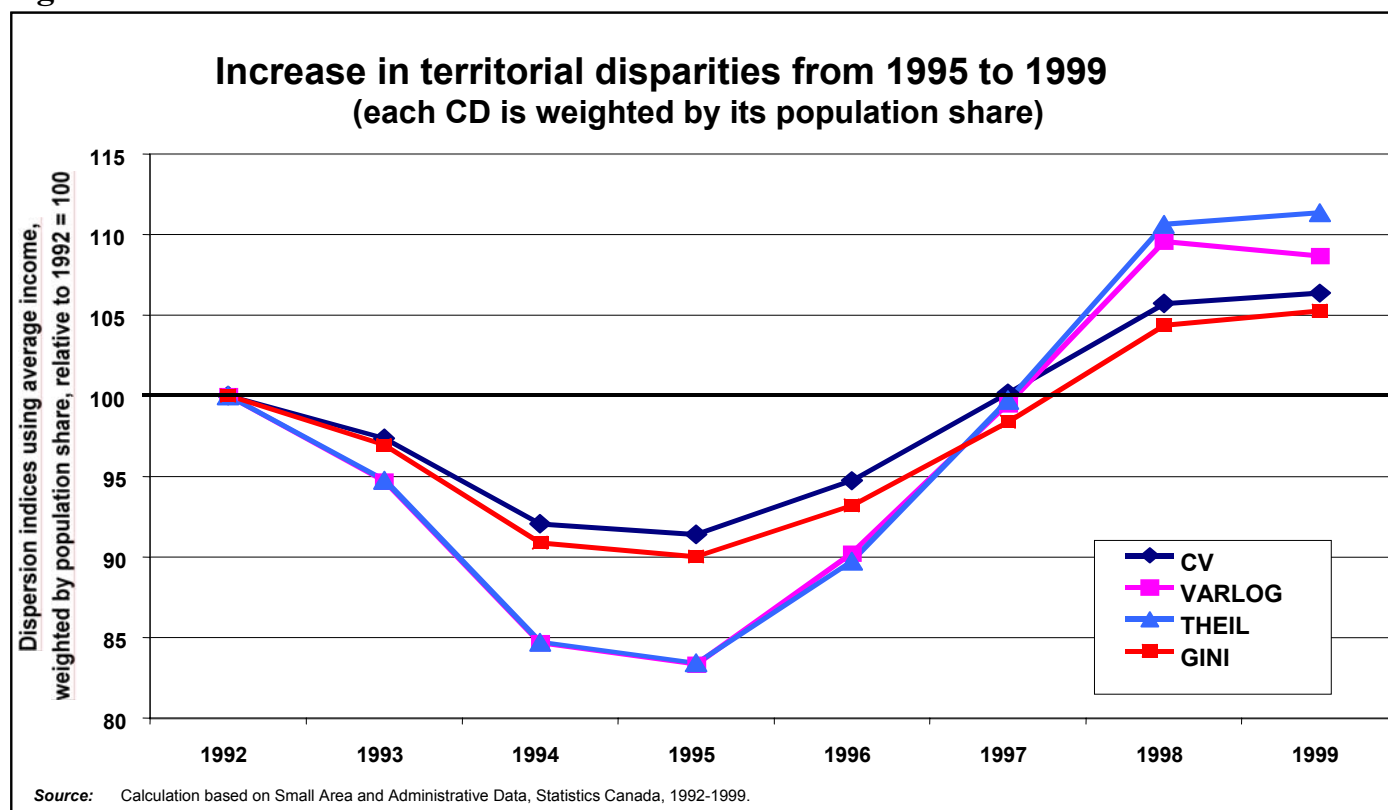
Figure 1 shows the weighted indices of dispersion of average income from 1992 to 1999. The deviation of each CD's average income from the national mean is weighted by the population share of that CD. The indices used are the coefficient of variation (CV), variance of the logarithms of income (VARLOG), and the Theil's and Gini coefficients. For ease of comparability, each series is normalized (1992 = 100). The slightly different trends between indices are due to the different sensitivity to changes in certain ranges of the income distribution. The actual values of the indices are in Appendix A.

A line trending down indicates less dispersion or less variability across census divisions and thus a convergence of average income across CDs. A line trending up indicates a divergence across CD average incomes. The weighted indices of dispersion of the average CD income capture the relevance of geography to personal income distribution. If the indices increase over time, it implies that location is becoming more relevant in capturing personal income disparity<sup>4</sup>. The results show territorial divergence over the reference period. However, the path tends to resemble the business cycle of the national economy. During the sharp recession of the early 1990s, the dispersion indices show a converging trend. This trend is reversed during the phase of economic expansion, particularly after 1995. By 1999, the indices of dispersion are higher than in 1992.

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<sup>4</sup> This would not necessarily imply, however, that personal income inequality had decreased or increased. This is because the computation is based on territorial *average* incomes, which do not provide any information on the personal income distribution (i.e. inequality) within each territorial unit.

