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The Contribution of Human Capital and Urbanization to Canadian Regional Growth[1]

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1. Introduction

The Canadian federation is an interesting source of empirical evidence concerning regional growth patterns for two reasons. First, due to Statistics Canada's work, many provincial data are available on a long time–series basis. Second, up to World War II, regional disparities in per capita income across the Canadian provinces were already remarkably high and then, in 1949, the entry of Newfoundland into the Canadian federation contributed to a worsening of the situation. In the 1950s and 1960s, according to Williamson (1965), the degree of regional disparity was greater in Canada than in other industrialized nations. But since the 1950s – as analysed in a series of Canadian studies carried out in the 1990s – the evolution of a variety of economic indicators (e.g. per capita income, earned income, output, and labour productivity) across the 10 Canadian provinces has been characterized by both β- and σ-convergence.[2] The poorer provinces have tended to grow faster than the rich ones (β-convergence) and the dispersion of economic indicators has shown a tendency to decrease over time (σ-convergence).

In this paper, we synthesize and extend the empirical analysis of two recent studies on the convergence of the Canadian provinces. In the first, Coulombe and Tremblay (2000) apply the theoretical framework of Barro, Mankiw and Sala-i-Martin (1995) – henceforth BMS – to the analysis of absolute convergence of per capita income and human capital indicators across the 10 Canadian provinces. In the second, Coulombe (2000) employs the conditional convergence model of Barro and Sala-i-Martin (1995) to explain the relative evolution of per capita income across the Canadian provinces in the 1950 to 1996 period. Coulombe uses relative rates of urbanization as environmental variables for steady-state provincial relative per capita income. In this paper, we analyse the interactions among human capital, urbanization, shocks to steady states, and the growth of relative per capita income across Canadian provinces in a conditional convergence framework.

The main finding of this study is that most predictions of the BMS (1995) framework are not rejected by Canadian regional empirical evidence. Both provincial relative human capital ratios and per capita incomes have converged, at an annual rate of approximately 5 percent, and the quantitative effects of urbanization and regional shocks to relative human capital and per capita income are similar, with one exception: in Alberta, the 1973 oil shock contributed to the rise in per capita income but not in human capital. In comparison, however, the negative shock in 1970 to Quebec's convergence path appears to have affected the evolution of both human capital and per capita income. Finally, we analyse the robustness of Coulombe's (2000) results with alternative panel-data econometric specifications.

The theoretical framework is highlighted in the following background section. The empirical methodology and the data are discussed in section 3 and the results presented in Section 4. We conclude in section 5 with a broad discussion of the determinants of regional growth.

2. Background

After years of focussing on business cycles, empirical macro-economics came back to the study of comparative growth in the late 1980s with the work of Baumol (1986), Barro (1991), Barro and Sala-i-Martin (1992), and Mankiw, Romer and Weil (1992).[3] The convergence property of the neo-classical growth model was the underlying framework of many of the new cross-country/region studies. Convergence implies that the steady-state equilibrium level of per capita income or output y^*_i (defined in efficiency units of labour) in economic unit i is independent of its initial $y_{i,0}$ value. During the convergence process toward steady state, the evolution of the logarithm of $y_{i,t}$ at time t is a weighted average of $y_{i,0}$ and y^*_i. Following Barro and Sala-I-Martin (1995), for periods of unit length (such as years), the convergence property could be written as

$$\log(y_{i,t}) = e_{-\beta} \log(y_{i,t-1}) + (1-e_{-\beta}) \log(y^*_i) \quad (1)$$

where parameter β is the annual speed of convergence. The economy converges to y^*_i if β is a positive fraction. With an additive error term, Eq. 1 can be tested in different ways. First, in a cross-sectional framework, Eq. 1 could be tested across N economic units for a sample of T years using only the information on $y_{i,T}$, $y_{i,0}$, and y^*_i. Second, using a pure time-series framework, it can be tested for one economic unit in a sample of T periods. Finally, cross-sectional and time-series information could be pooled in a sample of T periods across N economic units. We will follow this approach in our empirical analysis of the Canadian provinces' data set.[4]

In an absolute convergence analysis of a cross-section of countries/regions, y^*_i is assumed to be identical across the N cross-section observations. In a conditional convergence analysis, the N cross-section units are allowed to converge to different steady states y^*_i. In cross-country studies of developing and developed countries, the steady states y^*_i depend on a group of environmental variables associated with the institutional, social, political, demographic and economic policy frameworks.[5] But, in the study of regional growth within a developed country, the choice of the environmental determinants of y^*_i is more limited since most environmental cross-country variables can reasonably be assumed to be constant across relatively homogenous regions of a country such as Canada.

In this study, we follow Coulombe (2000) by using a variable based on relative urbanization rates to account for the different economic structures across the Canadian provinces. Carlino and Voith (1992) find that the percentage of the population living in metropolitan areas is an important determinant of aggregate productivity differentials across the US states. Furthermore, based on US state data covering the 1840 to 1890 period, Ades and Glaeser (1999) conclude that urbanization could be considered as a “reasonable proxy for economic development.” One could think of modelling relative y^*_i with the relative urbanization rate as a way of capturing agglomeration economies from a core-periphery structure as in Krugman (1991). A wide country with a sparsely distributed population concentrated close to its southern border with the US, Canada is a good candidate for the core-periphery structure since urbanization rates vary considerably across provinces.

