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Human Capital, Urbanization, and Canadian Provincial Growth

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Human Capital, Urbanization, and Canadian Provincial Growth*

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Summary: This paper investigates the conditional convergence of both human capital indicators and nominal per capita income across Canadian provinces in a panel-data empirical framework. Long-run relative provincial steady states are determined by relative rates of urbanization, one-time shocks to Quebec's and Alberta's relative steady states, and a Nova Scotia fixed effect. Indicators of relative human capital ratios appear to have converged following a pattern that is common and similar to per capita income but with two notable exceptions. First, in Alberta, the 1973 oil shock contributed to the rise in per capita income but its effect on human capital is significant only for females. Second, human capital appears to remain concentrated in the relatively poor province of Nova Scotia. Two notable findings come out of the analysis. First, nominal income disparities at the provincial level appear to be real, not just nominal. Second, the analysis suggests that at the regional level, human capital is a necessary but not sufficient condition for being wealthier in the long run.

JEL classification: O41, F43, J24, R11, R12, and R15
Keywords: convergence, urbanization, regional growth, human capital, Canadian regions, neo-classical growth model

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1. Introduction

The Canadian federation is an interesting source of empirical evidence concerning regional growth patterns, for two reasons. First, many provincial data are available on a long time-series basis, due to Statistics Canada's work. Second, regional disparities in per capita income across the Canadian provinces were already remarkably high up to World War II; then in 1949, the entry of Newfoundland into the Canadian federation contributed to a worsening of the situation.[1] But since the 1950s—as analysed in a series of Canadian studies carried out starting in the 1990s—the evolution of a variety of economic indicators (such as per capita income, earned income, output, and labour productivity) across the 10 Canadian provinces has been characterized by both β and σ-convergence.[2]

In a recent study, Coulombe (2000) employs the conditional convergence model in order to explain Canadian provincial growth since 1950. He concludes that since the mid-1980s, most Canadian provinces are in the neighborhood of their respective steady states, which are essentially determined by relative rates of urbanization. More urbanized provinces are richer, but the long-run regional income disparities are comparatively modest; the standard deviation of provincial per capita income by the end of the 1990s is just above 10%. However, this analysis is based on nominal differences in regional incomes, since comparable price level data are not available for Canadian provinces.[3] If the cost of living is higher in cities, the long-run differences detected by Coulombe (2000) might be mainly the result of higher costs of living in richer provinces. Thus the differences in per capita income might be nominal but not real! Given the unavailability of data to convert the analysis into real relative per capita income, the critique appears hard to overcome. In this paper, I try by an indirect approach to verify if long-run differences in per capita income across Canadian provinces are nominal or real by applying

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1 In the 1950s and 1960s, according to Williamson (1965), the degree of regional disparity was greater in Canada than in other industrialized nations.

2 Empirical studies on the convergence of Canadian regional data include Coulombe and Lee (1993, 1995, and 1998); Helliwell and Chung (1991); Helliwell (1994); Lee (1997); Lee and Coulombe (1995); and Lefebvre (1994). Coulombe and Day (1999) provide a comparative analysis with U.S. border states. The Canadian regional growth studies on convergence were reviewed and synthesized in Coulombe (1999).

3 Consumer price indices for the Canadian provinces are normalized at 100 in the base year and can only be compared in first differences. Recently, Statistics Canada has published comparable consumer price indices for the major Canadian cities.

the same conditional convergence framework of Coulombe (2000) to the analysis of both human capital indicators and per capita income across Canadian provinces. The idea is based on the empirical work of Coulombe and Tremblay (2001) that applies 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 ten Canadian provinces. If the same model of conditional convergence explains comparable long-run differences in per capita income and human capital, one should conclude that provincial income differences, are real unless educated people living in cities have a higher preference for leisure.

Many interesting findings emerge from the comparative exercise. The quantitative effects of urbanization on steady-state relative human capital and per capita income are very comparable and the long-run differences in per capita income appear to be real. In general, both income and human capital appear to converge to highly urbanized provinces and the negative shock in 1970 to Quebec's convergence path appears to have affected the evolution of both human capital and per capita income. There are, however, some notable exceptions to the parallel evolution of human capital and income, necessitating modifications to the conditional convergence framework of Coulombe (2000) so it would adequately reflect the regional evolution of human capital in Canada. In Alberta, the 1973 oil shock contributed to a rise in per capita income but its effect on human capital is not significant for the indicators based on male education. Furthermore a dummy variable had to be added to the human capital convergence model to capture a sizable and significant positive fixed effect in the relatively poor province of Nova Scotia. Finally, in these different conditional convergence frameworks, human capital appears to have converged significantly faster in most cases than per capita income. At the end of the paper, we present historical dynamic simulations of the human capital and per capita income conditional convergence models that emphasize how useful the approach is to explain Canadian provincial growth since 1950.

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.