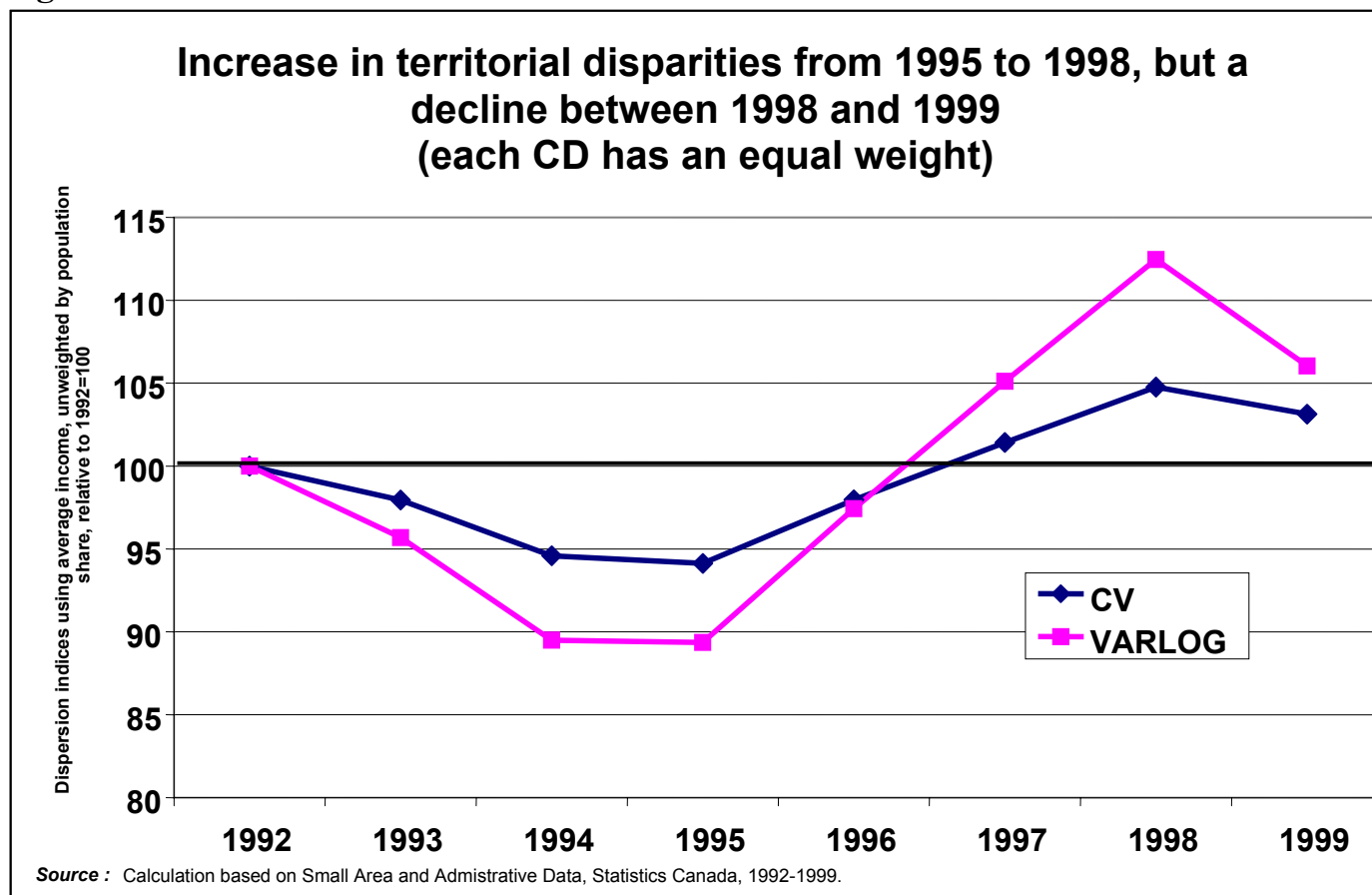
Figure 1



Similar analysis can be done using unweighted indices of dispersion. In this case, the deviation of the CD's average income from the national average is given the same weight regardless of the population of the CD. In this form, the index is not affected by changes in the relative population of each area, but only by changes in the dispersion of average income across CDs. This approach generates a more territorial-unit-focused understanding of change that can be important in assessing territorial disparity.

Figure 2 presents the trend of the unweighted indices of dispersion. In this case, only the coefficient of variation (CV) and variance of logarithms (VARLOG) are used. The trends are similar to those of the weighted measures; the disparity was higher in 1999 than in 1992 and the path tended to track the business cycle. However, between 1998 and 1999, the unweighted indices of dispersion record a reversal of the diverging trend that started in the mid-1990s. What happened between these years is that the average income of the more populous CDs grew more slowly than the less populous ones. Thus, dispersion indices that are not weighted for the population show this catch-up of the CDs with a smaller population.