The second theoretical framework used in this paper is borrowed from Coulombe and Tremblay’s (2000) empirical application of BMS’ (1995) open economy growth model, with its binding constraint for the financing of human capital, to the study of Canadian regional data sets. In their framework, BMS (1995) assume that physical capital could be financed abroad at the world interest rate whereas domestic residents cannot borrow abroad using human capital as collateral. In this framework, human capital accumulation becomes the driving force of output growth. In the case of a Cobb-Douglas production function with physical and human capital, BMS demonstrate that output per unit of labour $y_{i,t}$ could be expressed as a function of the human capital/labour ratio $h_{i,t}$ and exogenous parameters in the following way:

$$y_{i,t} = Bh_{i,t}^{\frac{\eta}{1-\alpha}} \qquad (2)$$

Here, α and η are, respectively, the elasticity of output with respect to physical and human capital; B is an exogenous parameter that should be constant across relatively homogenous economies. Coulombe and Tremblay’s (2000) analysis of human capital convergence across the Canadian provinces is based on the absolute convergence hypothesis. In this paper, we extend their empirical framework to the study of conditional convergence. Combining Eqs. 1 and 2 yields the following modified conditional convergence equation:

$$\log(h_{i,t}) = e_{-\beta} \log(h_{i,t-1}) + (1-e^{-\beta}) \log(h^*_i) \quad (3)$$

The same relative urbanization variable will be used as an instrumental determinant of the relative h^*_i. If y is a function of h as stated by Eq. 2, both should behave in a relatively similar manner in the convergence process toward steady state.

This set-up differs considerably from the one used in many cross-country studies, as in Barro (1997, 2001), where relative initial level of human capital $h_{i,0}$ is a determinant of the relative steady state of y^*_i. We will return to this difference in the role of human capital in the conclusion.

3. Empirical Methodology

The purpose of the empirical analysis is to verify if both relative $h_{i,t}$ and $y_{i,t}$ converge, at around the same speed as shown by Eqs. 1 and 3, to different long-run steady states determined by the same urbanization variable.

3.1 The Data

Our choice of human capital indicators is based on the analysis of Coulombe and Tremblay (2000). According to this study, the best available proxies of human capital at the regional level in Canada come from the percentage of males and of the population of both sexes in the population 15 years or over, and 25 years or over, who have achieved at least one university degree. In their absolute convergence framework, Coulombe and Tremblay (2000) find that (a) these indicators of human capital did converge roughly at the same speed as per capita income during the 1951 to 1996 period, and (b) the estimates of the human capital share in national income were around 0.5, a number consistent with findings in other studies.

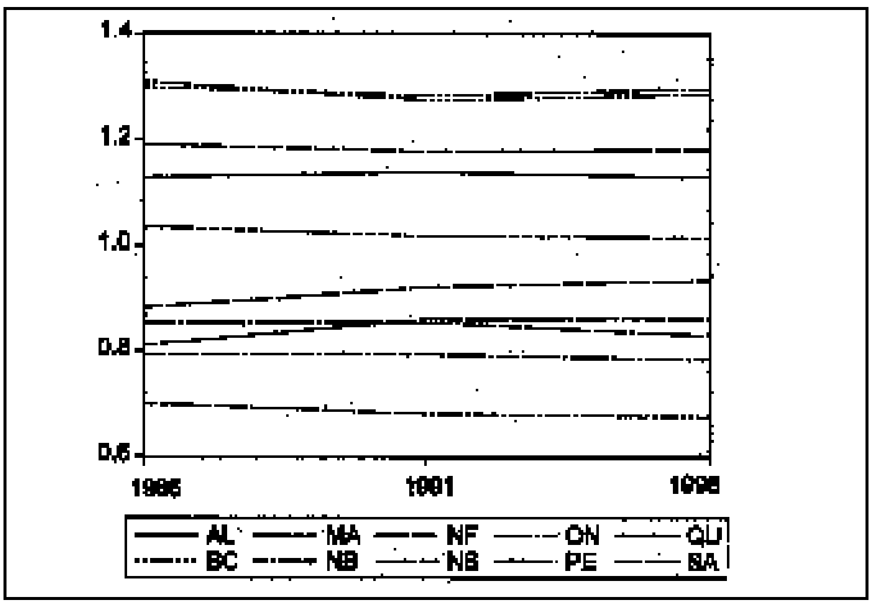
The data are taken from Statistics Canada's censuses of 1951, 1961, 1971, 1981, 1991 and 1996. For the growth regressions, human capital indicators (in common with all other variables) are measured as logarithmic differences from the unweighted sample mean. Such indexes based on the percentage of the population with at least one university degree might be useful mainly for measuring the relative stock of human capital in an economy, rather than its level, given that the provincial educational systems in Canada are relatively homogenous.