2. Background

After years of focussing on business cycles, empirical macroeconomics returned in the late 1980s to the study of comparative growth with the work of Baumol (1986), Barro (1991), Barro and Sala-i-Martin (1992), and Mankiw, Romer, and Weil (1992).[4] 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 *P* years, the convergence property could be written as

$$\log\left(\frac{y_{i,t}}{y_{i,t-P}}\right) = -(1-e^{-\beta P})\log(y_{i,t-P}) + (1-e^{-\beta P})\log(y^*_i), \qquad (1)$$

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, equation (1) can be estimated in different ways. First, in a cross-sectional framework, equation (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.[5]

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

4 See Temple (1999) for a survey of the new growth evidence.

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

economic policy frameworks.[6] 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) report that the percentage of the population living in metropolitan areas is an important determinant of aggregate productivity differentials across the U.S. states.[7] Furthermore, based on U.S. state data covering the 1840–1890 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). As a wide country with a sparsely distributed population concentrated close to its southern border with the United States, Canada is a good candidate for the core-periphery structure.

The second theoretical framework used in this paper comes from Coulombe and Tremblay's (2001) 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. 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

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

7 Other variables, including fixed effects (with the exception of the Nova Scotia fixed effect for the human capital convergence equation) such as net migration flows, and human capital dotations were not significant when the urbanization variable was included in the specification regression equation.

$h_{i,t}$ and exogenous parameters in the following way:

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

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. Combining equations (1) and (2) yields the following modified conditional convergence equation:

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

Coulombe and Tremblay's (2001) 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. The same relative urbanization variable utilized in the convergence regression of per capita income will be used as an instrumental determinant of the relative h^*_i. If y is a function of h as stated by equation (2), both should behave in a relatively similar manner in the convergence process toward steady state.

3. Empirical methodology

The purpose of the empirical analysis is to verify if both relative $h_{i,t}$ and $y_{i,t}$ converge, following a similar pattern as shown by equations (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 (2001). According to this study, the best available proxies of aggregate 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 and over, and 25 years and over, who have achieved at least

one university degree (M15, M25, P15, and P25 respectively for the remainder of the study). In their absolute convergence framework, Coulombe and Tremblay (2001) find that (a) these indicators of human capital did converge at roughly the same speed as per capita income during the 1951–1996 period; and (b) the estimates of the human capital share in national income with these indicators were around 0.5, a number consistent with findings in other growth studies (as in Mankiw [1995]). Since results for human capital indicators differ interestingly across sexes in the conditional convergence framework used in this model, we also produce results based on the percentage of the female population 15 years and over, and 25 years and over, who have achieved at least one university degree (F15 and F25 for the remainder of the study).

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 for measuring mainly the relative stock of human capital in an economy, rather than its level, given that provincial educational systems in Canada are relatively homogenous.

Regarding per capita income, we use provincial personal income less government transfers to individuals for the 1950–1996 sample.[8] As shown in previous Canadian studies following Coulombe and Lee (1995), the exclusion of transfers is important for the analysis of Canadian regional convergence. This is because a substantial part of personal income disparities across Canadian provinces is smoothed by interregional redistribution through fiscal federalism and the tax-transfer system.

We use the urbanization variable of Coulombe (2000), computed by Ray Bollman of 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 with 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 have not changed very much in

8 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.

recent years and the distribution of the relative index of urbanization across the provinces appears to be comparatively stable (see Figure 1). We assume that the relative indexes could be considered good candidates to proxy regional differential economic structures. Finally, all variables are measured as deviations from the sample mean.[9]

Insert Figure 1 here

3.2 Econometric methodology

Coulombe (2000) pools annual data of per capita income for the 10 Canadian provinces in the 1950–1996 sample. However, human capital data are not available on a yearly basis. To have a specification for the convergence of per capita income that is more comparable to the one used for human capital, we use an alternative pooling based on 5-year periods in the 1950–1995 sample for per capita income. The convergence regression equation used to test equation (1) for per capita income is the following:

$$GY_{i,t} = \gamma_1 Y_{i,t-P} + \gamma_2 UR_i + \gamma_3 DA_{i,t} + \gamma_4 DQ_{i,t} + \varepsilon_{i,t}. \quad (4)$$

$Y_{i,t}$ is the per capita income of province *i* at the end of period *t* and $GY_{i,t}$ is its mean annual growth rate during period *t*. $UR_{i,}$ 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 1970 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.[10] Finally, $G_{i,t}$ is the error term. The variables *UR*, *DA*, and *DQ* are the environmental variables used to proxy the y^*_i in equation (1). Both the Alberta and Quebec dummy variables were found to be significant in 1970.[11] In this framework, Alberta and Quebec's convergence paths were disturbed

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9 Variables are entered in the regressions as $\log(X_{i,t}/\text{MEAN}(X_{i,t}))$ where $\text{MEAN}(X_{i,t})$ is the unweighted mean of $X_{i,t}$ across the 10 units *i*.