Figure 2



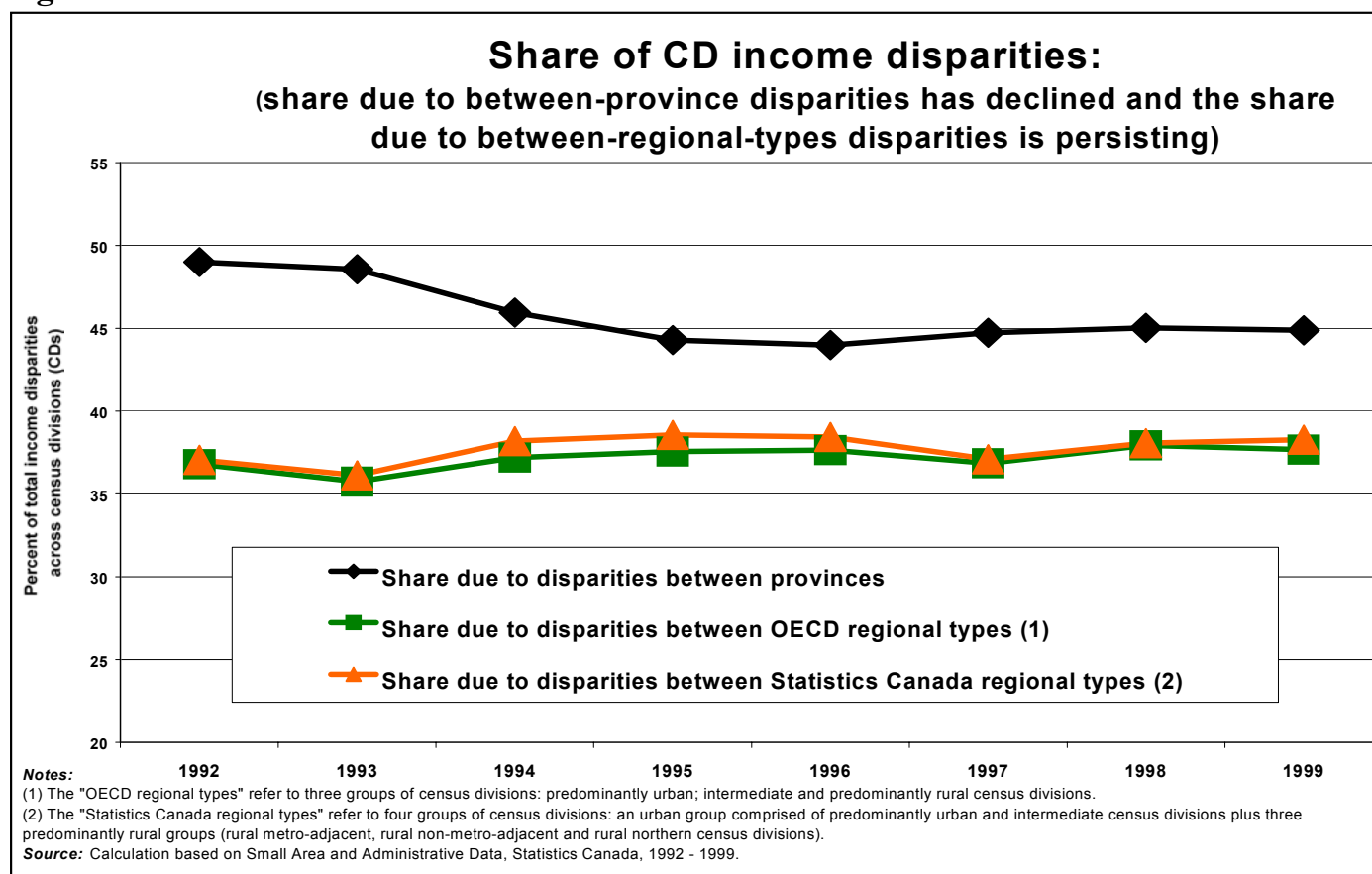
Theil's index possesses a property called decomposability. Once the CDs are placed into exhaustive and mutually exclusive groups, Theil's index can express the total disparity as the sum of between-group disparity and within-group disparity.

Figure 3 shows the results of a decomposition analysis using provincial and regional grouping of CDs.<sup>5</sup> The chart displays the share of the total income disparity across CDs that is due to the disparity between the designated groups (and the remaining disparity is due to the disparity across CDs within the designated groups). In other words, it shows the relative importance of disparities across groups relative to the importance of the disparities within groups<sup>6</sup>.

<sup>5</sup> For the analysis of Statistics Canada regional types, four groupings are used. The first group consists of predominantly urban and intermediate census divisions. Predominantly rural census divisions are grouped as rural metro-adjacent, rural non metro-adjacent, and rural northern census divisions.

<sup>6</sup> Since total disparity is the sum of between group and within group disparity, the share of within group disparity shows simply a reversed trend (Appendix A).

Figure 3



The income disparities between the 10 provinces represents about 45 percent of the total disparities across CDs (Figure 3). The income disparities between each of the four types of regions represents 36 to 38 percent of the total disparities across CDs.

The more important observation is that the share of total disparities due to inter-provincial disparities is decreasing, notably from 1993 to 1995, whereas the share of disparities across the rural / urban divide (as measured by the OECD regional types and the Statistics Canada regional types) has persisted throughout the 1990s.

The observation of an increase in disparities across CDs (from Figures 1 and 2) combined with the observation that the share of disparities due to differences across provinces is declining (from Figure 3) indicates that, within each province, CDs have become more heterogeneous over the period considered. Consequently, provincial-level per capita income comparisons capture a decreasing share of the total territorial income disparity. The persistence of disparities across OECD and Statistics Canada regional types means that relevance of the rural / urban divide is increasing, relatively. In summary, over the 1990s, the spatial income divide appears to have shifted, not dramatically but rather steadily, from an inter-provincial to a rural / urban divide.

The results suggest that the (macro) convergence among provinces in their per capita incomes was combined with a process of a (micro) divergence among sub-provincial territorial units, at least during the 1990s. Hence, a focus on provincial trends could overlook some of the emerging patterns of territorial disparity across Canada. If further confirmed, these results suggest that regional analysis requires a renewed



spatial perspective, which places a greater attention on the dynamics of smaller geographic units, rather than on a measure of per capita incomes at the provincial level.

## Results 2. Concentration of national aggregate income

In this section, the share of national aggregate income by different groupings of CDs is assessed. Changes in the aggregate income share of the larger CDs are compared with those in the smaller CDs to provide insights into the process of income concentration<sup>7</sup>.

Figure 4 displays the share of aggregate income captured by grouping the largest 5, 10, 20, 30, 50 and 100 CDs. During the first half of the 1990s, all these groupings showed a slight decrease of their relative share of aggregate income. Thus, smaller CDs gained, relatively. This trend was reversed during the second half of the decade. By 1999, income was more concentrated in a restricted number of large CDs. Each group's share of national aggregate income grew every year from the mid-1990s to the end of the decade, except for the grouping of the largest 5 CDs, whose share remained essentially flat between 1998 and 1999. However, these 5 CDs increased their aggregate income share by 2.8 percent over the eight years considered. The top 10 CDs gained about 3 percent, and the top 50 CDs almost 1.3 percent.

