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LONG-RUN PERSPECTIVE ON CANADIAN REGIONAL CONVERGENCE

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LONG-RUN PERSPECTIVE ON CANADIAN REGIONAL CONVERGENCE

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EXECUTIVE SUMMARY

There have been many empirical studies analyzing convergence across OECD countries and regions since the late 1980s. Until the 1990s, the general view on the persistence of large regional economic disparities in Canada was somewhat pessimistic. Many empirical studies on Canadian regional disparities have recently emerged and have somewhat altered the conventional wisdom regarding the persistence of regional disparities in Canada. This paper looks at the evolution of regional disparities in income/output per capita in Canada over a long period in light of recent studies on convergence. The authors analyze regional convergence in Canada by estimating β-convergence and testing stationarity of σ-convergence over the 1926-1994 period. The analysis shows, on average, a pattern of convergence across Canadian provinces since 1926, but the process by which poor regions catch up to rich ones is not a smooth, transitional dynamic one, hindered sporadically by white noise random shocks. There is no evidence of σ-convergence for the nine provinces prior to the entry of Newfoundland into Confederation in 1949; furthermore, most of the σ-convergence detected appears to have occurred during the 1950-1977 period.

1. REGIONAL DISPARITIES AND CONVERGENCE

The issue of the presence and persistence of regional disparities in income and output per capita in Canada has been documented in a large number of studies.[1] This phenomenon can be attributed to many factors including, but not restricted to: unequal endowment of natural resources, uneven distribution of skilled workers, lack of labour and capital mobility, and government policies. However, looking at this issue from a historical perspective, it should not come as a surprise to find regional economic disparities in a vast and diverse country such as Canada which, no more than a hundred years ago, was still in a phase of territorial expansion and settlement. Canada began to shape itself as a modern economy only after World War II. But even in the late 20th century, most of the landmass is still sparsely inhabited and the population is concentrated along the southern border with the US. The industrial structure is not spread out evenly across regions: an industrial core has developed in the Great-Lakes-Saint-Lawrence area, but economic activity in the remaining territory is largely oriented towards the exploitation of various natural resources.

Given the size and industrial structure of the country, the issue of regional disparities has, rightly or wrongly, occupied the political agenda since Confederation, but it has been even more prominent since World War II, with the advent of interregional income redistribution and regional development programs. The growing federal debt over the last two decades and the increased threat of Quebec secession following the tight outcome of the 1995 referendum have, more than ever, put the question of the sustainability and the desirability of large interregional transfers squarely among the key issues on the public-policy agenda.

Until the early 1980s, the general view on the persistence of large regional economic disparities in Canada was somewhat pessimistic. For example, Williamson (1965) found that Canada had the highest level of relative regional disparities among a group of highly developed countries. According to Marr and Paterson (1985), large differences in per-capita income among the provinces have prevailed since at least the end of the 1800s, which has led them to argue that "there has been no significant tendency for regional income differences to disappear" (p. 423). Furthermore, Mansell and Copithorne (1985, p. 1) have concluded that "the situation today is not significantly different from that of the period immediately following World War II."

Many empirical studies on Canadian regional disparities published in the 1990s have somewhat altered the conventional wisdom regarding the persistence of regional disparities in Canada. These studies follow from the controversy surrounding cross-country and cross-region convergence of per capita output.[2] A few comments on this issue would be helpful in setting the recently published results in perspective. Conditional convergence is a key prediction of the neoclassical growth models of Solow (1956) and Phelps (1966). It is only recently, following the construction of new data sets on income per capita for a broad sample of countries over a long period of time (more than a hundred years) by Maddison (1982) and Summers and Heston (1991), that the empirical hypothesis of convergence has been tested extensively. Baumol (1986) shows evidence of convergence in per capita income/output among developed countries. Lee (forthcoming) argues that the convergence pattern disappears when the analysis is confined to the last two decades. Nevertheless, many of these studies, including that of Abramovitz (1988), suggest that convergence among developed countries is a post-World War II phenomenon. On the other hand, Taylor and Williamson (1994), Williamson (1992, 1995), and Williamson, O'Rourke and Hatton (1993) have documented convergence among many OECD countries during the 1870-1913 period.[3] They observed that convergence came to a halt between 1914 and 1945 (two world wars having disrupted commodity and factor markets), but resumed its course after World War II. Thus, their studies highlight the importance of looking back into history to gain an understanding of the present situation.

The convergence hypothesis is easily rejected in studies that focus on the evolution of per capita incomes in a large number of countries, and these findings have been interpreted as supporting the new endogenous growth models of the 1980s (Romer, 1994). With the work of Barro and Sala-i-Martin (1991, 1992), the convergence controversy has been extended to the question of cross-country versus intra-country (regional) growth patterns. They show that convergence among regional units of the United States, Japan and Western European countries has typically proceeded since World War II at approximately the same speed as that observed among OECD countries. The key question raised by this wider perspective is whether increased trade, and economic and political integration, are likely to favour convergence of output per capita across economic units.

The convergence of per capita GDP and income, and factor productivity, among Canadian provinces in the post-1961 period is now well established. The robustness of this result was demonstrated with the use of cross-section analyses by Helliwell and Chung (1991) and Helliwell (1994), a time-series approach by Lefebvre (1994), and a pooled times series/cross-section approach by Coulombe and Lee (1993, 1995) and Lee and Coulombe (1995). However, Coulombe and Lee (1993) suggest that convergence is less clear for the 1926-1939 period. Helliwell (1994) argues that there is no difference in the rate of convergence between the 1920-1960 and the 1960-1990 periods.