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

11 In the annual set-up of Coulombe (2000), 1973 was the year in the data that maximise the *t* statistics for the parameter of the Alberta's oil shock variable.

by a one-time shock to their respective relative steady-state per capita income in 1970. With 5-year periods and the dependant variable measured at annual growth rate, the mean annual speed of convergence is $-log(1-5\gamma_1)/5$.

The panel regression equation for human capital convergence from equation (3) is the following:

$$GH_{i,t} = \gamma_1 H_{i,t-P} + \gamma_2 UR_i + \gamma_3 DA_{i,t} + \gamma_4 DQ_{i,t} + \gamma_5 DNS + \varepsilon_{i,t} \qquad (5)$$

Here, we use 10-year periods from 1951 to 1991, and the observation for the year 1996. $H_{i,\,t-P}$ 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 found to be not significant in most cases and was dropped from some regressions. The annual speed of convergence is $-log(1-9\gamma_1)/9$ where 9 is the period mean. Details on estimation procedures (iterated feasible generalized least-squares, or IFGLS) are given in the notes to Table 1.[12]

4. The results

Convergence regression results are displayed in Table 1 for per capita income and in Table 2 for human capital indicators. Interestingly, R^2 values are much higher for the human capital than for the per capita income regression. The conditional convergence hypothesis explains the evolution of human capital in Canada much more than it does the evolution of income. Generally, the evolution of human capital indicators is smoother than that of income. It could thus be better represented by a long-run model.

Insert tables 1 and 2 here

12 In the symposium paper, we compare IFGLS with seemingly unrelated regressions (SUR) results for per capita income convergence regression. SUR estimations could not be performed on human capital regressions, given the limited number of time-series observations.

4.1 Convergence speeds

All conditional convergence speeds (estimated coefficient of $\log(Y_{-1})$ and $\log(H_{-1})$) are highly significant and vary on an annual rate (convergence speed in Tables 1 and 2) between 4.75 per cent for per capita income and between 5.8 and 9.4 per cent 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 (2001). Omitting the determinants of long-run steady states, absolute convergence analyses tend to underestimate the convergence speed. Wald tests indicate that the null hypothesis of equality between the convergence speeds of indicators of human capital based on males 15 years and over, and the convergence speed of per capita income, could not be rejected. The other human capital indicators, however, have converged significantly faster (at the 5 per cent critical level) than per capita income. Consequently, the prediction of the BMS (1995) framework—both human capital and income converging at the same speed—could be rejected for most but not all human capital indicators.

4.2 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 Table 3 equal to $-\gamma_2/\gamma_1$ in the set-up of equation 4) do not differ much, ranging from 0.58 to 0.82. These results indicate that, in a rich province with an urbanization rate 10 per cent 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 5.8 to 8.2 per cent. This is one of the major findings of the paper since it indicates that nominal income differences across provinces are real and not just nominal.

Insert Table 3 here

4.3 Quebec dummy variable

In all regression set-ups, Quebec's 1970 dummy variable *DQ* is significant at the 5 per cent level with the exception of the human capital regression for males 15 years and over for which its *p*-

value is 6.6 per cent. The quantitative effect of the negative Quebec shock on the relative human capital steady state ($-\gamma_4/\gamma_1$ in the set-ups of equations 4 and 5) varies from 6.9 to 10.0 per cent for P15, P25, M15, and M25. These numbers are very similar to the negative long-run effect of the shock on relative per capita income, which is 8.7 per cent. 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.[13] The new results regarding human capital convergence regressions concur with the initial diagnosis since both human capital and personal income were affected in a similar way by the shock.

4.4 Alberta's oil shock

Alberta's dummy variable that captures the 1973 oil shock is significant at the 5 per cent level in the income regression but is not significant (with *p*-values ranging from 30 to 60 per cent) in human capital regressions based on P15, P25, M15, and M25. The long-run positive level effect on the relative per capita income in Alberta is 15.7 per cent. 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 is possibly not be very intensive in human capital.

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

4.5 The Nova Scotia fixed effect

The dummy variable for the Nova Scotia fixed effect on human capital is positive and significant at the 1 per cent level for all human capital indicators. Other things being equal, human capital tends in the long run to remain in this relatively poor and less urbanized province. The quantitative long-run effect is sizable ranging between 6.2 to 9.5 per cent for various human capital indicators.

Before advancing explanations for this interesting and relatively surprising finding (compared to the Quebec and Alberta shocks), some brief comments on Nova Scotia's university system are worth considering. University education has a long and rich history in this relatively small Atlantic province (fewer than 1 million inhabitants). Nova Scotia has one large (Dalhousie University) and numerous small and medium-sized universities. The oldest, the University of King's College (now affiliated to Dalhousie) was founded in 1789. Four other universities were founded between 1802 (St. Mary's University) and 1873 (Mount Saint Vincent University). Acadia University, founded in 1838, has been consistently ranked by an independent Canadian university ranking body[14] as one of the best overall, primarily undergraduate universities in Canada. Saint Francis Xavier University, founded in 1853, was the first North American university to teach female students while Mount Saint Vincent University was the first to teach female students exclusively.

