Regional Convergence in per Capita Personal Income in the US and Canada

Ilona Shiller

Abstract—This study examines regional convergence in per capita personal income in the US and Canada. We find that the disparity in real per capita income levels across US states (Canadian provinces) has declined, but income levels are not identical. Income levels become more aligned once costs of living are accounted for in relative per capita income series. US states (Canadian provinces) converge at an annual rate of between 1.3% and 2.04% (between 2.15% and 2.37%). A pattern of σ and β-convergence in per capita personal income across regions evident over the entire sample period, is reversed over 1979-1989 (1976-1990) period. The reversal may be due to sectoral or region-specific shocks that have highly persistent effects. The latter explanation might be true for half of the US and most of Canada.

Keywords—regional convergence, regional disparities, per capita income.

I. INTRODUCTION

The convergence hypothesis is a popular tenet in modern discussions in macroeconomics and international finance. It derives from the fundamental properties of the neoclassical single-sector growth model, and its assumptions of diminishing returns to scale. Recently there has been increasing attention paid to the question of whether economies exhibit a tendency to diverge or converge over time. Though much of the literature is concerned with the convergence or divergence of national economies there have also been a number of studies conducted at the regional level, in particular for the regions of the European Union (see, for example, [9]).

This study examines regional convergence in per capita income across US states and Canadian provinces. The US sample extends from 1929 to 2003, whereas the Canadian sample extends from 1951 to 1990. Alaska, Hawaii, and the District of Columbia (DC) are excluded from most empirical analyses of per capita income convergence across US states. Alaska and Hawaii are excluded due to their geographical isolation, whereas DC is excluded due to the mismatch of earned and generated residential personal income. Nunavut is excluded from the analysis because it was not in existence during the tested time period.

The renewed interest in the topic of regional disparities can be explained by at least three phenomena. First, due to the recent availability of regional data the relevant empirical studies can now be performed. Second, endogenous growth models, which can explain convergence as well as divergence among different groups of nations and within different regions of a country, are now popular in mainstream macroeconomics. Third, many growth and development related issues have recently emerged at the forefront of economic and political problems. Many of these issues have direct implications for regional studies. For example, even if North American economic integration is expected to make the whole region more prosperous, there is an increasing concern that an integrated North American market may exacerbate the problems of regional imbalance and inequality.

This study examines if real per capita personal income in the US and Canada has converged? We present three concepts of convergence and empirically test them. The study is organized as follows. Introduction is in section I. Section II discusses the notion of convergence, and briefly touches upon sources of income convergence/divergence. Data and test results are presented in section III. Finally, the results are discussed in the conclusion.

II. THE NOTION OF CONVERGENCE

Some economists argue that the notion of convergence is a disequilibrium phenomenon. That is, the convergence hypothesis assumes that regions are initially out of equilibrium. Over time, however, factors will migrate across regions to achieve equilibrium. The convergence hypothesis states that regions tend to gravitate towards their steady state level of growth over time.

Fig. 1 (Panels A and B) depicts regional per capita income relative to the national per capita personal income across states (provinces). Data are in logarithms. The log of the relative per capita personal income differs widely across regions in the beginning of our sample periods. In 1930, per capita income in New York, Connecticut, California, and Nevada exceeds the national average by 90.26%, 69.30%, 63.05%, and 53.13% respectively. Per capita income in Mississippi, Arkansas, South Carolina, and North Carolina falls short of the national average by 62.87%, 58.09%, 55.33%, and 46.32% respectively. In Canada, per capita personal income in British Columbia and Ontario is more than 18% above the national average in 1951. In contrast, per capita income in Newfoundland, Prince Edward Island, and New Brunswick is 51.74%, 45.21%, and 33.06% below the national average in 1951. Thus, divergence in per capita personal income across US states (Canadian provinces) is evident in the beginning of our samples. However, this pattern