Regarding income per capita, we use provincial personal income less government transfers to individuals for the 1950 to 1996 sample.[6] As shown in previous Canadian studies following Coulombe and Lee (1995), the exclusion of transfers is important for the analysis of Canadian regional convergence, given that a substantial part of personal income disparities across Canadian provinces is smoothed by inter-regional redistribution through fiscal federalism and the tax-transfer system.

We use the urbanization variable of Coulombe (2000) computed by Ray Bollman from Statistics Canada from census data on rural/urban populations. The urban population is defined as the population living within census metropolitan areas and census agglomerations over 10 000 inhabitants. We computed one observation per province for the relative index of urbanization relative to the unweighted provincial mean urbanization rate. Despite increased urbanization since World War II, relative rankings of provinces did not change very much in recent years (see Figure 1). Since the distribution of the relative index of urbanization across the provinces appears to be comparatively stable, we assume that the relative indexes could be considered as good candidates to proxy regional differential economic structures.

Figure 1

Relative urbanization rates



3.2 Econometric Methodology

All variables are measured as deviations from the sample mean.[7] Three different panel frameworks are used. First, for the per capita income convergence regressions (1), (2) and (3) of Table 1, we pool annual data for the 10 Canadian provinces in the 1950 to 1996 sample as in Coulombe (2000):

$$GY_{i,t} = \gamma_1 Y_{i,t-1} + \gamma_2 UR_i + \gamma_3 DA_{i,t} + \gamma_4 DQ_{i,t} \\ \gamma_{5,i} AR(1) + \gamma_{6,i} AR(2) + \varepsilon_{i,t} \qquad (4)$$

$Y_{i,t}$ is per capita income of province *i* at time *t* and $GY_{i,t}$ is its annual growth rate. UR_i is the urbanization variable and *DA* and *DQ* are regional dummy variables. *DA* takes the value zero for all provinces except Alberta for which it is zero prior to 1973 and 1 thereafter. This variable is intended to capture the effect of the oil shock. *DQ* takes the value zero for all provinces except Quebec for which it is zero prior to 1970 and 1 thereafter. It is intended to account for the decline in economic activity in Montreal.[8] Finally, $e_{i,t}$ is the error term. The variables *UR*, *DA* and *DQ* are the environmental variables used to proxy the y^*_i in Eq. 1. In this framework, Alberta's and Quebec's convergence paths were disturbed by a one-time shock to their respective relative steady-state per capita income in 1973 and 1970, respectively. Given the relatively high frequency of annual data for the study of long-run growth patterns, we correct each cross-sectional unit separately for autocorrelation with *AR*(1) and *AR*(2) terms. Note that $-g_1$ is the mean annual speed of convergence for the 10 provinces in the sample.

Human capital data are not available on a yearly basis. In order to have a specification for the convergence of per capita income that is more comparable to the one used for human capital, we use a second specification of regression Eq. 4 based on periods of five years in the 1950 to 1995 sample for regression (4) in Table 1. In this framework, the *AR* parameters were not significant and were dropped from the regressions. Both the Alberta and Quebec dummy variables were found to be significant in 1970. With five-year periods, the mean annual speed of convergence is $-\log(1-5\gamma_1)/5$.

The third panel specification tests human capital convergence from Eq. 3 for regressions (5) to (8) in Table 2:

$$GH_{i,t} = \gamma_1 H_{i,t-T} + \gamma_2 UR_i + \gamma_4 DQ_{i,t} + \varepsilon_{i,t} \qquad (5)$$

Table 1

Regressions for per capita growth rate *GY*

	(1) IFGLS	(2) SUR	(3) SUR	(4) IFGLS
Observations	440	440	440	90
Y(-1)	-0.0506 (0.0135)	-0.0436 (0.0055)	-0.0411 (0.0052)	-0.0423 (0.0077)
UR	0.0393 (0.0142)	0.0286 (0.0076)	0.0262 (0.0074)	0.0339 (0.0086)
DQ	-0.0052 (0.0021)	-0.0012 (0.0013)		(-0.0037) (0.0014)
DA	0.0078 (0.0033)	0.0049 (0.0013)	0.0039 (0.0008)	0.0066 (0.0027)
Convergence speed	0.0506	0.0436	0.0411	0.0533
Elasticity to *UR*	0.78	0.66	0.64	0.8
R^2	0.23	0.13	0.13	0.2

Notes: Standard errors in parentheses. Details on estimation procedures in section 3.2.

Table 2

Regressions for human capital indicator growth rate *GH*

Human capital indicator	(5) M15	(6) M25	(7) P15	(8) P25
Observations	50	50	50	50
H(-1)	-0.0454 (0.0081)	-0.0511 (0.0067)	-0.0490 (0.0046)	-0.0559 (0.0056)
UR	0.0306 (0.0089)	0.0394 (0.0071)	0.0267 (0.0047)	0.0391 (0.0056)
DQ	-0.0029 (0.0015)	-0.0038 (0.0009)	-0.0042 (0.0010)	-0.0051 (0.0012)
Convergence speed	0.0583	0.0684	0.0464	0.0777
Elasticity to *UR*	0.67	0.77	0.54	0.7
R^2	0.72	0.75	0.79	0.77

Notes: M15 (M25) refers to the percentage of males for the population 15 years or over (and 25 years or over) who have achieved at least one university degree. P15 (P25) refers to the percentage of the population of both sexes for the population 15 years or over (and 25 years or over) who have achieved at least one university degree. Details on estimation procedures in section 3.2.