Given this record, one should not be surprised to find that Nova Scotians are well endowed in human capital as demonstrated by the Nova Scotia fixed effect. What is really striking, however, is that despite their educational achievement, Nova Scotians appear to remain relatively poor. Interpreted in the framework of the conditional convergence model, the Nova Scotia case suggests that human capital is a necessary but not sufficient requirement for having a higher income in the long run. Without higher urbanization, human capital does not generate higher (post-transfer) income. Why do educated Nova Scotians not migrate to urbanized provinces in order to generate more income? Well, they do migrate (as demonstrated in the next paragraph) but the migration flow is not sufficient to compensate for the propensity of educated Nova Scotians to remain in their beloved province.

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14 University rankings are produced in Canada by the magazine, *Maclean's*.

4.6 Quantitative effect on 25 years and over indicators versus 15 years and over

Interestingly, the *UR* elasticity is higher for human capital indicators based on the 25 years and over (M25 and P25) groups than for the 15 years and over (M15 and P15). Similarly, the quantitative negative effect of Quebec's shock is more important for human capital indicators based on the 25 years and over than for the 15 years and over. The positive quantitative effect of the Nova Scotia fixed effect is smaller for the 25 years and over than for the 15 years and over. All these results could be explained by one well-known fact that comes out of many Canadian interprovincial migration studies: the educated young people in poorer Canadian provinces (such as Quebec and Nova Scotia) tend to migrate to rich provinces (Ontario, Alberta, and British Columbia) as they get older. Interpreted in the framework of this paper, generally the educated young in poor provinces tend to migrate to more urbanized provinces as they get older (over 25 year of age). More specifically, this pattern emphasizes the 1970 exodus of Anglophones from Quebec and mitigates the tendency of educated Nova Scotians to remain in their relatively poor province.

4.7 Convergence regressions for female education indicators

Estimations results for the human capital convergence regression based on female university education (F15 and F25) are presented in Table 4. On qualitative grounds, results concur with the preceding analysis, with one notable exception. The Alberta dummy variable is significant at the 10 per cent level for the F15 indicator and at the 1 per cent level for the F25 indicator. The oil shock appears to have attracted educated females but not educated males. We have two possible explanations for this situation. First, the wealth generated by oil extraction might have boosted the service sector and the demand for educated females. Second, possibly both educated males and females were attracted to Alberta by the economic boom following the oil shock, but the aggregate effect of the shock on male educational achievement was alleviated by the massive inflows of non-educated males working in the oil extraction and construction industries.

On quantitative grounds, it interesting to note that both the long-run effect of Quebec's shock and the Nova Scotia fixed effect are significantly larger for female than for male education. We do not have an explanation for this intriguing result.

4.8 Dynamic simulations

We generated panel-data models using estimated parameters from regression equations (4) and (5). We then carried out dynamic simulations using only initial historical data (1950 for per capita income and 1951 for the P15 human capital indicator) and the urbanization variable (one observation per province).

It is certainly a challenge to try forecasting 45 years of relative regional evolution. We were surprised, however, by the general fit between the predicted path and the actual data for most provinces.

Insert Figures 2a to 2f here

First, we report the dynamic forecast for provincial relative per capita income (provincial average equals 1) of the model created from regression (4). Six cases are displayed in Figures 2a to 2f. In each figure, the predicted path is confronted with actual data for the 1950–1995 period. In all cases, and for the four other non-reported cases as well, the fit between the predicted convergence path and the actual data is surprisingly good. These results illustrate the robustness of Coulombe's (2000) results obtained with an annual set-up of the same conditional convergence model. The effect of the oil shock on Alberta's relative income is illustrated in Figure 2a and the negative effect of the Quebec shock on its relative income is depicted in Figure 2f. The catch-up process of Newfoundland since 1950 is portrayed extremely well by the conditional convergence model (Figure 2b). The convergence path of the relatively rich province of Ontario from an initial relative situation above steady state is depicted clearly in Figure 2d.

The overall picture does not change much when different years are chosen as the starting point for the simulation. For an individual province, however, the choice matters since the province might be experiencing a temporary boom or slowdown. The *level* of the transitory path toward the steady state for a given province is determined by its relative initial situation in the year arbitrarily chosen to start the simulation. Figure 2e illustrates a problem that could surface because of this, as shown in the case of Prince Edward Island. Even though the actual income ended right on the predicted path after 45 years of evolution, one could argue that the convergence model does not adequately explain the economic development of this poor province

since the predicted path overshoots the actual path between 1950 and 1995. But when we start the dynamic simulation in 1955, this overshooting completely disappears and the actual path evolves around the predicted path. All dynamic simulation results (including the next on human capital) should be interpreted with this point in mind.