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is reversed over time and we can observe a trend toward convergence of regional per capita incomes. Per capita personal incomes became more aligned at the end of our sample periods. In 2003, per capita income in New York, Connecticut, California, and Nevada exceeds the national average by 20.15%, 41.83%, 10.87%, and 2.71% respectively. Per capita income in Mississippi, Arkansas, South Carolina, and North Carolina falls short of the national average by 22.97%, 20.21%, 14.15%, and 7.24% respectively. In Canada, per capita personal income in British Columbia and Ontario is only 13.37% and 1.14% above the national average in 1990. In contrast, per capita income in Newfoundland, Prince Edward Island, and New Brunswick is only 28.57%, 26.45%, and 23.10% below the national average in 1990.

Why do regional personal incomes vary or converge?

A. Real per capita income as a percentage of US average

B. Real per capita income as a percentage of Canadian average

How does the theory explain this phenomenon? To answer these questions we identify potential sources of income convergence or divergence. There are two sources of income convergence: one specified by models of growth and another by models of trade.

The neoclassical Solow growth model, with diminishing returns to capital, argues that additional factor inputs yield smaller increments to output in regions with higher incomes than they do in regions with lower incomes. The pace of income convergence in the growth model significantly increases because labour and capital mobility speeds up the rate at which any differences in factor returns will tend to be migrated away over time. The neoclassical Heckscher-Ohlin trade model argues that incomes of regions vary because of differing factor endowments and factor prices. Economic integration and liberalized trade in goods leads to income convergence through factor price equalization. The problem with the factor price equalization (FPE) or convergence in the micro sense is that it describes outcomes in the steady state equilibrium but does not say anything about factor prices in the adjustment phase to steady state. The FPE theorem also holds under restrictive assumptions of zero trade barriers, identical linear homogeneous technology and preferences across regions, and all regions producing all products. The same models can explain why regions diverge.

Under the neoclassical growth model, assumptions of decreasing returns and factor mobility have to hold. The models of growth based on increasing returns in physical or human capital externalities, advanced by Paul Romer and Robert Lucas respectively, predict the possibility of income divergence. In these models, lack of knowledge increases the returns to human capital in regions with a lot of physical capital. Additionally, due to the external economies of scale the returns to skilled workers may be higher in locations with large concentration of skilled workers. The prediction of these models is that skilled workers will migrate to the locations with other skilled workers and income differences will increase over time.

Trade models, based on the increasing returns argument advanced by Paul Krugman, also predict the possibility of income divergence through the divergence in industrial structure or in factor endowments. If high-tech, high-wage industries are subject to external economies, then the opening up of trade will cause the concentration of all high-tech, high wage industries in few regions. This in turn causes regional incomes to diverge as the remaining regions are left with only the low-tech, low-wage industries. Macro convergence achieved through the FPE may not result in macro convergence of per capita regional personal income because macro convergence is a function of convergence not only in factor prices but also in factor quantities.

Per capita income could also vary across regions due to interregional differences in labour force participation that yield differences in the ratio of workers to population; per capita income would vary by region even if the factor returns were identical. Per capita income variations can be caused by the regional variations in the industry mix, which means that even if factor returns are equalized within industries and workers with identical skills and work effort receive the same level of compensation across different regions, average returns across workers can vary by region. People, in addition, may sort themselves by region in terms of the human capital they bring to the market. Moreover, another possible reason to explain why personal income varies is that regions differ in terms of the amenities and comforts offered. Differences in the cost of living and those between worker characteristics can also account for variability of personal provincial income.

Only in the case where the variations in factor returns are larger than the previously mentioned differences suggest will there be an incentive for the factor migration that tends to equalize factor returns across regions. Regional disparities may be a cause of concern due to either equity or efficiency considerations. From the point of equity, regional disparities may cause output to be unfairly divided. From the point of efficiency, regional disparities may cause resources to be inefficiently allocated. Regions in Canada and the US are
heterogeneous, in resource endowments and accesses to markets [14].