Here, data are available for 10-year periods from 1951 to 1991, and for the year 1996. $H_{i,t-T}$ is the relative human capital indicator at the beginning of the period and $GH_{i,t}$ is its mean annual relative growth rate during the period. The Alberta dummy variable was not significant and was dropped from the regressions. The annual speed of convergence is -log(1-9γ_1)/9 where 9 is the period mean.

Two different estimation procedures were used. First, in most regressions, we use iterated feasible generalized least squares (IFGLS) to account for cross-section heteroscedasticity with cross-section weighting. We are also using White's heteroscedasticity consistent errors and co-variance estimates to allow cross-sectional variances to differ across time. Second, for regressions (2) and (3) in Table 1 for the annual data specification of Eq. 4, we use SUR-weighted least squares to account for both cross-section heteroscedasticity and contemporaneous correlation. We were unable to estimate SUR-weighted least squares for the human capital and the five-year period income regressions, given the limited number of cross-section and time-series observations.[9]

4. The Results

Convergence regression results are displayed in Tables 1 and 2. Interestingly, R^2 values are much higher for human capital than for per capita income regressions. The conditional convergence hypothesis explains a much larger proportion of the evolution of human capital than of income in Canada.

Convergence Speeds

All conditional convergence speeds (estimated coefficient of *Y*(-1) and *H*(-1)) are highly significant and vary, on an annual rate (convergence speed in Tables 1 and 2), between 4.1 and 5.3 percent for per capita income and between 4.6 and 7.8 percent for human capital indicators. As expected, these conditional convergence speeds are higher than the absolute convergence speeds estimated in previous Canadian studies, including the human capital convergence analysis of Coulombe and Tremblay (2000). Omitting the determinants of long-run steady states, absolute convergence analyses tend to underestimate the convergence speed.[10] Wald tests indicate that the null hypothesis of equality between the convergence speeds of indicators of human capital based on the males and on the population of both sexes 15 years or over (regressions (5) and (7)), and the convergence speed of per capita income of regressions (1) and (4) could not be rejected. Human capital indicators based on the population 25 years or over, however, have converged significantly faster than per capita income for a relatively comparable estimation procedure (IFGLS). Consequently, the prediction of the BMS (1995) framework of both human capital and income converging at the same speed could not be rejected for the human capital indicators from the population 15 years or over.

Urbanization Variable

In all regressions, estimated coefficients of the urbanization variable *UR* are positive and very significant. The quantitative effects of relative urbanization rates on long-run relative human capital or income steady states (*UR* elasticity in Tables 1 and 2) do not differ much across different regression frameworks, ranging from 0.54 to 0.80 percent. These results indicate that, in a rich province with an urbanization rate 10 percent higher than the average, per capita income and human capital would be higher at steady state than the provincial average by an amount ranging from 5.4 to 8.0 percent.

Interestingly, the *UR* elasticity is higher for human capital indicators based on the population 25 years or over than for the population 15 years or over. One explanation of this result might be that the educated young people in poorer Canadian provinces tend to migrate to rich provinces as they age. This is a well-known fact from many Canadian interprovincial migration studies.

Quebec Dummy Variable

In all regression set-ups using IFGLS, Quebec's 1970 dummy variable *DQ* is significant at the 5 percent level with the exception of the human capital regression from males 15 years or over for which its p-value is 6.6 percent. In the SUR set-up of regression (2), the Quebec dummy variable was not significant and was dropped in regression (3). Dynamic simulations described in a later section, "SUR versus IFGLS with cross-section weighting," indicate that it might be misleading to drop Quebec's 1970 dummy variable. The quantitative effect of the negative Quebec shock on the relative human capital steady state varies from 6.4 to 8.6 percent in regressions (5) to (8). The negative long-run effect of the shock on relative per capita income is 8.7 percent in regression (4) and 10.3 percent in regression (1). Coulombe (2000) associates this shock with the economic decline of Montreal relative to Toronto and with the exodus of the well-educated English-speaking minority from the 1970s on.[11] The new results regarding human capital convergence regressions appear to support our initial diagnosis since both human capital and personal income were affected in the same way by the shock.

Alberta's Oil Shock

Alberta's dummy variable that captures the 1973 oil shock is significant at the 5 percent level in all income regressions but is not significant (with p-values ranging from 30 to 60 percent) in all (not reported) human capital regressions. The *DA* variable was dropped from the reported result in Table 2. The long-run positive-level effect on the relative per capita income in Alberta varies from 9.5 and 11.2 percent in the two SUR set-ups to 15.4 and 15.6 percent in the IFGLS regressions. These interesting results suggest that the oil shock did contribute to the substantial rise in Alberta's income. However, it did not encourage the formation of human capital through university education investment and migration into Alberta.

Incomes, but not human capital, converged to the oil barrel. The type of economic activity related to oil extraction and exploration might not be very intensive in human capital.