Insert Figures 3a to 3j here

Dynamic simulations of the human capital convergence model created from equation (5) are reported in Figures 3a to 3j for the P15 indicator of the 10 provinces. With the exception of Nova Scotia and Quebec, the human capital conditional convergence model predicts that provinces should converge to their long-run equilibrium determined by their relative urbanization at a speed of about 6.6 percent per year. For Quebec, the convergence process was disturbed in 1970 by a negative permanent level shock to its long-run steady state. Nova Scotia constitutes a special case with its significant positive fixed effect. With the exception of the prairie provinces of Alberta and Manitoba (Figures 3a and 3b), the fit between the predicted and the actual paths is remarkably good even though, interestingly, it appears that Newfoundland's human capital started to converge only in 1961 (Figure 3c).

For the case of Nova Scotia (Figure 3j), the predicted path for the model without the fixed effect (predicted rejected model) is shown with the predicted path of the base model including the fixed effect. The rejected model indicates clearly the danger of performing dynamic simulation over 45 years of data when the model is inadequate. Based only on its relatively low urbanization, Nova Scotia's human capital was supposed to be close to its long-run level, below the Canadian average, in 1951. The fixed effect captures the long-run positive gap in Nova Scotia relative human capital and the P15 indicator appears to converge at the predicted 6.6 per cent annual speed in common with the other provinces. The same type of analysis is performed with the case of Quebec (Figure 3i) for which two predicted paths are shown. The model without the Quebec 1970 break (predicted rejected model) systematically overshoots the actual path after the 1960s, contrary to the base model that does include the break.

Even though the conditional convergence model appears to reasonably predict the long-run relative human capital stock of Alberta and Manitoba, the predicted path significantly

undershoots the actual path for these two provinces. Manitoba's picture would look much better, however, if we start the dynamic simulation in 1961. However, even in this case, the transitory path for the evolution of Alberta's human capital stock is poorly explained by the conditional convergence model.

5. Conclusion

This paper proposes a comparative analysis of the evolution of human capital and per capita income across the 10 Canadian provinces since 1950, using the conditional convergence property of the neo-classical open economy growth model of BMS (1995) as the underlying theoretical framework. The dynamic simulation analysis illustrates the usefulness of the approach for explaining long-run regional developments in Canada.

Since 1950, it appears that both relative per capita income and human capital indicators in the Canadian regions did generally converge to different long-run steady states determined mainly by their relative urbanization. Human capital tends to concentrate in more urbanized regions and this suggests that the remaining per capita income differences across Canadian provinces are real and not just nominal.

The advantage of the time-series dimension of the study over the pure cross-section approach is highlighted by the analysis of structural shocks to relative steady states. We could find two significant regional steady-state shocks, the Alberta oil shock and the exodus of Anglophones from Quebec in the early 1970s. The two shocks did not appear similar in nature. 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, people, and educated females, but it did not appear to significantly affect the relative human capital ratio compared with the other provinces.

The difference in the nature of the Quebec and Alberta shocks might be interpreted as an example of the limitations of the aggregative neo-classical growth approach to capture regional developments. In the BMS framework, physical capital is freely financed abroad, the formation of human capital is the only driving force of regional development during the transition process toward steady state, and both relative human capital and per capita income evolve symmetrically. This story appears to better represent Quebec's relative evolution in the 1970s

since its relative decline might be associated with a human capital shock. But the effect of the oil shock on the relative fortunes of an oil-producing province is something that goes beyond the neo-classical growth model. Not surprisingly, the evolution of per capita income and human capital does not appear symmetrical in this case.

But perhaps the most important contribution of this paper is to show that, despite a relatively high long-run relative human capital level, a province such as Nova Scotia might remain relatively poor in the long-run. This result suggests that, at the regional level, human capital is a necessary but not sufficient condition for being wealthier in the long run. What *is* necessary and sufficient is human capital concentration coupled with higher urbanization.

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Table 1. Estimation results for income convergence regression (equation 4)

$\log(Y_{-1})$	-0.042*** (0.0077)
UR	0.0339*** (0.0087)
DATABASES	0.0066** (0.0027)
DQ	-0.0037*** (0.0014)
Annual convergence speed	0.0475

Total panel observations: 90. Sample: 1950–1995.
S.E. of regression 0.0119. R-squared 0.26.

Notes: Iterated feasible generalized (linear) least-squares estimations using cross-section weighted regressions to account for cross-sectional heteroskedasticity. The ***, **, and * indicate that the null hypothesis could be rejected at 1 per cent, 5 per cent, and 10 per cent critical levels, respectively. White heteroskedasticity-consistent standard error (between brackets) (HCCME) allows for asymptotically valid inferences in the presence of heteroskedasticity. Estimations are done using EViews 3.1.