In this paper, we attempt to analyze the evolution of regional disparities in income/output per capita in Canada over a long time span in light of past studies on convergence. This exercise serves two purposes. First, we try to explain the apparent contradiction between the convergence results arising from recent work and the pessimistic view that prevailed in the early 1980s. Does the contradiction follow from the improvement of statistical techniques used in recent studies or from the historical record? If a measure of regional disparities has shown a clear tendency to decrease over the long-run, these disparities may continue to decline in the future. While an analysis of this nature could be misleading, its results may serve to motivate a more detailed analysis on convergence. Second, the evolution of regional disparity patterns can provide a hint about the appropriate theoretical framework for understanding regional growth trends in Canada.

The standard neo-classical growth theory predicts a smooth convergence of regional per capita output, based on the assumptions that regions of a country are relatively similar with respect to technology and preferences, and that policies do not differ significantly across them. In a stochastic framework, the long-run value of the dispersion index (for example, the standard deviation of the log of per capita income) is determined by the variance of random shocks and by the speed of convergence, β.[4] Starting from a situation where the dispersion of income is greater than its steady-state value, the measure of dispersion will decrease at a smooth rate, determined by the speed of convergence, β, approaching monotonically its steady-state value. Alternative theories predict other scenarios of evolution of regional disparities. For instance, nearly anything can happen in an endogenous growth framework, where large interregional trade flows and factor mobility do not necessarily imply convergence of output/income per capita.[5]

A clear pattern of evolution of regional disparities – an inverted U – was predicted by Williamson's (1965) theory of development phases, one of the dominant model in regional studies in the 1970s and early 1980s. According to this theory, during the first stage of development, in the transition to an industrial economy, regional disparities widen. They remain stable at a high level during a second stage that can last for a considerable time, depending on the speed of adjustment of the population across regions and on the strength of market forces. In the third stage, as the country matures, regional disparities in income per capita follow a steady decreasing trend toward their long-run value. The theory is a spatial extension of Kuznets' (1955) analysis of the evolution of income inequality across households in an economy. Williamson's hypothesis was tested for Canada in Green (1969, 1971). Using estimates of per capita gross value added for the years 1890, 1910, 1929 and 1956, Green found that regional disparities were stable from 1890 to 1910, increased between 1910 and 1929, and decreased slightly during the period 1929-1956. However, McInnis (1968) has shown that regional disparities actually decreased between 1910 and 1920. Our own work indicates that an analysis based on a limited number of observations, such as those of Green and McInnis, should be interpreted carefully, given the importance of stochastic shocks and structural breaks. More extensive data are needed to identify a precise pattern.

Our analysis focuses on the evolution of annual time series for four different measures of provincial per capita income in Canada since 1926. Two concepts of convergence are used to evaluate the patterns of regional disparities. The speed of convergence (β-convergence), a concept widely used in empirical studies, is estimated for different sub-periods. Using stationary tests, we also analyse whether the dispersion of per capita income shows a tendency to decrease (σ-convergence). Our main conclusion is that the null hypothesis of no convergence prior to 1950 cannot be rejected based on the analysis of σ- and β-convergence. However, there has been a steady trend towards convergence in Canada since 1950. Furthermore, had it not been for taxes and transfers, regional disparities may have reached their steady state (no σ-convergence) since 1977.

The remainder of the paper is organized as follows. The two concepts of convergence, β and σ, are explained in Section 2, while the data set is presented in Section 3. Tests for the stationarity of dispersion indexes (σ-convergence) are presented in Section 4, and the speed of convergence of alternative per capita economic indicators is estimated in Section 5. Finally, our results are analysed in a historical context in Section 6.

2. TWO CONCEPTS OF CONVERGENCE

The speed of convergence (β) and the evolution of dispersion (σ) are two concepts that have been widely used in recent empirical studies on growth.

The concept of β-convergence refers to the speed at which the income/output per capita of a poor region approaches the level of a rich one. β-convergence would be observed if, in a cross-section data set, economic units that are initially poor tend to grow faster than rich ones. If the β coefficient is estimated without taking into account the characteristics that determine the steady state of the economy – such as the savings rate, technology and institutions –, it is then referred to as *absolute convergence*. The *conditional convergence* hypothesis, on the other hand, refers to cases where differences in steady states are contemplated. For example, two economies might have different savings rate, reflecting differences in rates of time preference. In this case, the standard neo-classical framework predicts that the two economies will enjoy the same steady-state growth rate, but the one with a higher savings rate will have a higher steady-state income per capita. In this context, the conditional convergence concept refers to the hypothesis that the economy initially further away from its own steady state will grow faster. The absolute convergence hypothesis is usually tested for homogeneous groups of economies such as OECD countries, US states, or Canadian provinces, where characteristics such as preferences and institutions are relatively similar.

The coefficient for absolute β-convergence is estimated using a non-linear regression of cross-sectional data of the following form:[6]

$$\frac{1}{T-t} \bullet \ln\left(\frac{Y_{iT}}{Y_{it}}\right) = B - \left(\frac{1-e^{-\beta(T-t)}}{T-t}\right) \bullet \ln Y_{it} + u_i \qquad (1)$$

where T and t are the final and initial years of the study period, respectively, and i is an economic unit. Y is the per capita economic indicator (e. g., income, output or factor productivity) and u is an error term. Therefore, the left-hand side is an approximation of the average annual growth of the economic unit i between times t and T. B is, in absolute convergence analysis, a constant term across economic units. It is determined by the steady-state value of growth patterns of economic indicators. The coefficient $(1 - e^{-\beta(T-t)})/(T-t)$ captures the part of growth that can be explained by the initial level of the economic indicator. The gap between different economic units declines exponentially at the speed of β from t=0 to T, as t approaches infinity. Convergence, corresponding to a positive β coefficient, implies a negative relationship between the average growth rate during the period under study and the log of the initial level of the per capita economic indicator. The higher the value of β, the faster the per capita economic indicator in the poor region converges toward the level of the rich one.

The second concept of convergence – σ-convergence – is based on time series analysis and focuses on the evolution of a dispersion index of a per capita economic indicator. The dispersion index can be measured in several ways. We chose the standard deviation of the log of per capita income, as in Barro and Sala-i-Martin (1991, 1992).