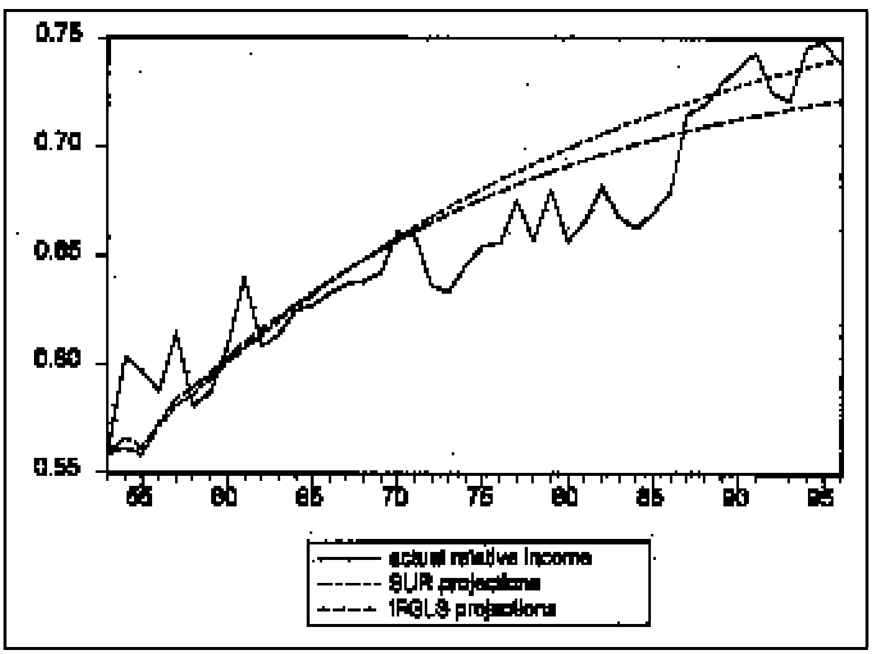
SUR Versus IFGLS with Cross-Section Weighting

The two different econometric set-ups of income regression produce substantially different results regarding the speed of convergence and the significance of Quebec's dummy variable. With SUR weighting, the speed of convergence is around 4.4 percent and Quebec's dummy variable is not significant; with the IFGLS cross-section weighting, the speed of convergence is just over 5 percent and Quebec's dummy variable is very significant. To evaluate these conflicting results, we generated panel-data models using estimated parameters from regression Eqs. 1, 3 and 4. We then proceeded to carry out dynamic simulations using historical data to 1953 in the annual set-up and to 1950 in the five-year period framework.

It is certainly a challenge to try forecasting more than 40 years of relative regional evolution. We were surprised, however, by the general fit between the predicted path and the actual data for most provinces, especially with the five-year period set-up of regression (4). Figure 2 illustrates the dynamic forecast for the relative per capita income of Newfoundland using the SUR and the IFGLS regressions in the annual set-up.

Figure 2

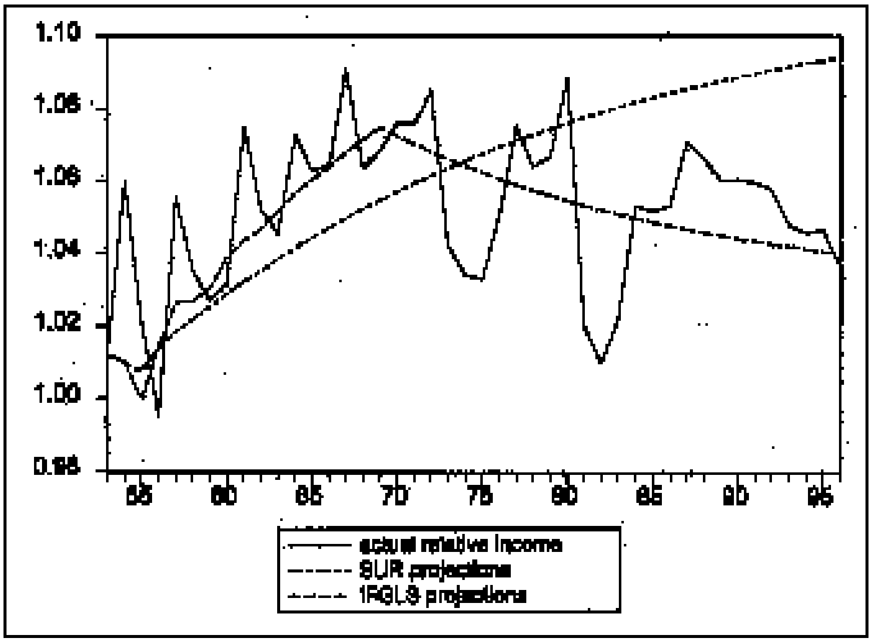
Dynamic simulation of alternative regression models, Newfoundland



Both models are good candidates to represent the long-run convergence pattern of Canada's poorest province toward its long-run relative steady state (not shown in Figure 2) below the provincial average. In both cases, Newfoundland appears to be in the neighbourhood of its long-run relative equilibrium by the end of the sample. Given the high degree of annual variation in the actual data, it is hard to guess which formulation best describes the historical behaviour. Such dynamic simulations are very sensitive to the choice of starting date since the initial year, 1953 in this case, determines the level of the convergence path toward steady state. But Figure 3, dealing with Quebec, is more revealing.