There are three concepts of convergence. The first concept of convergence is referred to as σ-convergence. This occurs when the cross-sectional dispersion decreases over time. σ-convergence is measured using the cross-sectional standard deviation of the logarithm of per capita income. The stochastic neoclassical model predicts that the long-run value of the dispersion index (represented by the standard deviation of the logarithm of per capita income) is a function of the variance of random shocks and of the speed of convergence. If the current dispersion index exceeds its steady state value, the dispersion index will monotonically decline at a smooth rate equal to the convergence rate, beta, and ultimately approach its steady state value.

A second concept includes β-convergence. β-convergence occurs when initially poor regions grow faster than their rich counterparts. This type of convergence would imply that the poor regions eventually catch up with the rich regions. The unconditional convergence parameter β is calculated by regressing the growth rate in per capita income on the initial level of per capita income. This type of convergence can be analysed with various techniques. In general, either linear or non-linear regressions are involved. A significantly negative slope coefficient value implies unconditional convergence in the β-sense. A test of conditional convergence includes additional information to account for the difference between the average income level across regions and the individual region’s steady-state income level. The calculated β-value is called the conditional β-estimate.

Some of the significant differences between σ and β-convergence are the following. β-convergence is measured between two time periods, while σ-convergence is measured over time. The β-coefficient is able to predict not only the speed of convergence but also whether the cross-sectional dispersion will fall or rise over time. β-convergence is a necessary but not a sufficient condition for σ-convergence. The cross-sectional dispersion can be affected by external shocks, which would cause the σ-coefficient to increase in spite of a positive β-coefficient.

The final concept of convergence is referred to as stochastic convergence. Bernard and Quah have developed a definition of convergence using the notions of unit roots and cointegration. In these models, convergence in per capita income requires that permanent shocks to the national economy are associated with permanent shocks to regional economies. If some component of regional per capita income deviations is due to permanent regional-specific shocks, such as localized technology shocks, convergence may not be achieved. Thus, this definition of convergence requires that a non-zero mean stationary stochastic process characterizing deviation in a region’s per capita income relative to per capita income in the nation.

[5] argues that both time-series and cross-sectional tests are necessary for detecting convergence. Furthermore, they stress that two conditions must be met for convergence to hold: (i) shocks to relative regional per capita income should be temporary (stochastic convergence), and (ii) regions having per capita incomes initially above their compensating differential should exhibit slower growth than those regions having per capita incomes initially below their compensating differential (cross-sectional convergence).

Cross-sectional (i.e., [8]; [7]), time-series [15], and a pooled time/series cross-section ([21]; and [4]) approaches were followed to examine the convergence in per capita incomes across regions and nations. Previous research reports mixed results. [22] uses annual data for 72 countries over the period from 1950-1990 and finds no convergence overall, but a homogeneous group of countries. [17] and [16] find cross-sectional conditional convergence among a group of countries after controlling for savings rates, population growth rates, and educational attainment. [18] find that US states, Japanese and Western European regions converged at a speed of 2% across states/regions within countries. Other studies find no convergence among regions in Italy [11], UK [13], and Greece [2].

III. CONVERGENT OR DIVERGENT BEHAVIOUR?

Annual data for US (Canadian) per capita personal income are available from the Economist from 1929 to 2003 (the Statistics Canada1 for 10 provinces and 2 territories from 1951 to 1990). Ideally, regional per capita personal incomes should be deflated using regional price deflators for data to be comparable across regions. Since the regional price indexes are not available, this is not possible, and the national US (Canadian) consumer price index with the base year at 1967 (1992) is used instead.