According to Barro and Sala-i-Martin (1995, p. 31), σ-convergence would be observed if "... the dispersion of real per capita income across a group of economies tends to fall over time." Such a general definition allows a number of different interpretations, from both theoretical and empirical standpoints, linked to the statistical characteristics of an eventual decreasing trend.[7] In our analysis of the evolution of regional disparities in Canada since 1926, the most intricate problem is related to structural breaks present in time series. What happens to the concept of σ-convergence if shocks on output persist into the indefinite future? As has been shown in a general framework by Perron (1989), the presence of a unit root in a time series indicates that the series is trend-stationary and contains a small number of stuctural breaks, or that the true data generating process is characterized by a random walk. The two alternative models generate data with identical asymptotic statistical properties. In practical terms, σ-convergence will be observed in our analysis if the time series of the dispersion index is integrated of order one and shows a negative drift (stochastic trend), or follows a decreasing trend-stationary process.

As discussed in Barro and Sala-i-Martin (1995, section 11.1), the two concepts of convergence, β and σ, are interrelated. The catch-up process (β-convergence) works to reduce cross-sectional dispersion in per capita income (σ-convergence) or in output, but exogenous disturbances in relative growth rates tend to increase dispersion.

3. THE DATA

β- and σ-convergence analyses have been performed on time series of four concepts of national income for all Canadian provinces. Annual data are available from Statistics Canada from 1926. The four concepts of per capita income are presented, along with their definitions, in Table 1.

The ratio of per capita personal income of each Canadian province to the average per capita income for the ten provinces has been computed. The ten time series are presented in Figures 1, 2 and 3 to illustrate the relative evolution of the provinces' per capita income over the period studied.[8] Per capita income for Canada is depicted in Figure 4. The time series for Newfoundland starts in 1949, the year in which that province joined the Canadian Confederation.

Table 1

National Income Concepts

PI	Personal income per capita
PIT	Personal income minus government transfers per capita
PDI	Personal disposable income per capita = PI – Personal direct taxes
EI	Earned income per capita = PIT – Net interest earnings – Dividends