Figure 3

Dynamic simulation of alternative regression models, Quebec



The IFGLS of regression (1), borrowed directly from Coulombe (2000), is very good at tracking the broken convergence path of Quebec, disturbed in 1970 by the shock of Montreal's decline. However, the SUR representation of regression (3) does a poor job, undershooting the actual path up to 1973 and overshooting it thereafter. In the last years of data, the SUR projection does not reflect the actual evolution in Quebec.

Five-Year-Period IFGLS Dynamic Simulations

The last reported results deal with the dynamic simulations of the model created from regression (4). Four cases are displayed in Figures 4 to 7.

Figure 4

Dynamic simulation of the 5-year-period models, Quebec

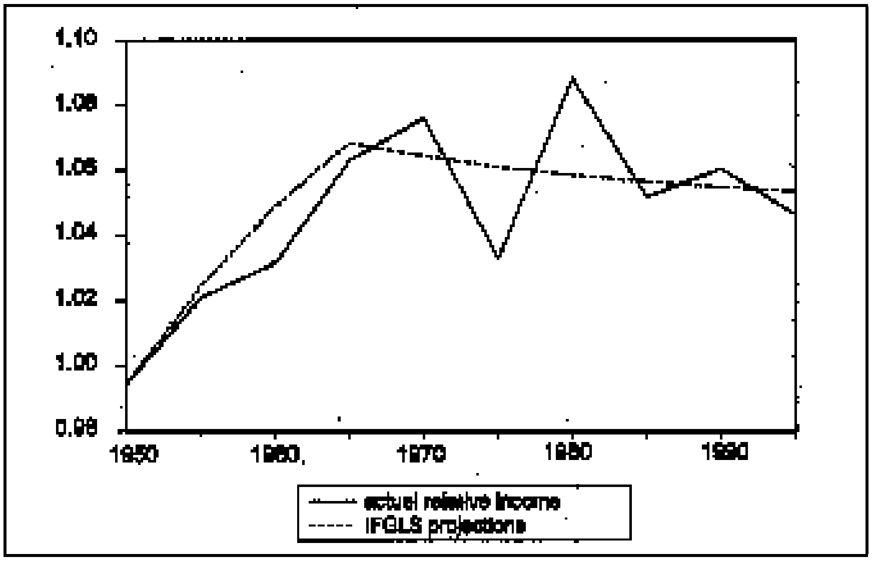


Figure 5

Dynamic simulation of the 5-year-period model, Ontario

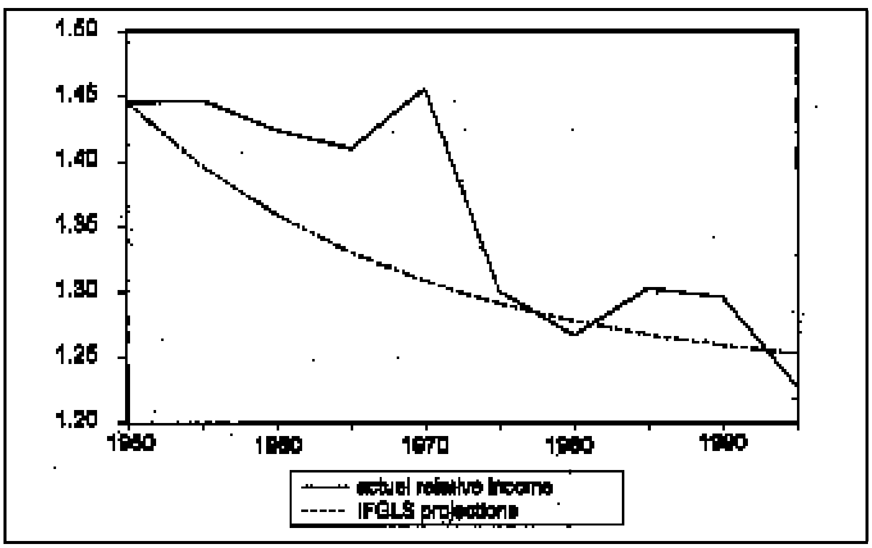


Figure 6

Dynamic simulation of the 5-year-period model, Newfoundland

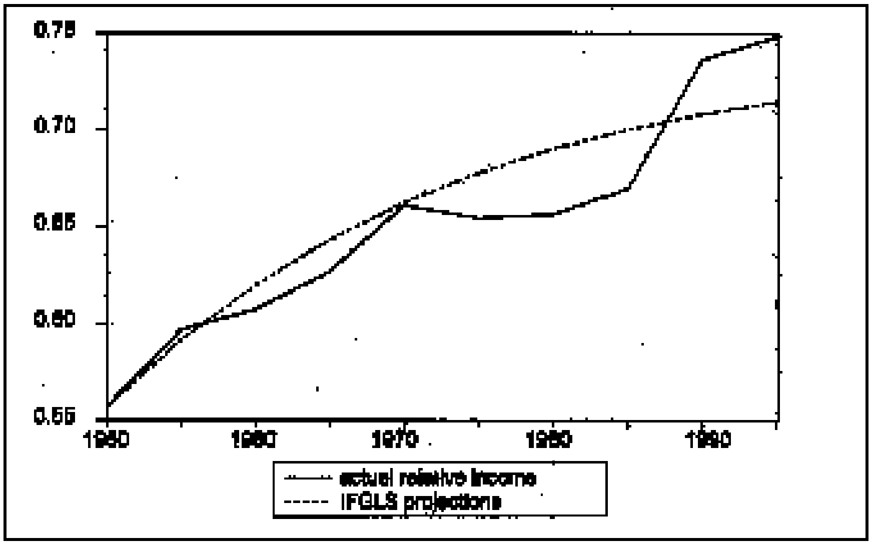
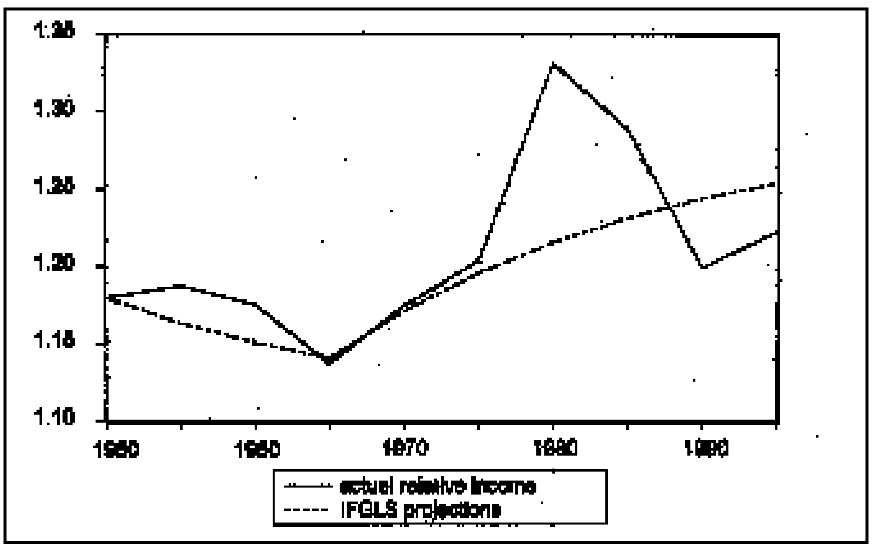


Figure 7

Dynamic simulation of the 5-year-period model, Alberta



In all cases, and for the other six non-reported cases as well, the fit between the predicted convergence path and the actual data is surprisingly good. Quebec and Newfoundland are again reported to provide comparisons with the annual models. The effect of the oil shock on Alberta's relative income is illustrated in Figure 7. The convergence path of the relatively rich province of Ontario from an initial relative situation above steady state is depicted in Figure 5.

Alternative Specifications

Contrary to the broad cross-country sample of Barro (2001), the convergence process appears log-linear as in his OECD sample. For example, when the square of $Y_{i,t\text{-}1}$ is added to the specification of regression Eq. 4, the variable is not significant with a p-value of 43 percent.