σ-convergence is perhaps the simplest and most widely used test for convergence. Fig. 2 uses a standard cross-sectional measure of dispersion, the (un)weighted standard deviation of log per capita personal income, to show the trajectory of the dispersion in regional per capita personal income over time. Panel A uses the unweighted cross-sectional standard deviation of the logarithm of per capita income and the graph shows that the disparity in per capita income levels across all states has not changed over 1929-2003 period. However, the unweighted cross-sectional standard deviation of the logarithm of per capita income across Midwest, Northeast, and Energy producing states does show a pattern of convergence. Panel B uses weighted cross-sectional standard deviation of the logarithm of per capita income and the graph reinforces our initial finding that the disparity in US per capita income levels across all states has not changed over 1929-2003 period. Once, we account for differences in population levels across states, we also find that the pattern of convergence across Midwest, Northeast, and Energy producing states disappears as well. Panel C uses the unweighted cross-sectional standard deviation of the logarithm of Canadian per capita income and the graph shows that the disparity in per capita income levels across all states has diminished over 1951-1990 period, with the exception of the period between 1976 and 1990 when it either stayed on the

1We used Canadian Economic Observer and Cansim database for this particular variable.
same level or rose significantly. The dispersion in relative regional Canadian per capita incomes fell dramatically between 1954 and 1976, declining to 0.18 in 1976. After 1976 it rose slowly but steadily to 0.21 in 1982, although it declined to 0.17 in 1990.

To find out how the dispersion index of regional per capita income has evolved over time, one can either find the change rate of the standard dispersion of per capita income over time using the regression of a logarithm of the (un)weighted standard deviation of the per capita income on a linear time trend or test for the stationarity of the dispersion series of regional per capita income. The second approach accounts for the presence of breaks and structural shocks which cannot be established a priori. Table 1 presents results of log-linear dispersion regressions. Panel A (B) describes US (Canadian) results for regressions with the unweighted and weighted cross-sectional dispersion series used as dependent variables. Using unweighted cross-sectional dispersion series as a dependent variable, we find that all states except for Alaska, Hawaii, and DC are converging at a statistically significant rate of 4.10%. We also find that the dispersion in per capita personal income across energy producing (Midwest) states declines at a rate of 1.65% (1.71%), whereas it increases at 5.04% (5.17%) across northeast (west) states. Using weighted cross-sectional dispersion series as a dependent variable, we find that agricultural, midwest, northeast, and west states are converging at a statistically significant rate of 0.51%, 0.16%, 0.60%, and 7.86% respectively. We also find that the dispersion in per capita personal income across energy producing (south) states increases at a rate of 0.13% (0.55%). The results of log-linear regression model with the unweighted Canadian cross-sectional dispersion series as the dependent variable show that the dispersion in per capita income falls across all and across Atlantic provinces at approximately the same rate of 1.8%, whereas it falls across energy producing provinces (British Columbia, Saskatchewan, and Alberta) at a rate of 2.12%.

To account for the possibility of inherent structural breaks (shocks) in the dispersion index time series, we also present unit root test results for per capita US (Canadian) dispersion measure results in Panels A (B). Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) univariate unit root test results are presented. All tests are run with an included drift term and an appropriate lag length selected by minimizing the Schwartz information criterion (SIC). PP tests are superior to ADF tests (the former allows disturbances to be serially correlated and heteroscedastic), but the disadvantage of the latter procedures lies in their inability to distinguish between the unit root and near unit root processes. For this reason, we give preference to the KPSS test results because the KPSS test allow for heterogeneous/homogeneous innovations and for all ARMA processes, and satisfies PP regularity assumptions. KPSS test results show that the null of level stationarity is rejected for all unweighted dispersion series, except the series across all states, all states except for Alaska, Hawaii, and DC, agricultural, energy producing, and south states where shocks to the US per capita regional unweighted cross-sectional dispersion series are temporary in nature. Testing the US per capita regional weighted cross-sectional dispersion series for the presence of unit roots, we find that only dispersion series across all states, and all states except the three noted above are stationary. Results in Panel B of Table 2 show that prices are available only for the 1980-1990 period, we are unable to check whether the plunge oil prices was a possible reason for exhibited divergence.