Figure 1
Relative Personal Income per Capita, Atlantic Provinces, 1926-94

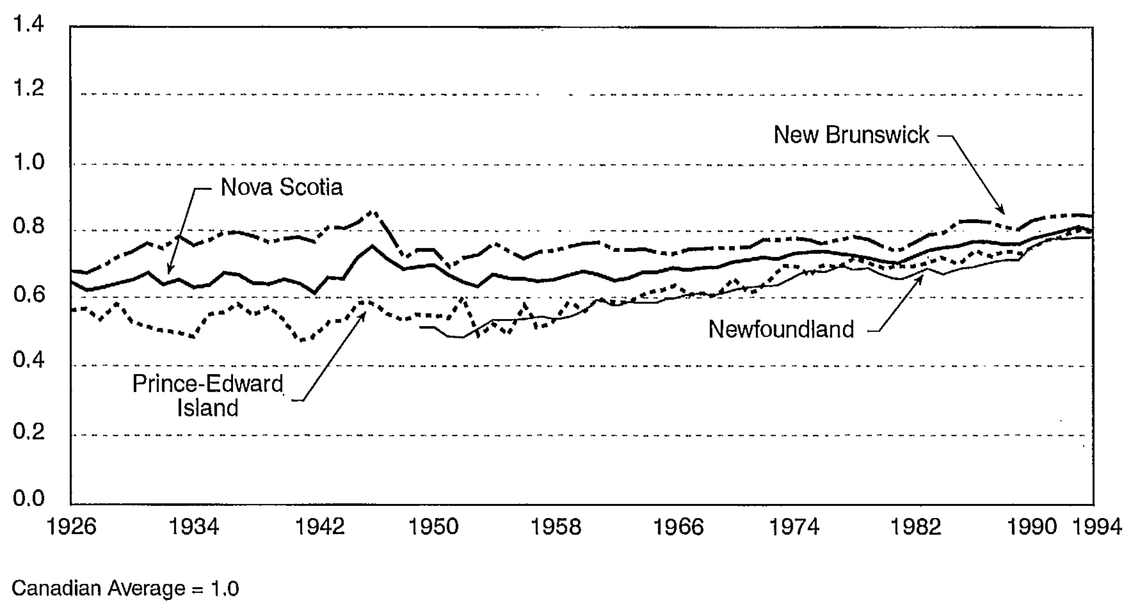


Figure 2
Relative Personal Income per Capita, Ontario and Quebec, 1926-94

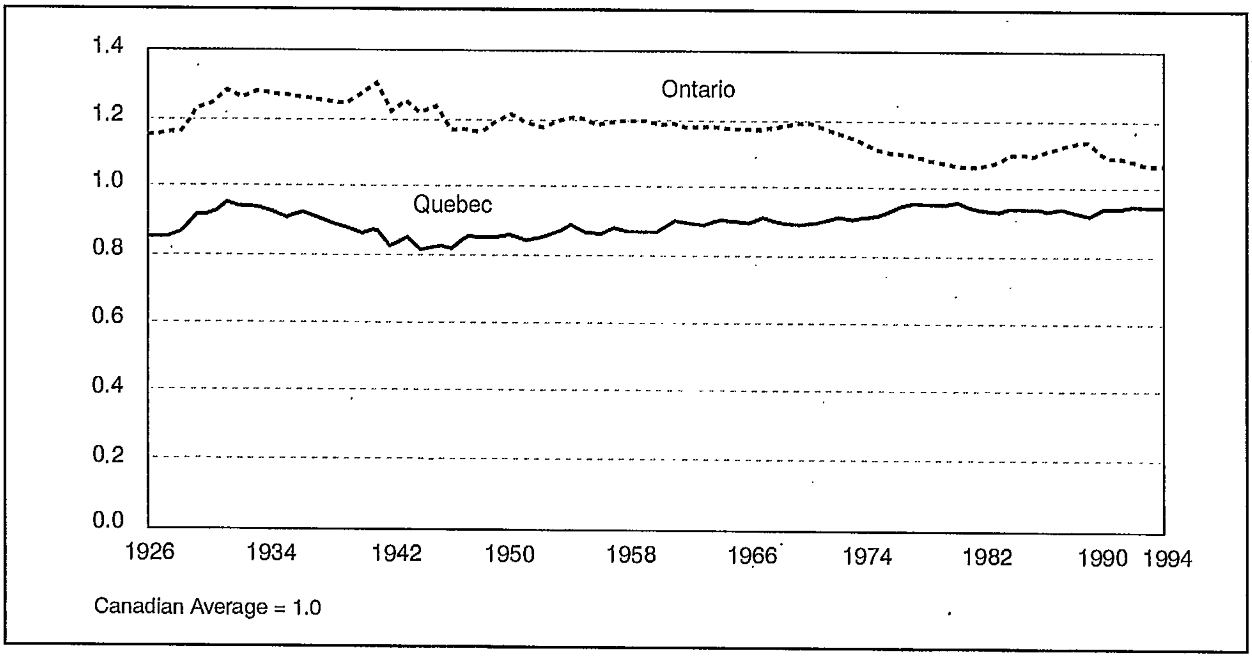


Figure 3
Relative Personal Income per Capita, Prairie Provinces and British Columbia, 1926-94

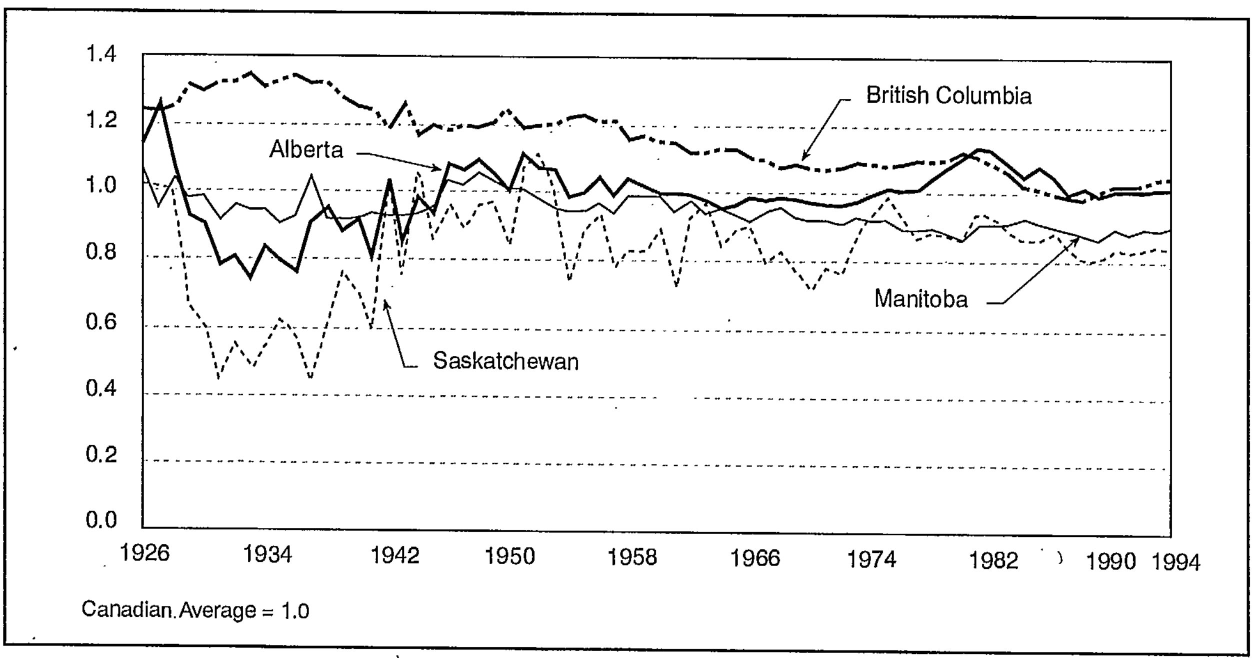
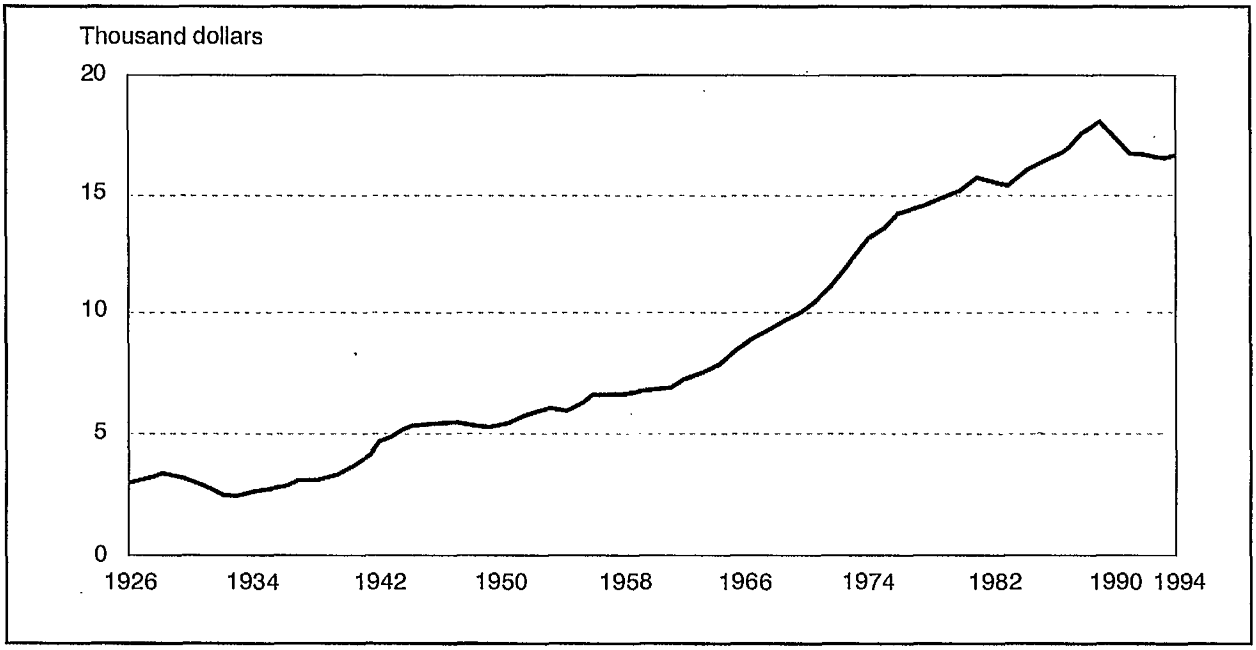