If the initial level of human capital is added as an independent variable (jointly with the initial level of income) to the specification of regression Eq. 4, the variable is not significant with a p-value of 57 percent for the P15 human capital indicator. Again, this result appears similar to Barro's (2001) findings for the income growth rate regression in the OECD sample. In the case of perfect capital mobility, it is a miss-specification to use both the log of $y_{i,0}$ and $h_{i,0}$ as independent variables in a convergence regression. In relative terms, both variables should be proportional according to Eq. 2. Coulombe and Tremblay's (2000) direct estimation of a linear version of Eq. 2 illustrates the collinearity between the two variables. When the log of relative $y_{i,t}$ is regressed on the log of relative $h_{i,t}$ in the 1951 to 1996 sample (without a constant), in the case of the P15 indicator of human capital, the estimated coefficient is 0.73 and the R^2 is 0.76. The implicit estimated human capital share η, which is 0.73(1-α), is 0.49 and is consistent with other measures of the human capital share as in Mankiw, Romer and Veil (1992).

Finally, when the initial level of income is dropped from the specification of regression Eq. 4 and the initial level of human capital is added as an independent variable, the human capital variable is highly significant, as in Coulombe and Tremblay (2000). In the case of the P15 human capital indicator, the estimated coefficient is -0.007 with a t-statistic of -6.8. In this case, however, the urbanization variable is no longer significant. This modified income convergence regression underlines a causal relationship from initial human capital to future income growth.

5. Concluding Discussion

The analysis in this paper illustrates the usefulness of the conditional convergence model and of the neo-classical growth model of an open economy by BMS for explaining regional developments in Canada since 1950. Since World War II, it appears that both relative per capita income and human capital indicators in the Canadian regions did converge at a speed of about 5 percent per year to different long-run steady states, determined mainly by relative urbanization. The analysis appears robust to pooling periods of one, five and ten years and to alternative econometric specification. Furthermore, models created from panel regressions illustrate the usefulness of the approach with dynamic simulations.