2One possible explanation for this divergence found in the literature is the plunge in oil prices during the early 1980s. Due to the fact that the data of oil prices are available only for the 1980-1990 period, we are unable to check whether the plunge oil prices was a possible reason for exhibited divergence. 3KPSS test is better able to differentiate between long and short memory processes. The alternative hypothesis in KPSS test is that the series are integrated with an integration parameter being one or less than one.
unweighted Canadian cross-sectional dispersion series are non-stationary and, thus, the null hypothesis of no convergence cannot be rejected.

We also test for unconditional (for the US and Canadian sample) and conditional (for the Canadian sample only) β-convergence using cross-sectional and cross-sectional time series approaches. In [1], which focuses on cross-sectional convergence, a negative β-coefficient is shown to imply β-convergence in the equation of the following form:

\[ \log Y_{it} - \log Y_{i0} = \alpha + \beta Y_{i0} + \epsilon \]

over the period from 0 to T, where \( Y \) is per capita personal income and subscript \( i \) denotes regions. In cross-sectional US tests, we use per capita personal income (un)adjusted for costs of living across US states. For per capita income convergence may be a gradual process because of sustained differences in hours of work and especially unemployment. Regional differences in unemployment rates affect regional convergence in housing affordability and imply differences in living standards of workers across North America. Other studies account for the costs of living by considering housing costs (i.e., [10]) and observed prices of goods and services (i.e., [20]). We also adjust for the differences in housing costs across US states. This means that instead of using relative regional per capita income, we use relative regional per capita income adjusted for differences in housing costs because housing costs account for the biggest share of one’s monthly expenses in North America. The adjustment is done by subtracting the vector of logarithmic equivalents of the variable \( X \) from the vector of logarithmic relative per capita incomes. The vector of \( X \) is calculated as follows:

\[ X_{it} = \left[ (p_{it} / p_{i0}) - 1 \right] \times 0.3571 + 1 \]

Where \( p_{it} \) bar is the average cross-sectional sales price across the US states. The annual US regional sales prices are available from the EconoMetric site only starting 1963. To make results for adjusted and unadjusted for costs of living comparable, we use the sample period from 1969 to 2003 to estimate β-convergence across US states.

Panel A (B) of Table 3 shows the results of simple cross-sectional tests estimated using US unadjusted (adjusted) for costs of living per capita incomes for the overall time period, and for each 4-year and 6-year period.

\[ x_{it} = \left[ \frac{p_{it}}{p_{i0}} - 1 \right] \times 0.3571 + 1 \]

This table reports results of univariate unit root tests. The null hypothesis for the ADF and PP tests is nonstationarity, whereas the null hypothesis for the KPSS test is stationarity. Initially 12 lags of the tested variables are included, but the final test statistics are based on the optimal lag length selected by minimizing SIC. The significance of results is established using the tabulated critical values for these tests. **, * stand for the significance of results at the 1%, 5%, and 10% significance levels respectively.
The results reported in Panels A and B are mostly consistent and indicate that there is evidence of β-convergence across US states, except over the 1979-1989 time period when slope coefficients are either insignificant or insignificantly positive. Using adjusted per capita incomes, we find higher β-estimates and lower estimates for logarithms of real per capita incomes. This means that unadjusted for costs of living estimates are biased downward. For example, the rate of convergence across US states over the 1969-2003 period reported in Panel A is only 1.02% compared to the rate reported in Panel B of 1.83%. Thus, after taking regional differences in housing costs into account, the distribution of income gets compressed because richer (poor) provinces tend to have higher (lower) housing costs. Panel C of Table 3 shows the results of simple cross-sectional tests estimated using Canadian unadjusted for costs of living differences per capita incomes for the overall time period, and for each decade. All of the β-coefficients are negative and support our hypothesis of β-convergence for the overall period of 1951-1990 and all sub-periods. However, the coefficients for 1976-1990 and 1971-1980 periods are not statistically significant and the null hypothesis of no β-convergence during these periods cannot be rejected at the 5% level. In unreported results and in support of the β-test results, we find correlation coefficients among the growth rate of per capita Canadian income and the log of initial per capita income over different time periods to be negative6.