Figure 4
Real Personal Income per Capita, Canada, 1926-94



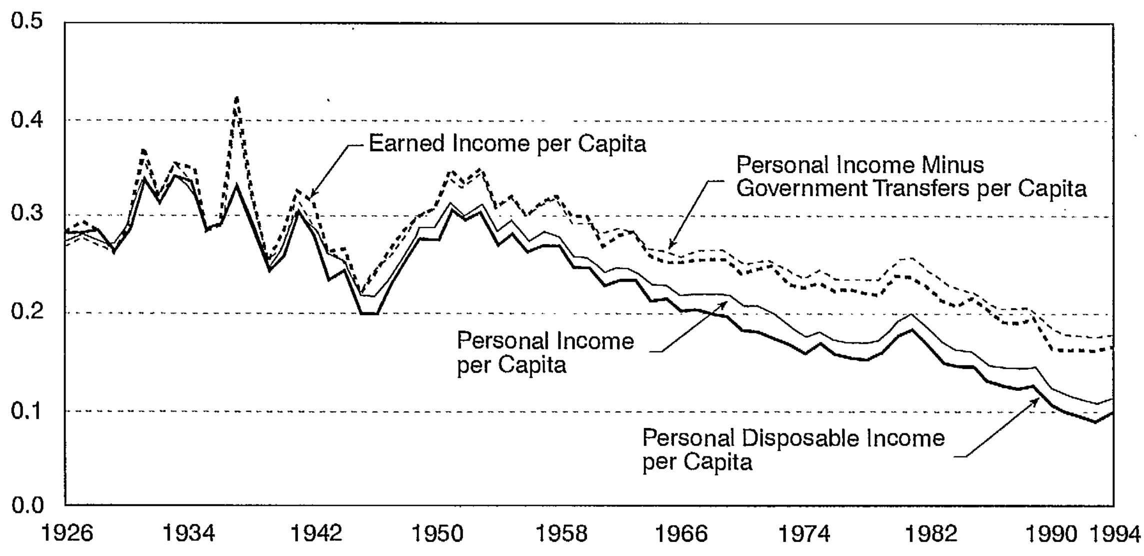
Some key facts emerge from these figures. By far the poorest province in 1949, Newfoundland caught up quickly and its per capita income today is close to the average for the other Atlantic provinces, as shown in Figure 1. The catch-up process for Prince Edward Island (PEI) appears to have steadied since the early 1950s. The "boom" experienced by the Halifax harbour at the beginning of World War II is also evident. After the shock of World War II, the relative income of New Brunswick and Nova Scotia started a steady catch-up process in the early 1950s. Figure 2 shows that the relative per capita income of Quebec, the second largest province, decreased throughout the 1930s and the early 1940s, but caught up slowly from World War II on until the mid-1970s. Relative per capita income in the richest (and biggest) province, Ontario, remained steadily at 20 % above the Canadian average from the early 1930s to the early 1970s; this gap has since narrowed. Manitoba (Figure 3) remained close to the Canadian average until the end of the 1950s, but its relative per capita income has steadily declined since. The striking pattern of relative personal income per capita in Saskatchewan can also be observed in the same figure. It is extremely volatile, driven by the success of crops and the evolution of relative prices of agricultural products. The collapse of relative agricultural prices in the 1930s had a particularly devastating effect on the economy of that province. Until the mid-1940s, Alberta's economy depended on agricultural products and its relative personal income per capita followed much the same path as that of Saskatchewan during that period. The pattern became smoother with the rapid expansion of the petroleum industry after World War II. Alberta's relative per capita income rose and fell from 1975 to the 1990s, along with the rise and fall of the relative prices of oil and natural gas. Until very recently, the diversified resource-based and export-oriented economy of British Columbia – the Pacific Coast province – generated per capita income above the Canadian average.

4. ANALYSIS OF DISPERSION INDEXES TIME SERIES

As noted above, the standard deviation (unweighted) of the log of provincial per capita income is used as the measure of dispersion for estimating σ-convergence. The time series of this dispersion index for each of the four income concepts are depicted in Figure 5 for the period 1926-1994. The tendency of dispersion indexes to decrease over time can be tested with several alternative techniques. For example, Helliwell (1994) regresses the dispersion index for the Canadian provinces on a log-linear time-trend for the 1926-1990 period. He concludes that the rate of σ-convergence is the same for the overall period as for the post-1960 period. This conclusion is based on the observation that adding the 1926-1960 data to those for the 1960-1990 period improves the R^2 and leaves the estimated rate of unaffected.