The usefulness of the time-series dimension of the study over the pure cross-section approach is highlighted by the structural shocks to the relative steady state of Alberta and Quebec in the 1970s. The two shocks did not appear symmetrical. The shift of economic activity from Montreal to Toronto translates into a decrease of both relative human capital and per capita income in Quebec. In Alberta, the oil shock was an attractor of income and people but did not appear to affect the relative human capital ratio significantly compared with the other provinces. Given the relative slowness of the convergence process, a one-time shock to steady state has a long-lasting effect on growth rates and implies a change in the slope of the convergence transitory path.

This paper ends with a discussion of the role of human capital and urbanization in economic growth. In broad, cross-country per capita growth studies such as Barro (1997, 2001), the initial relative level of human capital – habitually measured by advanced educational achievement – is often used as an initial state variable. Initial human capital, especially university education of males, appears to produce in this framework a significant positive effect on per capita growth. In this paper, however, human capital is instead used as an endogenous variable in the convergence process; and it performed its role extremely well, better even than per capita income. The difference in the role of human capital in the two types of studies might be attributed to the **heterogeneity** problem raised by Harberger in 1987 regarding broad-sample cross-country regressions.[12] In a cross-country regression including Nepal, Japan, Canada, Spain, Guatemala and Algeria, the initial level of human capital might be a good proxy for the substantial differences, to say the least, in the political, institutional and social (PIS) characteristics across the countries. It might be the differences in the PIS characteristics that make the initial human capital state variable significant with a positive sign. In Canada (perhaps with the exception of Quebec whose French cultural heterogeneity is captured with a dummy variable in this paper), the PIS characteristics are relatively homogenous across the provinces. In this relatively homogenous data set, initial human capital is negatively correlated with future income growth by the convergence framework since per capita income is a function of human capital, and initial income is negatively correlated with future growth. But in a homogenous empirical framework, human capital does not capture PIS heterogeneity; it captures only what it is – human capital. And it is endogenous to the growth process.

The same could be said about other variables such as the one for population growth. This variable might reflect a good amount of PIS heterogeneity in broad cross-country growth studies whereas it might reflect a completely different situation in studies of Canadian regions. Across Canadian provinces, population growth is driven mainly by interprovincial and international migration and people are known to migrate to the rich provinces of Ontario, Alberta and British Columbia. In international studies of developing and developed countries, the population growth variable might capture effects related to the role of women within the family, the society and other key social organizations that are very hard to measure.

But the geographical, climatological and the natural resources (GCR) characteristics of the Canadian provinces are not that homogenous. The dummy variable for Alberta's oil shock captures part of the GCR heterogeneity associated with resources endowment. However, part of what remains in the GCR heterogeneity may be captured by the urbanization variable. Maybe people and human capital congregate in pleasant, safe areas in good locations with an agreeable climate. Perhaps these factors are driving the urbanization variable. But this variable might capture many other factors that are hard to measure; many things occur when many people assemble in one location.

The choice of language used in economic activities and the educational system might be viewed as one characteristic of the social network. In this context, Quebec's 1970 dummy variable might be viewed as representing the shift from English to French as the dominant economic language. The well-educated English-speaking minority of Montreal might not have been comfortable with this shift affecting their social network and might have decided to move out of the province. From an aggregated point of view, there was a negative effect on the Quebec growth path, as illustrated in this study. But, as shown in Coulombe (2000), French-speaking Quebeckers' incomes have been closing the gap with Ontario's incomes since 1970. With the exodus of its English elite, Quebec as a province might be poorer, but the income of its French-speaking population has risen.

Notes

1 Some empirical results are taken from Coulombe (2000), which is forthcoming in Regional Studies.

2 Empirical studies on the convergence of Canadian regional data include Coulombe and Lee (1993, 1995, 1998), Helliwell and Chung (1991), Helliwell (1994), Lee (1997), Lee and Coulombe (1995) and Lefebvre (1994). Coulombe and Day (1999) provide a comparative analyses with US border states. The Canadian regional growth studies on con-

vergence are reviewed and synthesized in Coulombe (1999).

3 For a survey of the new growth evidence, see Temple (1999).

4 For a discussion of empirical methodology associated with the estimation of Eq. 1, see Barro (1997, chapter 1) and Temple (1999, sections 3 to 5).

5 See Barro (1997) for an example of conditional convergence cross-country studies.

6 Personal income data were taken from the CANSIM series D11701-D11710; data for government transfers were taken from various series in Statistics Canada Catalogue No. 13-213.

7 Variables are entered in the regressions as log(*Xi,t*/MEAN(*Xi,t*) where MEAN(*Xi,t*) is the unweighted mean of *Xi,t* across the 10 units *i*.

8 For more detail on the choice of the date of the structural shock and the possibility of shocks to other provinces, see Coulombe (2000).

9 Estimations and dynamic simulations were performed using EViews 3.1.

10 For a discussion of this problem, see Barro (1997, Chapter 1).

11 See Coulombe (2000) for a broad discussion on the Quebec shock.

12 For an analysis of this point, see Temple (1999, section 4.1).

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