Table 2. Estimation results for human capital convergence regression (equation 5)

Human capital indicator	P15	P15	P25	P25	M15	M25
$\log(H_{-1})$	-0.049*** (0.0045)	-0.050*** (0.0046)	-0.062*** (0.0048)	-0.063*** (0.0049)	-0.045*** (0.0082)	-0.053*** (0.0067)
UR	0.029*** (0.0046)	0.029*** (0.0047)	0.049*** (0.0051)	0.050*** (0.0053)	0.031*** (0.0091)	0.044*** (0.0072)
DA	---	0.0048 (0.0058)	---	0.0074 (0.0050)	---	---
DQ	-.0045*** (0.00096)	-.0045*** (0.00097)	-.0062*** (0.0012)	-.0063*** (0.0012)	-0.0031* (0.0016)	-.0041*** (0.00093)
DNS	0.0047*** (0.00043)	0.0048*** (0.00043)	0.0050*** (0.00041)	0.0051*** (0.00042)	0.0041*** (0.00065)	0.0033*** (0.00053)
Conver-gence speed	0.066	0.067	0.091	0.094	0.058	0.072
S.E. of regression	0.0092	0.0092	0.0093	0.0092	0.0059	0.0068
R-squared	0.81	0.81	0.81	0.82	0.74	0.76

Notes: See note to Table 1 for estimation procedures. Sample 1951–1996. 50 panel observations. P15 (P25) refers to the percentage of the population of both sexes for the population 15 years and over (and 25 years and over) who have achieved at least one university degree. M15 (M25) refers to the percentage of males for the population 15 years and over (and 25 years and over) who have achieved at least one university degree.

Table 3. Long-run effect of environmental variables

Dependant variable	Per capita income	P15	P25	M15	M25
Elasticity to UR	0.8	0.58	0.79	0.67	0.82
Quebec's shock	-0.087	-0.09	-0.1	-0.069	-0.078
Alberta's shock	0.157	---	---	---	---
NS fixed effect	---	0.095	0.081	0.091	0.062

Note: Computed from Tables 1, 2, and 3 using long-run solutions of equations (4) and (5).

Table 4. Estimation results for convergence regression equation (5) for female education

Human capital indicator	F15	F25
$\log(H_{-1})$	-0.083*** (0.0016)	-0.071*** (0.0022)
UR	0.069*** (0.0020)	0.058*** (0.0029)
DA	0.0086* (0.0045)	0.011*** (0.0040)
DQ	-0.014*** (0.00083)	-0.013*** (0.0010)
DNS	0.014*** (0.00055)	0.0098*** (0.00047)
Convergence speed	0.15	0.11
S.E. of regression R-squared	0.016 0.93	0.015 0.89
Elasticity to UR	0.83	0.81
LR effect of Quebec's shock	-0.165	-0.186
LR effect of Alberta's shock	0.104	0.155
LR effect of NS fixed effect	0.167	0.138

Notes: See note to Table 1 for estimation procedures. Sample 1951–1996. 50 panel observations. F15 (F25) refers to the percentage of the female population for the population 15 years and over (and 25 years and over) who have achieved at least one university degree.