The hypothesis of conditional β-measures is examined for the Canadian sample of per capita incomes6. Conditional convergence occurs when the income of each province is moving towards its own steady state level. To strengthen σ and β-convergence results conditional convergence is tested to support our hypothesis of the same steady-state personal per capita incomes across all provinces. A test for conditional convergence is used to explain additional information to include mean differences in housing costs into account, the distribution of differences in housing costs across provinces may have biased the estimation of β. That means that each province may be approaching its own steady state level.

Following this approach regressions augmented for educational attainment are run. It is argued that per capita income should grow more rapidly in provinces with greater human capital. The first column of Table 4 confirms our σ and β-convergence results obtained earlier in that the speed of unconditional convergence across the 1976-1990 period is only 0.64%. The second column of Table 4 shows the results reported in Panel B of 1.83%.

This table reports results of conditional cross-sectional tests of the growth rate in per capita personal income on the initial level of per capita income and on a proxy for educational attainment. The table reports real per capita Canadian income unadjusted for costs of living over 1976-1990 period.

TABLE I

<table>
<thead>
<tr>
<th>Panel B</th>
<th>Unconditional convergence test results for real per capita Canadian income over 1951-1990 period</th>
<th>Dispersion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Period</td>
<td>Intercept log(Y0)</td>
<td>β</td>
</tr>
<tr>
<td>1969-2003</td>
<td>-0.02795</td>
<td>0.01266</td>
</tr>
<tr>
<td>1969-1979</td>
<td>-0.01810</td>
<td>-0.02400</td>
</tr>
<tr>
<td>1974-1978</td>
<td>-0.0053</td>
<td>-0.1392</td>
</tr>
<tr>
<td>1978-1982</td>
<td>-0.0129</td>
<td>0.0239</td>
</tr>
<tr>
<td>1983-1987</td>
<td>0.0023</td>
<td>0.0213</td>
</tr>
<tr>
<td>1989-1993</td>
<td>-0.0126</td>
<td>0.0213</td>
</tr>
<tr>
<td>1997-2001</td>
<td>-0.0022</td>
<td>-0.0409</td>
</tr>
</tbody>
</table>

TABLE II

<table>
<thead>
<tr>
<th>Panel C</th>
<th>Conditional convergence test results for real per capita Canadian income over 1951-1990 period</th>
<th>Dispersion Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Period</td>
<td>Intercept log(Y0)</td>
<td>β</td>
</tr>
<tr>
<td>1951-1990</td>
<td>-0.7704</td>
<td>0.6379</td>
</tr>
<tr>
<td>1957-1997</td>
<td>-0.1895</td>
<td>0.0246</td>
</tr>
<tr>
<td>1963-2003</td>
<td>-0.1015</td>
<td>-0.0165</td>
</tr>
<tr>
<td>1969-1999</td>
<td>-0.3381</td>
<td>-0.1577</td>
</tr>
<tr>
<td>1975-2003</td>
<td>-0.3782</td>
<td>-0.2188</td>
</tr>
</tbody>
</table>


6 However, the value for the 1971-1980 period is the lowest. This implies that the poor provinces are growing faster than the rich provinces. Results are available upon request.

6 [23] notes that no empirical research in Canada has considered effects of human capital on macro convergence in Canada. And the neoclassical growth model considers only two inputs: labour and capital.
for the augmented equation, where human capital is measured by the proportion of labour force with university degrees. They indicate that conditional β-convergence is more rapid (at 1.26%) and less significant statistically, though the sign of the augmenting variable is as expected. The explanatory power of the equation is even poorer than before.

In the third column of Table 4 the results of the second augmented regression are presented, where the proportion of the labour force with a post-secondary education is used as a proxy for human capital. The β-coefficient in this regression is very low (0.17%). The coefficient of human capital variable is positive as expected and highly statistically significant. However, the explanatory power of this third regression is considerably better than that of the other two.