Figure 4

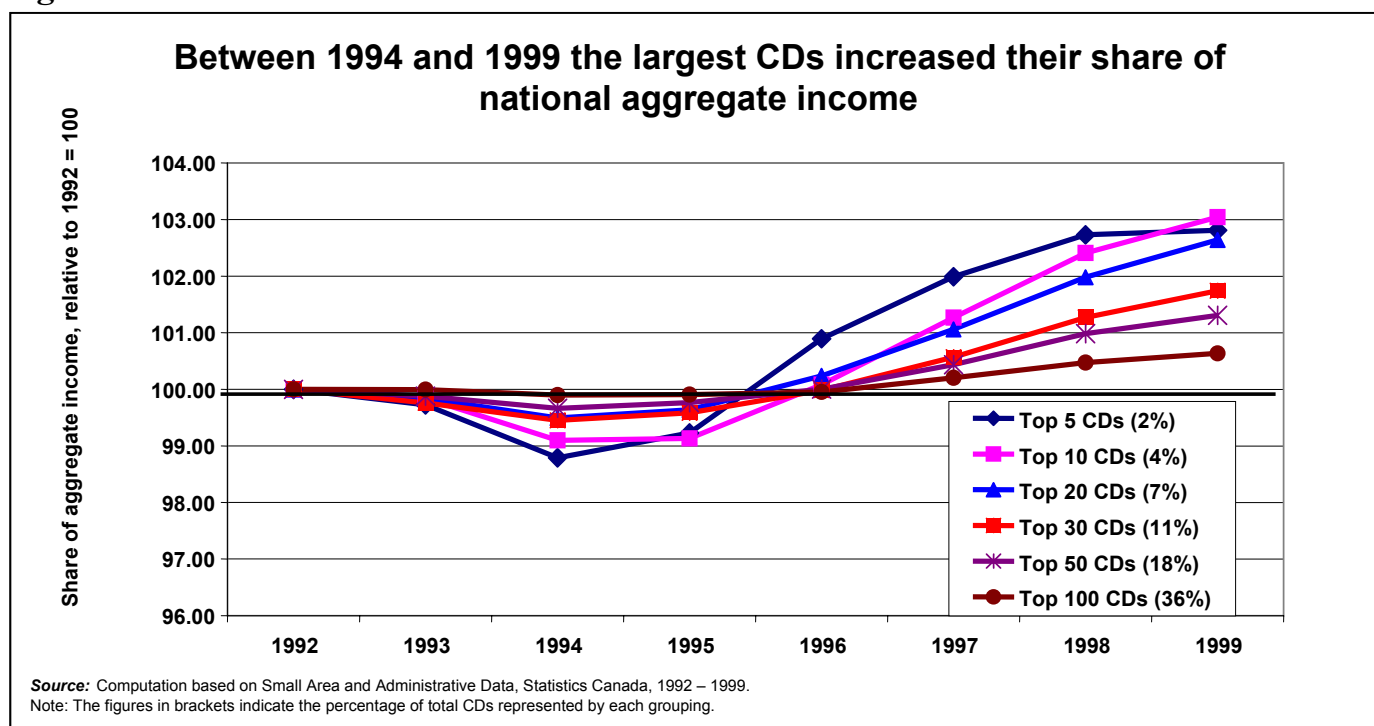
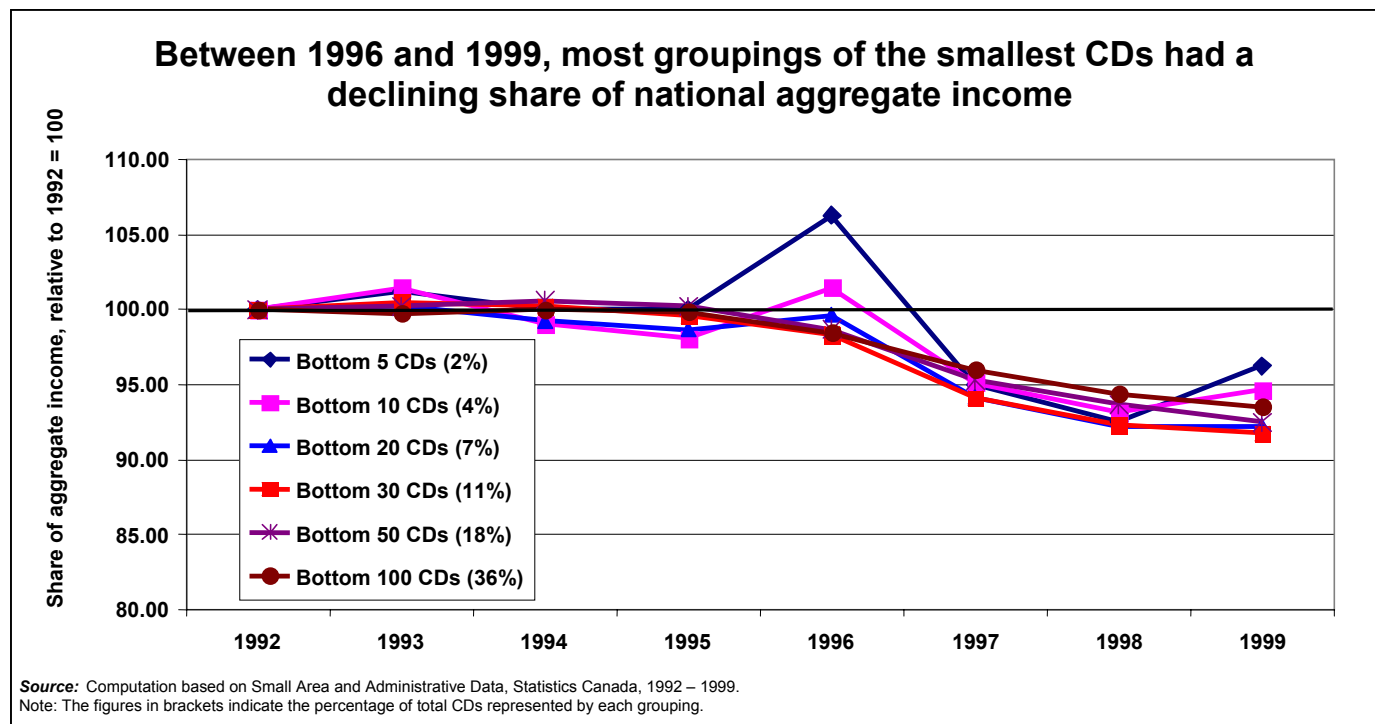


Figure 5 illustrates the evolution of the aggregate income shares of the smallest CDs. Six groupings are considered, which range from the 5 smallest CDs to the 100 smallest CDs in terms of aggregate income. As expected, the trends are the opposite of those seen for the largest CDs. Furthermore, the decline is almost continuous over the period considered except for those three groups encompassing the smallest 20 CDs, which show a more irregular trend. For some of these CDs, the aggregate economic decline is not only in

<sup>7</sup> As applied to CDs, small and large refers to national aggregate income and not to population size or geographical dimension.