As mentioned before, σ-convergence across economic units would be observed if the measure of dispersion of the economic indicator shows a tendency to fall over time. The estimation of a decreasing trend is an intricate problem given the presence of structural breaks and permanent shocks. A closer look at Figure 5 reveals that we cannot eliminate *a priori* the possibility of breaks in and permanent shocks to the times series of dispersion indexes. It is for this reason that, in our analysis, the deterministic time-trend hypothesis put forward by Helliwell (1994) is jointly tested with the hypothesis of unit roots and drift, by using augmented Dickey-Fuller tests (ADF) and Phillips-Perron unit root tests (PP) for the four dispersion indexes times series. The

Figure 5
Dispersion in per Capita Income,[1] Canada, 1926-94



1 Measured as the standard deviation (unweighted) of the log of provincial income per capita.

presence of a unit root in a time series during a given interval indicates that the evolution of the time series is characterized by either structural breaks or permanent shocks. In both cases, the deterministic time-trend representation without a structural break is not an appropriate depiction of the evolution of the time series. A time series that is integrated of order one can nevertheless show a tendency to decrease if it has a negative drift. In such a case, the trend is said to be stochastic.[9]

ADF tests based on the following two equations were used for the dispersion index time series σ_t:

$$\Delta\sigma_t = \alpha_0 + \alpha_1\sigma_{t-1} + \sum_{j-1}^{p} \gamma_j \Delta\sigma_{t-j} + \epsilon_t \qquad (2)$$

$$\Delta\sigma_t = \alpha_0 + \alpha_1\sigma_{t-1} + \alpha_2 t + \sum_{j-1}^{p} \gamma_j \Delta\sigma_{t-j} + \epsilon_t \qquad (3)$$

where ϵ_t is assumed to be white noise. The number of lagged terms p is chosen to ensure that the errors are uncorrelated. The null hypothesis for a unit root test is $\alpha_1 = 0$. The null hypothesis for a zero drift test is $\alpha_0 = 0$. And the null hypothesis of a zero trend test is $\alpha_2 = 0$ in equation (3).

The PP method uses a non-parametric correction for serial correlation. Unit root tests are first performed in equations (2) and (3) with p set at 0. The statistics are then transformed to remove the serial correlation.

Both ADF and PP tests were performed for a number of sub-periods. Since Newfoundland, by far the poorest province at that time, entered the Canadian Confederation in 1949, we chose to start the post-World War II period in 1950. Furthermore, the post-World War II period was divided in two sub-periods since a change of pattern in σ-convergence for a number of cross-country and cross-region data sets of developed countries has been reported in recent studies (Sala-i-Martin, 1995). Results for the ADF and PP tests for the 1926-1948, 1950-1977, and 1978-1994 periods are presented in Tables 2 to 4.[10] For equations (2) and (3), the null hypothesis of no σ-convergence could not be rejected if both α_0 and α_2 equal zero.[11]

For the 1926-1948 period (Table 2), the ADF test results are unambiguous. The four σ series of PI, PIT, PDI and EI are nonstationary and the joint tests suggest that the null hypothesis of a unit root, zero drift and no trend cannot be rejected at the 10% critical value. The PP test results are slightly ambiguous because the null hypothesis of a unit root can be rejected for four out of the eight tests performed, with t-statistics marginally below the 10% critical level. However, the joint hypothesis of unit root, zero drift and no trend cannot be rejected at the 10% critical level for any of the four series. Overall, this suggests that **the null hypothesis of no σ-convergence cannot be rejected for the 1926-1948 period.**

Table 2

Unit Root Tests, 1926-48

Null Hypothesis		ADF Test Statistics	PP Test Statistics	Critical Value: 10%
Constant,	PI	–0.90	–1.98	–2.57
no trend	PIT	–1.48	–2.85	
$\alpha_i = 0$	PDI	–0.74	–1.87	
T Test	EI	–1.50	–3.13	
$\alpha_0 = \alpha_1 = 0$	PI	0.48	1.99	3.78
F Test	PIT	1.09	4.09	
	PDI	0.43	1.78	
	EI	1.14	4.92	
Constant,	PI	–2.22	–2.63	–3.13
trend	PIT	–2.24	–3.14	
$\alpha_i = 0$	PDI	–1.95	–2.63	
T Test	EI	–2.20	–3.43	
$\alpha_0 = \alpha_1 = \alpha_2 = 0$	PI	2.19	2.50	4.03
F Test	PIT	1.94	3.34	
	PDI	1.66	2.35	
	EI	1.80	3.96	
$\alpha_1 = \alpha_2 = 0$	PI	3.18	3.74	5.34
F Test	PIT	2.91	5.01	
	PDI	2.30	3.51	
	EI	2.68	5.94	

Results for the 1950-1977 period (Table 3) clearly suggest that the null hypothesis of no σ-convergence can be rejected, even though the ADF and PP tests provide a slightly different story. The ADF tests suggest that the four series are integrated of order one and drifting, while the PP tests suggest the four time series are trend-stationary.

Results for the post-1978 period (Table 4) are not ambiguous. All tests suggest that the joint unit root, zero drift and no trend null hypothesis cannot be rejected at the 10% critical level for PIT and EI, but it is rejected at the same critical level for PI and PDI. These results suggest that the null hypothesis of no σ-convergence cannot be rejected for the 1978-1994 period for PIT and EI, while it is rejected for PI and PDI. Thus, transfers and taxes appear to have played a significant role in determining convergence. Had it not been for taxes and transfers, σ-convergence may have reached its steady state. This is not surprising since the process of σ-convergence stopped for about a decade starting in the mid-1970s in all OECD economies, according to Sala-i-Martin (1995, p. 22).