Simple cross-sectional tests will not be very reliable because of the relatively few degrees of freedom. Therefore, the conceptually superior methodology of [21] is followed. Because of the relatively few degrees of freedom. Therefore, the conceptually superior methodology of [21] is followed. The null hypothesis of no β-convergence can be rejected. The results of the pooled cross-section time series are slightly different as compared with the results of the simple cross-sectional tests, but the former tests are considered more reliable.

While the cross-sectional evidence supports the convergence hypothesis, it is possible that relative regional per capita incomes are separate random walks. [6] argue that the cross-sectional convergence tests examine only the two end-points in the sample for each region. It might be possible that the time series on relative per capita incomes is non-stationary, so that the appearance of convergence at the two end-points is random. Therefore, the time-series test for convergence is useful in examining the dynamic path of relative provincial per capita personal income.

### Table V

<table>
<thead>
<tr>
<th>Time Period</th>
<th>intercept</th>
<th>Regressions</th>
<th>$R^2$</th>
<th>DW</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-1975</td>
<td>-0.00020</td>
<td>-0.01349</td>
<td>0.0179</td>
<td>2.183021</td>
<td>20.84252</td>
</tr>
<tr>
<td>1976-1980</td>
<td>0.00016</td>
<td>-0.01939</td>
<td>0.02039</td>
<td>2.043877</td>
<td>24.08546</td>
</tr>
<tr>
<td>1981-1985</td>
<td>0.00000</td>
<td>-0.02122</td>
<td>0.0224</td>
<td>2.4353</td>
<td>9.7605</td>
</tr>
</tbody>
</table>

Pooled cross-section / time-series test results are presented in this Table. Our US adjusted and unadjusted for costs of living samples are divided into 5 (7) sub-periods, each of 7 (5) years in duration. The Canadian unadjusted for costs of living samples are divided into 4 (8) sub-periods, each of 10 (5) years in duration. The number of observations equals the number of states (provinces) times the number of sub-periods.

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7 The source of the data: Statistics Canada. “Labour force estimate by education level, age, sex, Canada/Province, average annual” on Labour force Historical review. [CD-ROM]. 71 F0004 XC8. Ottawa: Statistics Canada, 1998. We have chosen to use measures of educational attainment out of labour force, because of the data unavailability of these measures out of the population for the entire 1976-1990 sample period.

8 The assumption here is 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” [21].
Let us consider the time-series properties of the per capita personal income across US states (Canadian provinces) relative to the per capita personal income in the nation. We use the logarithm of annual data on relative per capita personal income over the 1969-2003 period for the US data and over the 1951-2003 period for the Canadian data. To check the stochastic convergence hypothesis, we use univariate ADF, PP, and KPSS tests. Tests for a unit root are often criticized on the grounds that a permanent component may be present in a time-series, but this component may not be responsible for a large proportion of the total variation in the series. As noted previously, KPSS results are given preference over ADF and PP test results.

The null hypothesis of level stationarity based on results presented in Panel A (for unadjusted for costs of living real relative per capita incomes) of Table 6 fails to be rejected for Florida, Idaho, Louisiana, Nebraska, New Mexico, New York, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Texas, Washington, West Virginia, Wisconsin, Wyoming. For the rest of the US states, the null is rejected, meaning that shocks to real relative per capita incomes in these states are present. Panel B of Table 6 shows that shocks to real relative per capita incomes in Alberta, Saskatchewan, and Yukon are temporary, whereas real relative per capita incomes in the rest of Canada are separate random walks that approach their own steady state. That is, once shocked, relative provincial per capita personal incomes do not return to a deterministic trend. The results presented in Table 7 for adjusted for costs of living real US relative per capita incomes are generally consistent with those in Table 6 (Panel A). State per capita relative personal incomes in Florida, Louisiana, New Mexico, New York, North Dakota, Oklahoma, Rhode Island, Texas, Washington, and West Virginia are also stationarity. Additionally, state per capita relative personal income series in Colorado, Illinois, Indiana, Iowa, Kansas, Maryland, Michigan, and Ohio are also stationarity.