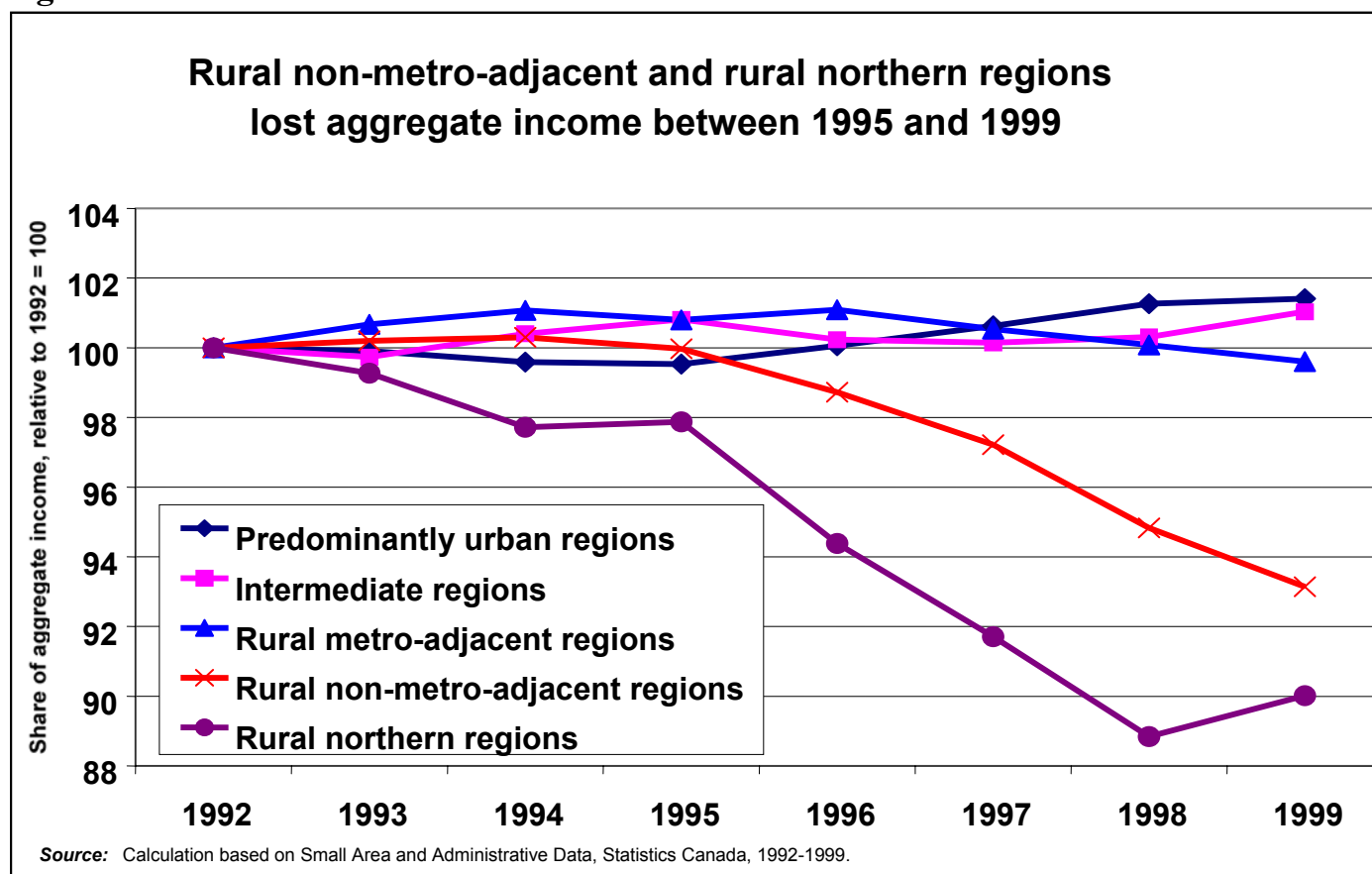
relative terms, but also in absolute terms. In any given year, approximately 15 percent of all CDs experienced an absolute decline in aggregate income size. It should be noted that these were not always the same CDs.

Figure 5



This process is also associated with the regional types. Figure 6 shows the trend of aggregate income share for the Statistics Canada regional types. For ease of comparison, the 1992 values are set to 100. The changes are not large in absolute terms but the trends, in relative terms, are quite clear. The national aggregate incomes of CDs that are in rural northern and rural non-metro-adjacent regions shrank in relative terms over the entire period, losing about 5 to 10 percent of their initial national aggregate income share. The share of aggregate income of CDs in predominantly urban, intermediate, and rural metro-adjacent regions remained essentially stable.

Figure 6



These results confirm the tendency toward economic concentration in Canada observed in other research. Moreover, the findings appear interesting for what they tell about the nature of economic growth over this period. Even in a decade marked by the rise of the “new economy”, which according to some is less dependent on location, the centripetal forces leading to economic concentration seem to have prevailed over the centrifugal forces that should have led to de-concentration. These results raise questions about the sustainability of economic activities and services based on the type of region and the possible effect of aggregate size on per-capita income indicators.