Table 3

Unit Root Tests, 1950-77

Null Hypothesis		ADF Test Statistics	PP Test Statistics	Critical Value: 10%
Constant.	PI	–0.04	–0.32	–2.57
no trend	PIT	–0.75	–0.50	
$\alpha_i = 0$	PDI	–0.44	–0.11	
T Test	EI	–0.82	–0.48	
$\alpha_0 = \alpha_1 = 0$	PI	11.33	3.98	3.78
F Test	PIT	3.85	1.10	
	PDI	9.56	3.21	
	EI	3.64	0.92	
Constant.	PI	–2.81	–6.79	–3.13
trend	PIT	–2.85	–6.18	
$\alpha_i = 0$	PDI	–3.09	–6.97	
T Test	EI	–2.67	–5.73	
$\alpha_0 = \alpha_1 = \alpha_2 = 0$	PI	12.52	18.83	4.03
F Test	PIT	5.78	13.59	
	PDI	11.79	19.60	
	EI	5.15	11.75	
$\alpha_1 = \alpha_2 = 0$	PI	4.00	23.28	5.34
F Test	PIT	4.10	19.27	
	PDI	4.79	24.79	
	EI	3.65	16.67	

Table 4

Unit Root Tests, 1978-94

Null Hypothesis		ADF Test Statistics	PP Test Statistics	Critical Value: 10%
Constant.	PI	–0.11	–0.28	–2.57
no trend	PIT	–0.33	–0.41	
$\alpha_i = 0$	PDI	–0.17	–0.32	
T Test	EI	–0.58	–0.57	
$\alpha_0 = \alpha_1 = 0$	PI	0.96	0.77	3.78
F Test	PIT	1.05	0.95	
	PDI	0.96	0.79	
	EI	0.84	0.85	
Constant.	PI	–3.23	–3.22	–3.13
trend	PIT	–2.82	–2.81	
$\alpha_i = 0$	PDI	–3.38	–3.38	
T Test	EI	–3.05	–3.03	
$\alpha_0 = \alpha_1 = \alpha_2 = 0$	PI	5.11	5.03	4.03
F Test	PIT	3.82	3.81	
	PDI	5.38	5.33	
	EI	3.89	3.91	
$\alpha_1 = \alpha_2 = 0$	PI	5.97	5.91	5.34
F Test	PIT	4.20	4.20	
	PDI	6.33	6.30	
	EI	4.78	4.67	

5. ESTIMATES OF β-CONVERGENCE

The estimates of the speed of convergence for the 1926-1994 period follow the methodology developed in Coulombe and Lee (1993, 1995) and Lee and Coulombe (1995). The idea here is to use additional information coming from the evolution of relative growth patterns within the entire study period (1926-1994) in a pooled cross-section/time series approach. The study period is divided into nine sub-periods, each of seven years in duration except for the last one.[12] Thus, the number of observations equals the number of provinces times the number of sub-periods. For each sub-period, the growth rates relative to the Canadian average during the period are regressed on the initial level of income relative to the Canadian average for the same period, as shown in equation (4):

$$\frac{1}{7} \bullet \ln \left(\frac{Y_{it+7}/\overline{Y}_{t+7}}{Y_{it}/\overline{Y}_t}\right) = A - \left(\frac{1-e^{-\beta 7}}{7}\right) \bullet \ln \left(\frac{Y_{iT}}{\overline{Y}_t}\right) + u_i \qquad (4)$$

where $i = 1, ..., 9, 10$ (after 1949) and

$t = 1927, 1934, 1941, 1949, 1956, 1963, 1970, 1977$ and 1984.

$\overline{Y}$ refers to the weighted Canadian average (by population), and A is a constant term across sub-periods and sections.[13] This methodology is based on the assumption that the comparison between the growth rates of any two provinces during the same sub-period provides the same information as does a comparison between the growth rates of the same provinces during two sub-periods. In both cases, convergence implies that a (relatively) poorer province should grow at a faster rate than a (relatively) richer one. If a poor province grows faster than the Canadian average during the first sub-period, convergence implies that per capita income in this province will grow more slowly relative to the Canadian average during the second sub-period, since that province is now relatively richer than it was in the first sub-period. The resulting increase in degrees of freedom is particularly helpful in the case of Canada, because there are only nine provinces for the 1926-1949 period, and ten after 1949.

Estimation results for the β coefficients are presented in Table 5 for the sub-periods 1927-1948, 1949-1977, and 1977-1994. The point estimates are surprisingly high for the 1927-1948 sub-period. The results indicate that the poor provinces are catching up to the rich ones at a rate of between 3.5 and 4.2% annually. However, because the noise is important during that period (as indicated by the modest R^2), the t-statistics are low. The null hypothesis of no β-convergence cannot be rejected at the 5% critical level (one-tailed test). However, the null hypothesis could barely be rejected with a one-tailed test at the 10% critical level.

The null hypothesis of no convergence can be rejected at the 5% critical level for the four concepts of income for the other two sub-periods even though the estimated speed of convergence

Table 5

Speed of Convergence

	PI	PIT	PDI	EI
1927-48 period	0.0351 (1.641)	0.0397 (1.624)	0.0369 (1.672)	0.0421 (1.697)
R^2	0.12	0.12	0.13	0.13
Number of observations	27	27	27	27
1949-77 period	0.0229 (3.339)	0.0136 (2.326)	0.0253 (3.428)	0.0171 (2.298)
R^2	0.26	0.14	0.27	0.14
Number of observations	40	40	40	40
1977-94 period	0.0277 (3.511)	0.0195 (3.442)	0.0322 (3.618)	0.0207 (3.188)
R^2	0.47	0.45	0.50	0.42
Number of observations	20	20	20	20

The sub-periods used are 1927-34, 1934-41, 1941-48, 1949-56, 1956-63, 1963-70, 1970-77, 1977-84, 1984-94. The results are obtained using iterative, weighted, nonlinear least squares.
The numbers in parentheses are *t*-ratios.

is lower for the post-1949 period than for the pre-1949 period. As in Coulombe and Lee (1995), the speed of convergence is much slower for PIT and EI than for PI and PDI after 1949. This suggests that the interregional redistribution of income resulting from the tax-transfer system has contributed *ex post* to stronger convergence among Canadian provinces after 1949.