Figure 1: Relative urbanization rates

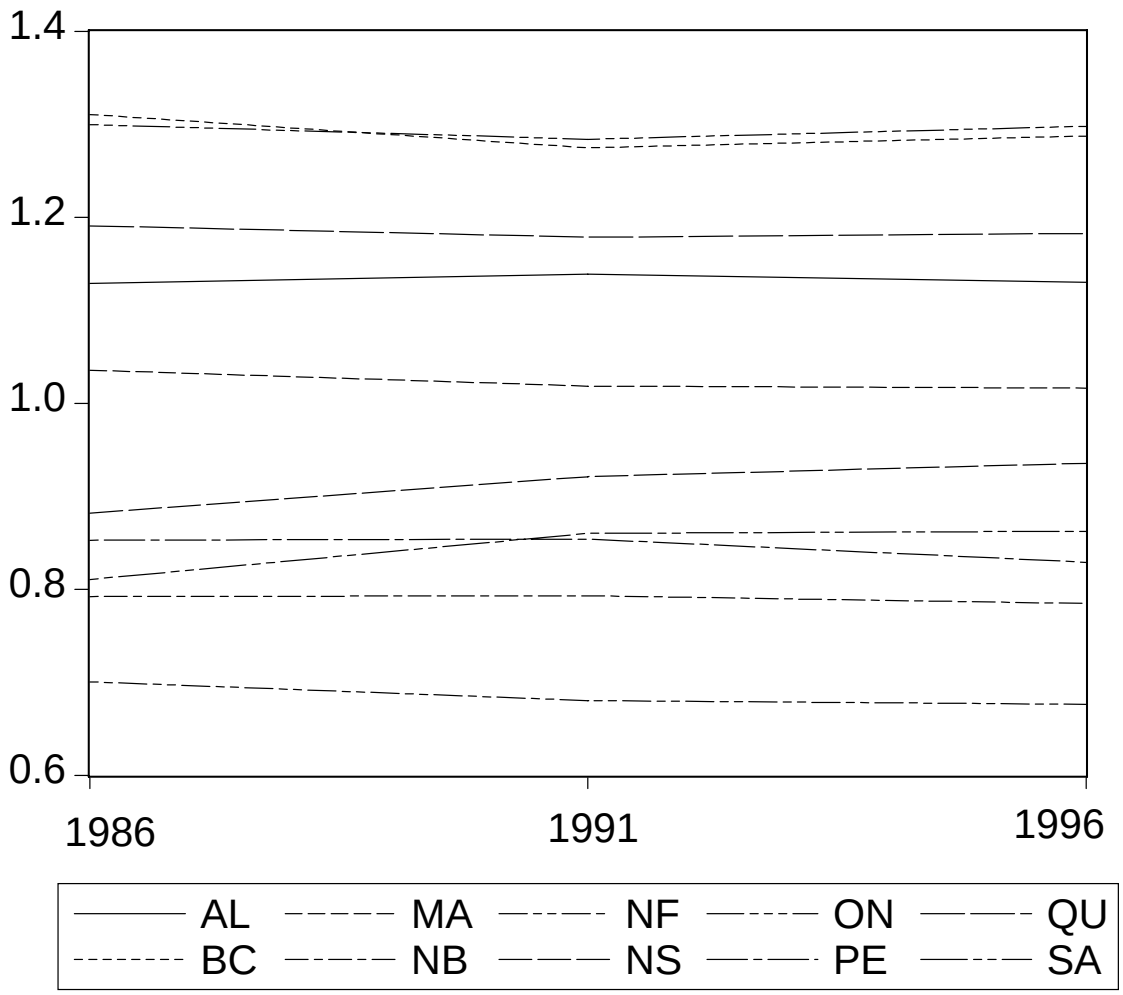


Figure 2: Dynamic simulation of per capita income

Figure 2a: Alberta

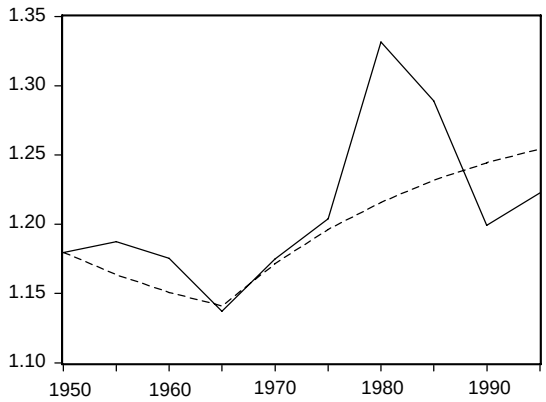


Figure 2b: Newfoundland

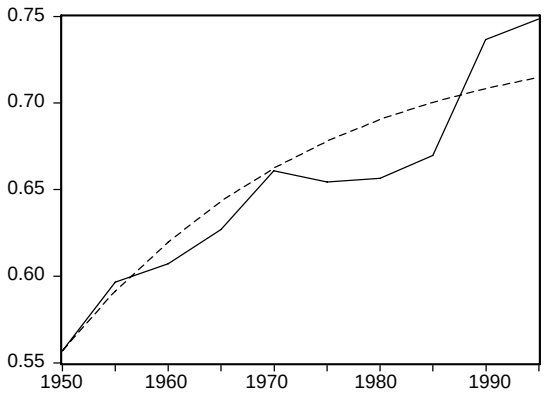


Figure 2c: Nova Scotia

Figure 2d: Ontario

Figure 2e: Prince Edward Island

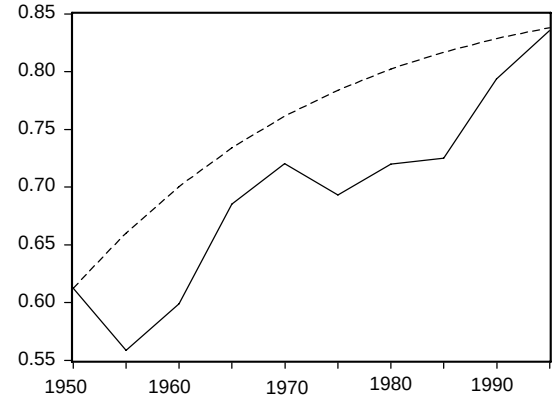
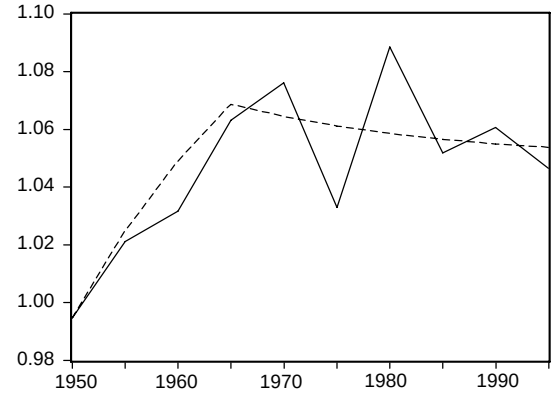