### Results 3. Persistence of disparity and regional clusters

The final dimension of disparity considered in this work shifts the focus onto the performance of the individual CDs rather than on regional income indicators. Map 1 provides a concise representation of the pattern of income levels and trends between 1992 and 1999 for each of the CDs. For this classification, the median CD income was used instead of the average income. First, two categories of income level were generated: CDs whose median income was above the national median income for six or more years out of the eight years considered and the CDs that had a median income below the national median for six or more years out of the eight years. Then, two trend categories were defined by fitting a trend line to the CD’s relative median income (relative to the national median). The slope coefficient of the time trend was used to classify the CDs into two groups. The group named “increasing” includes CDs with a trend slope that is

positive and greater than 0.2. The group named “decreasing” encompasses the CDs with a slope trend smaller than  $-0.2$ .

Combining these two classifications, four CD types were generated. The first type includes the CDs that are persistently below national median income and whose income is decreasing relative to the national level -- in other words, the poor that are getting poorer (dark red). At the opposite end are the CDs that are persistently above the median income -- whose median income is growing relative to the national level (dark green). These are the rich CDs that are getting richer. The two intermediate classes (light red and light green) are those that converged toward the national level -- CDs above the national medium income with decreasing relative income, and CDs below the national medium income with relative income that is increasing. The CDs that do not fall in one of these categories (those reporting fluctuating trends) are collapsed into the “mixed” group.

The patterns that emerge from the map suggest a considerable degree of spatial clustering of CDs with similar economic performances. Income trends are spatially dependent, and this is particularly obvious when small geographic units are considered. There also appears to be some evidence of diverging trends between clusters of CDs.

The map indicates the location, typically peripheral, of pockets of persistently poor CDs that are getting relatively poorer over time. These CD clusters are found in the Atlantic provinces, particularly in Newfoundland and Labrador, northern New Brunswick, northern Manitoba, and southern British Columbia. Other clusters of CDs present the opposite characteristics; they have median income persistently above the national level and are moving further above the median. Thus, these are rich CDs that are getting richer over time. Their location is typically close to urban cores. However, they do not always include the urban core itself and often extend far beyond it. Clusters of these CDs are found around Montreal, in southwestern Ontario, around Winnipeg, and the census divisions of Regina and Calgary. It is also interesting to notice that several of these clusters transcend provincial boundaries thereby providing a different regional perspective on the nature of income disparities.

## **Conclusions and implications for further research**

The analysis shows the variety of spatial processes associated with income disparity trends. Because these spatial processes are to some degree independent from each other, assessing territorial disparities for policy purposes requires a broad set of measures, each providing information on a specific dimension of disparity. In combination, these will provide a more comprehensive set of results on which to base policy analysis.

The findings in this paper represent a first exploration of sub-provincial income disparities in Canada. The short period of time considered in the study is problematic. In particular, this short time frame makes it difficult to discern whether the patterns observed are due to longer-term trends in the economy or to shorter-term, cyclical fluctuations. Lengthening the time frame would be of particular value in future research. Nevertheless, the analysis produced some noteworthy results:

- Between 1992 and 1999, the share of territorial income disparity in Canada increased. The convergence / divergence path that was observed followed the national business cycle.

- The share of income disparity due to between-province disparity decreased over the 1990s, while within-province disparity increased substantially. In other words, the average provincial income is less relevant in explaining the increasing spatial disparity. In contrast, the disparities between OECD regional types and between Statistics Canada regional types became more important. Although the changes are not dramatic, and despite still-sizeable provincial differences, the geography of income disparities is shifting slowly but steadily from a provincial to a rural / urban divide.
- An increasing share of aggregate income is concentrated in a small number of CDs. After a slight decrease at the beginning of the 1990s, the share of income in the largest CDs increased steadily from 1995 onward. Furthermore, the income share of the smallest CDs declined almost steadily from 1992 to 1999.
- An assessment of persistence of conditions suggests a relative stability of conditions, which is not surprising given the short period of time considered. However, clusters can be identified of persistently low-income CDs in marginal and northern areas whose relative economic position tends to further deteriorate through time. In contrast, clusters of rich CDs can be found in core urban regions whose relative economic position is improving still more.

Alessandro Alasia is a post-doctoral research fellow with the Research and Rural Data Section, Agriculture Division, Statistics Canada. Neil Rothwell is an analyst in the same section.