6. CONCLUSION

The neo-classical growth story suggests that within regions having similar technology and preferences, the catch-up process of poor regions to rich ones follows a smooth, transitional dynamic path altered only temporarily by white noise random shocks. Our analysis of the long-run growth patterns of Canadian provinces shows that this story is not representative of the convergence process observed among Canadian provinces since 1926. There is no evidence of σ-convergence for the nine provinces prior to the entry of Newfoundland into Confederation in 1949. Furthermore, most of the σ-convergence detected appears to have occurred during the 1950-1977 period for PIT and EI. Similarly, the shocks that impacted the Canadian regions in the 1930s and 1940s are so important that the null hypothesis of no β-convergence cannot be rejected at the 5% critical level prior to 1950. Finally, the fact that there is no evidence to support σ-convergence after 1977 for PIT and EI dos not, by itself, contradict the neo-classical growth theory since one can always argue that the dispersion of income had, by then, reached its steady-state value.

Although the inverted-U hypothesis of Kuznets (1955) and Williamson (1965) could be relevant to the Canadian economy, there is no empirical support for it in the Canadian data when our findings are interpreted in the light of Green's (1969 and 1971) estimates of regional disparities in per capita gross value added (GVA) from the census data of 1890, 1910 and 1929 and McInnis' (1968) results. Green's dispersion index was the sum of the absolute value of the provincial deviations of GVA per capita from the national average. Between 1890 and 1910, the unweighted deviation remained steady. Then convergence occurred between 1910 and 1920 and remained steady until 1927 (McInnis, 1968). But it started to reverse itself at the beginning of the Depression. Regional disparities remained at a high level and showed no tendency to decrease from 1926 to the early post-World-War II period. Note that this period more or less coincides with that studied by Taylor and Williamson (1994), Williamson (1992, 1995), and Williamson, O'Rourke and Hatton (1993), who observed no convergence over the 1914-1938 period among most OECD member countries. This second stage of regional economic development in Canada was characterized by slow growth in the 1930s and large structural shocks to the industrialization process associated with World War II. The third phase of decreasing inequalities started in the early 1950s and was marked by rapid industrialization and the emergence of the welfare state. In conclusion, the tendency towards a gradual narrowing of regional disparities in Canada was interrupted during two important episodes, when the convergence process came to a halt: the 1890-1910 period (the wheat boom) and the 1926-1950 period (the Great Depression followed by World War II). Over these two periods, regional disparities remained steady or increased.

The main result of our study is broadly consistent with the observations of Taylor and Williamson (1994), Williamson (1992, 1995) and Williamson, O'Rourke and Hatton (1993) that there was no convergence among developed countries over the period 1926-1950, but that this process resumed its course afterwards. The non-smoothness of the convergence process among developed countries and across regions of developed countries is a phenomenon as puzzling for the neo-classical growth theory as the absence of convergence between poor and rich countries.

Both stylized facts underline the importance of the process of industrial development, geography and history to the understanding of economic growth patterns.

Finally, from a policy point of view, our analysis suggests that pressures will likely come to bear on the interregional transfer system in Canada in the future. The degree of dispersion (σ-convergence) of EI and PIT has been relatively stable since the mid-1970s, at a low historical level. However, with taxes and transfers, the degree of dispersion continued to decline as shown by σ-convergence of PI and PDI. This may indicate that the effects of factor mobility and relocation of firms on the convergence process may have reached their limits in reducing regional disparities within the existing Canadian economic structure. Only taxes, transfers and, possibly, other government programs are left to close further regional gaps. It thus appears that the Canadian industrial structure and/or barriers to factor mobility will have to change in some fundamental way if they are to have a significant impact on regional disparities.

ENDNOTES

1. See Mansell and Copithorne (1985) for a survey of studies on Canadian regional disparities up to the early 1980s. The paper also includes a brief review of recent studies on Canadian regional convergence.

2. See Barro and Sala-i-Martin (1995) for an extensive discussion of these issues.

3. However, they observe divergence from 1830 to 1870.

4. See Barro and Sala-i-Martin (1995) for an extensive discussion of these issues.

5. According to Romer (1988) and Lucas (1986), the failure of cross-country convergence is a key empirical fact that underscores the usefulness of endogenous growth models.

6. See Barro and Sala-i-Martin (1995) for a complete discussion of the methodology.

7. See, for example, Bernard and Durlauf (1994) for a discussion of issues related to alternative definitions of convergence, the persistence of shocks, and the implications of empirical tests in a neo-classical stochastic growth framework.

8. These are not adjusted for differences in prices across provinces due to the lack of provincial CPIs prior to 1961. Coulombe and Lee (1995) demonstrate that adjusting these series with provincial CPIs do not have a significant effect on the estimated speed of convergence.

9. See Stock and Watson (1988) for a simple introduction to the notions of stochastic versus deterministic trends.

10. ADF and PP tests have been performed for the overall study period and the 1950-1991 sub-period. Results point in the same direction as those analysed in the main text.

11. Time series approaches to convergence have usually focused on the stationarity of differences between ratios of economic indicators. See, for example, Carlino and Mill (1993) and Lefebvre (1994). The interpretation of convergence tests is far from being a settled issue; see, for example, Bernard and Durlauf (1994).

12. As shown in the Appendix to Coulombe and Lee (1995), the estimation of β coefficients using this methodology is robust to alternative definitions of sub-periods, i.e., from peak to peak, from trough to trough, or for a ten year sub-period. The idea is simply to have a sub-period that encompasses the business cycle in order to abstract from the non-synchronization of regional business cycles observed in Canadian data. The last sub-period is extended to 10 years in order to include the most recent data.

13. The term B in equation (1) is not constant across sub-periods since it is a function of the trend growth rate of productivity (see Barro and Sala-i-Martin, 1995, chapters 1 and 11). In order to account for the decline in the growth rate of productivity in the mid-1970s, we have extracted the trend in this constant term by regressing the growth rate of i with respect to the Canadian average on the initial level of income per capita of i divided by the Canadian average as in our previous studies. It can then be demonstrated that the term A is constant through time.

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