### IV. Conclusion

In this study we show that the divergence in personal regional per capita income across US states (Canadian provinces) has diminished over time. Overall, results suggest that the gap in regional real per capita incomes has narrowed and that the absolute regional level of the real income has increased, but incomes have not equalized across regions. The US σ-convergence results are mixed. Plotting the unweighted by population share cross-sectional standard deviation of real per capita income versus time, we see that the disparity in per capita income has declined over the overall time period (1929-2003), but not over the 1979-1989 period. No changes in dispersion of per capita income are observed for the trajectory of weighted by population share cross-sectional standard deviation of real per capita US income. The results of simple cross-sectional and pooled cross-section-time-series tests are consistent and show that US states are converging at a rate between 1.3% and 2.04% annually. We also adjust US real
Table B. Unit root tests on Canadian provincial per capita income (1951–1990)

<table>
<thead>
<tr>
<th>Province</th>
<th>ADF Stat</th>
<th>PP Stat</th>
<th>KPSS Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>-1.9205</td>
<td>-2.4320</td>
<td>0.1790</td>
</tr>
<tr>
<td>BC</td>
<td>0.3197</td>
<td>-0.1399</td>
<td>Stat</td>
</tr>
<tr>
<td>Manitoba</td>
<td>-0.8508</td>
<td>-0.6217</td>
<td>0.6993</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>-0.9185</td>
<td>-0.2439</td>
<td>0.4952</td>
</tr>
<tr>
<td>Quebec</td>
<td>-0.2315</td>
<td>-0.2677</td>
<td>0.2457</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>-0.4189</td>
<td>-0.4743</td>
<td>0.1489</td>
</tr>
<tr>
<td>Yukon &amp; NW Territories</td>
<td>-1.9477</td>
<td>-2.2741</td>
<td>0.1373</td>
</tr>
</tbody>
</table>

This table reports results of univariate unit root tests. The null hypothesis for the ADF and PP tests is nonstationarity, whereas the null hypothesis for the KPSS test is stationarity. Initially 12 lags of the tested variables are included, but the final test statistics are based on the optimal lag length selected by minimizing SIC. The significance of results is established using the tabulated critical values for these tests, and *, **, and *** stand for the significance of the results at the 1%, 5%, and 10% significance levels, respectively.

personal per capita incomes for costs of living using housing costs and find slightly higher convergence rates than those calculated using unadjusted for costs of living real per capita incomes. Using unit root tests, we find that 10 US state real per capita income series (Florida, Louisiana, New Mexico, New York, North Dakota, Oklahoma, Texas, Washington, and West Virginia) are stationary and, hence, these states are also statistically converging. Additionally, we find that state real per capita income series for 7 (8) US states are stationary including Idaho, Nebraska, Oregon, Pennsylvania, South Dakota, Wisconsin, and Wyoming (Colorado, Illinois, Indiana, Iowa, Kansas, Maryland, Michigan, and Ohio). The rest 26 states face permanent shocks to their per capita incomes due to state- or region-specific influences (i.e., variation in productivity levels, differences in resource endowments, climate, preferences, etc).

Canadian convergence tests appear to have converged in both the β and σ senses during the entire study period. However, the β and σ-measures both suggest that the 1976-1990 sample period is different from the much of the rest of the examined period of 1951-1990. The pace of both the β and σ-convergence is considerably slower during the 1976-1990 period than it is earlier and the augmented regression results support the possibility that differences in province’s steady-state income levels may explain some of the slowdown. The results of the pooled cross-section time-series indicate that the poorer provinces are catching up to the richer ones at a rate of between 2.15% and 2.37% annually. Testing for stochastic convergence, we find that most provinces, except Alberta, Saskatchewan, and the Yukon and Northwest Territories, face region - specific shocks that have highly persistent effects.

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REFERENCES


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