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## Appendices

### Appendix A

**Table 1. Summary table of measures and statistics**

| Index/ indicator  | 1992   | 1993   | 1994   | 1995   | 1996   | 1997   | 1998   | 1999   |
|---|--------|--------|--------|--------|--------|--------|--------|--------|
| Average income (\$1995)                                       | 25,800 | 25,000 | 25,600 | 25,800 | 25,900 | 26,200 | 26,900 | 27,300 |
| Weighted indices of dispersion of average income <sup>1</sup> |        |        |        |        |        |        |        |        |
| Coefficient of variation                                      | 15.00  | 14.60  | 13.81  | 13.71  | 14.21  | 15.02  | 15.86  | 15.96  |
| Variance of logarithm   | 0.47   | 0.44   | 0.39   | 0.39   | 0.42   | 0.46   | 0.51   | 0.51   |
| Gini coefficient  | 8.45   | 8.19   | 7.68   | 7.61   | 7.87   | 8.31   | 8.82   | 8.89   |
| Theil's index (total)   | 0.50   | 0.47   | 0.42   | 0.42   | 0.45   | 0.50   | 0.55   | 0.56   |
| Unweighted indices of average income <sup>1</sup>             |        |        |        |        |        |        |        |        |
| Coefficient of variation                                      | 20.31  | 19.89  | 19.21  | 19.12  | 19.90  | 20.60  | 21.28  | 20.95  |
| Variance of logarithm   | 1.08   | 1.03   | 0.97   | 0.96   | 1.05   | 1.13   | 1.21   | 1.14   |
| Theil decomposition <sup>1</sup> (average income)             |        |        |        |        |        |        |        |        |
| Between provinces   | 0.24   | 0.23   | 0.19   | 0.18   | 0.20   | 0.22   | 0.25   | 0.25   |
| Within provinces  | 0.25   | 0.24   | 0.23   | 0.23   | 0.25   | 0.28   | 0.30   | 0.31   |
| Between as % of total   | 49.00  | 48.56  | 45.95  | 44.29  | 43.98  | 44.72  | 45.03  | 44.87  |
| Within as % of total  | 51.00  | 51.44  | 54.05  | 55.71  | 56.02  | 55.28  | 54.97  | 55.13  |
| Between OECD types <sup>2</sup>                               | 0.18   | 0.17   | 0.16   | 0.16   | 0.17   | 0.18   | 0.21   | 0.21   |
| Within OECD types   | 0.32   | 0.30   | 0.27   | 0.26   | 0.28   | 0.31   | 0.34   | 0.35   |
| Between as % of total   | 36.79  | 35.74  | 37.19  | 37.56  | 37.64  | 36.85  | 37.93  | 37.67  |
| Within as % of total  | 63.21  | 64.26  | 62.81  | 62.44  | 62.36  | 63.15  | 62.07  | 62.33  |
| Between StatCan types <sup>2</sup>                            | 0.18   | 0.17   | 0.16   | 0.16   | 0.17   | 0.18   | 0.21   | 0.21   |
| Within StatCan types  | 0.31   | 0.30   | 0.26   | 0.26   | 0.28   | 0.31   | 0.34   | 0.34   |
| Between as % of total   | 37.06  | 36.13  | 38.19  | 38.56  | 38.44  | 37.10  | 38.07  | 38.28  |
| Within as % of total  | 62.94  | 63.87  | 61.81  | 61.44  | 61.56  | 62.90  | 61.93  | 61.72  |
| Concentration: Percent aggregate income of:                   |        |        |        |        |        |        |        |        |
| Top 5 CDs   | 29.45  | 29.37  | 29.09  | 29.22  | 29.71  | 30.03  | 30.25  | 30.27  |
| Top 10 CDs  | 42.43  | 42.37  | 42.05  | 42.06  | 42.47  | 42.97  | 43.46  | 43.72  |
| Top 20 CDs  | 57.03  | 56.93  | 56.74  | 56.82  | 57.16  | 57.63  | 58.16  | 58.53  |
| Top 30 CDs  | 64.82  | 64.66  | 64.46  | 64.55  | 64.81  | 65.19  | 65.64  | 65.95  |
| Top 50 CDs  | 73.31  | 73.22  | 73.06  | 73.13  | 73.31  | 73.62  | 74.03  | 74.26  |
| Top 100 CDs   | 85.94  | 85.94  | 85.85  | 85.86  | 85.90  | 86.12  | 86.35  | 86.49  |
| Bottom 5 CDs  | 0.08   | 0.08   | 0.08   | 0.08   | 0.09   | 0.08   | 0.07   | 0.08   |
| Bottom 10 CDs   | 0.21   | 0.21   | 0.20   | 0.20   | 0.21   | 0.20   | 0.19   | 0.19   |
| Bottom 20 CDs   | 0.52   | 0.52   | 0.51   | 0.51   | 0.51   | 0.49   | 0.48   | 0.48   |
| Bottom 30 CDs   | 0.90   | 0.90   | 0.90   | 0.89   | 0.88   | 0.85   | 0.83   | 0.82   |
| Bottom 50 CDs   | 1.86   | 1.86   | 1.87   | 1.86   | 1.83   | 1.77   | 1.74   | 1.72   |
| Bottom 100 CDs  | 5.05   | 5.03   | 5.05   | 5.04   | 4.97   | 4.85   | 4.76   | 4.72   |

## Appendix A (continued)

**Table 1. Summary table of measures and statistics (continued)**

| Index/ indicator   | 1992  | 1993  | 1994  | 1995  | 1996  | 1997  | 1998  | 1999  |
|--|-------|-------|-------|-------|-------|-------|-------|-------|
| Concentration: Percent aggregate income by CD regional types |       |       |       |       |       |       |       |       |
| Urban  | 53.46 | 53.41 | 53.24 | 53.21 | 53.50 | 53.80 | 54.13 | 54.22 |
| Intermediate   | 20.10 | 20.05 | 20.18 | 20.26 | 20.15 | 20.13 | 20.16 | 20.31 |
| Rural metro-adjacent   | 14.00 | 14.09 | 14.15 | 14.13 | 14.15 | 14.08 | 14.01 | 13.94 |
| Rural non-metro-adjacent                                     | 10.75 | 10.77 | 10.78 | 10.75 | 10.61 | 10.45 | 10.20 | 10.01 |
| Rural northern   | 1.69  | 1.67  | 1.65  | 1.65  | 1.59  | 1.55  | 1.50  | 1.52  |

**Notes:**

- (1) the original values of the indices are multiplied by 100 for convenience of display.
- (2) The “OECD regional types” refer to three groups of census divisions: predominantly urban; intermediate; and predominantly rural census divisions. The “Statistics Canada regional types” refer to four groups of census divisions: an urban group comprised of predominantly urban and intermediate census divisions plus three predominantly rural groups (rural metro-adjacent, rural non-metro-adjacent and rural northern census divisions).
- (3) 278 census divisions were used in the analysis.

**Source:** all figures are the authors’ calculations based on data provided by Statistic Canada’s SAAD Division.

## Appendix B

### Specification of Indices

For all the equations,  $y$  indicates the average per capita income,  $Y$  the aggregate income,  $Pop$  the population,  $i$  the subscript for the  $i^{\text{th}}$  territorial unit, and  $r$  the  $r^{\text{th}}$  aggregate of territorial units (e.g. a province). The superscript ‘\*’ indicates national values, the superscript ‘ $^{cs}$ ’ indicates cumulative shares, and the subscripts “bg” indicates “between-group” and “wg” indicates “within-group”.