Figure 2f: Québec



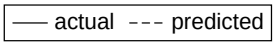


Figure 3: Dynamic simulation of human capital indicator P15

Figure 3a: Alberta

Figure 3b: Manitoba

Figure 3c: Newfoundland

Figure 3d: British Columbia

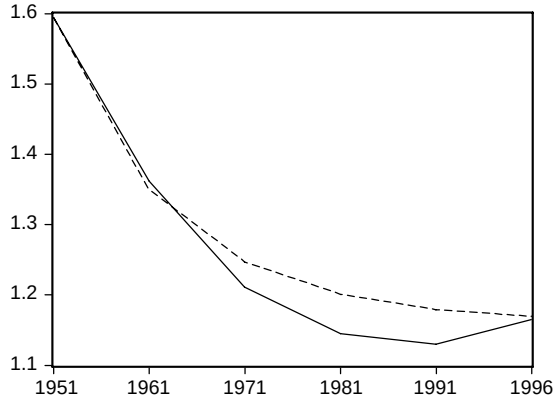


Figure 3e: New Brunswick

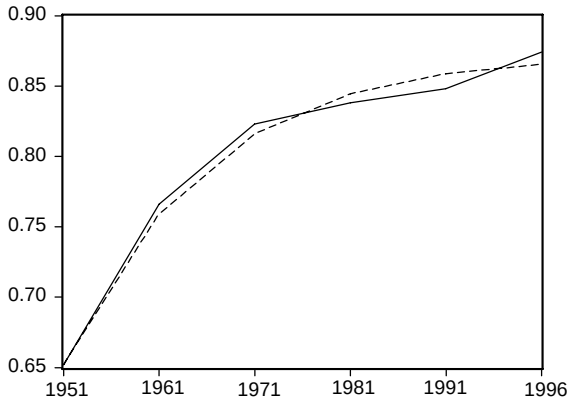


Figure 3f: Ontario

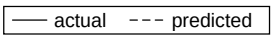


Figure 3 (continuation): Dynamic simulation of human capital indicator P15

Figure 3 g: PEI

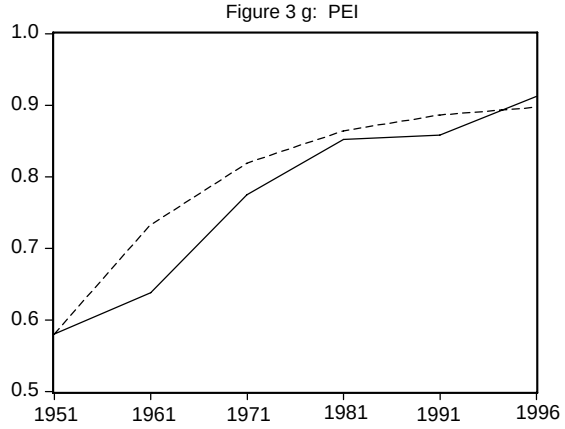


Figure 3h: Saskatchewan

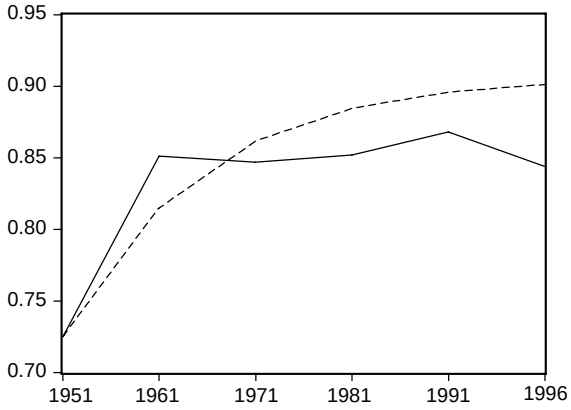


Figure 3i: Québec

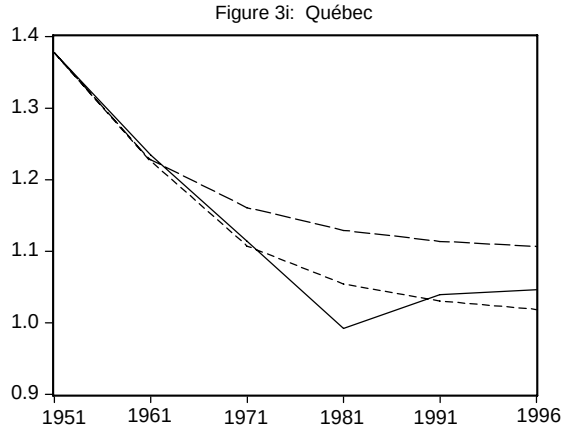


Figure 3j: Nova Scotia