Coefficient of variation, weighted (CV<sub>w</sub>) and unweighted (CV<sub>u</sub>)

$$CV_w = \frac{\sqrt{\sum_{i=1}^N \frac{Pop_i}{Pop^*} (y_i - y^*)^2}}{y^*} \qquad CV_u = \frac{\sqrt{\sum_{i=1}^N \frac{1}{N} (y_i - y^*)^2}}{y^*}$$

Variance of logarithms, weighted (VL<sub>w</sub>) and unweighted (VL<sub>u</sub>)

$$VL_w = \sum_{i=1}^N \frac{Pop_i}{Pop^*} \cdot \left( \log \frac{y_i}{y^*} \right)^2 \qquad VL_u = \sum_{i=1}^N \frac{1}{N} \cdot \left( \log \frac{y_i}{y^*} \right)^2$$

**Gini coefficient**

$$GINI = 1 - \sum_{i=1}^N \left[ (y_i^{cs} + y_{i-1}^{cs}) \cdot (Pop_i^{cs} - Pop_{i-1}^{cs}) \right]$$

**Theil’s index**

$$T_{tot} = \sum_{i=1}^N \frac{Y_i}{Y^*} \log \left( \frac{Y_i/Y^*}{Pop_i/Pop^*} \right)$$

**Decomposition of Theil’s index**

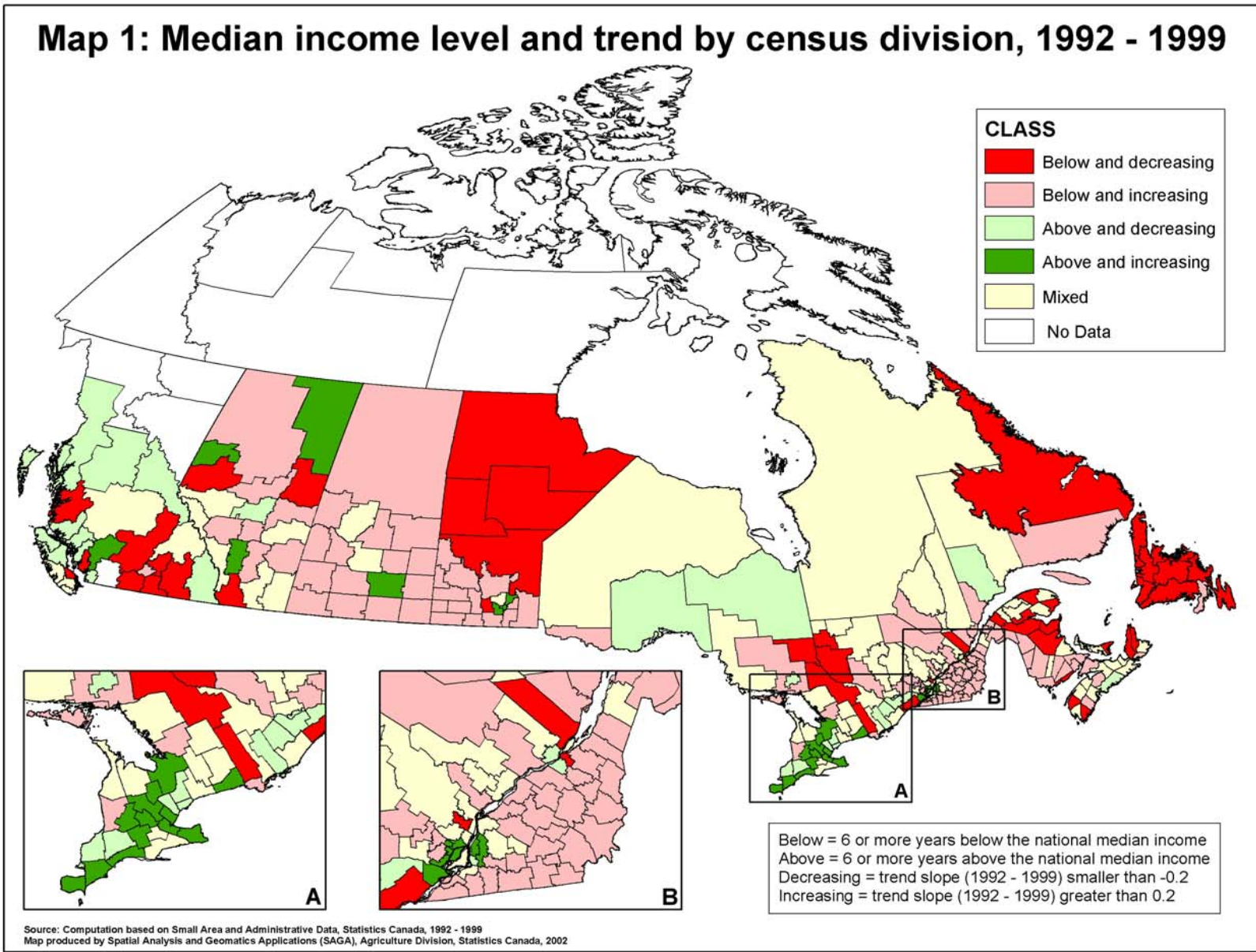
$$T_{tot} = T_{bg} + T_{wg}$$

$$T_{bg} = \sum_r \frac{Y_r}{Y^*} \log \frac{Y_r/Y^*}{Pop_r/Pop^*}$$

$$T_{wg} = \sum_r \frac{Y_r}{Y^*} \left[ \sum_{i \in r} \frac{Y_i}{Y_r} \log \frac{Y_i/Y_r}{Pop_i/Pop_r} \right]$$



Appendix C



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