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New Evidence of Convergence Across Canadian Provinces: The Role of Urbanization

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ABSTRACT

This paper uses the conditional convergence model for explaining the relative evolution of per capita income across the ten provinces of the Canadian federation between 1950 and 1996. Provincial relative per-capita income steady states are determined by the relative rates of urbanization. Empirical results indicate that the provinces have converged at a speed of about 5 percent per year and, since the mid-1980s, most provinces appeared to be in the neighborhood of their respective steady state. The analysis also indicates that for the provinces of Alberta and Québec, the convergence process was disturbed in the 1970s by different permanent level shocks to their long-run steady states.

JEL classifications: O41, R11, R12, R15

Keywords: convergence, urbanization, regional growth, Canadian regions, neo-classical growth model

RÉSUMÉ

Nouveaux résultats portant sur la convergence des provinces canadiennes : le rôle de l'urbanisation - Dans la présente étude, nous tentons d'expliquer l'évolution relative du revenu par habitant entre les dix provinces canadiennes de 1950 à 1996 en utilisant le modèle de convergence conditionnelle. En régime de croissance équilibrée, le revenu provincial relatif par habitant d'une province est principalement déterminé par son taux relatif d'urbanisation. Les résultats de l'analyse empirique indiquent que les économies provinciales ont convergé à un taux annuel moyen d'environ 5 % et que, depuis le milieu des années 1980, la plupart des provinces avoisinent le niveau de leur régime de croissance équilibrée. Cependant, l'analyse montre que dans le cas de l'Alberta et du Québec, le processus de convergence a été perturbé par un bris structurel dans les années 1970 qui s'est traduit par un choc une fois pour toutes sur le niveau du régime de croissance équilibrée.

JEL : O41, R11, R12, R15

Mots clés : convergence, urbanisation, croissance régionale, régions cnadiennes, modèle de croissance néo-classique

New Evidence of Convergence Across Canadian Provinces: The Role of Urbanization

1- Introduction

Following BAUMOL, 1986; DOWRICK and NGUYEN, 1989; BARRO, 1991; BARRO and SALA-I-MARTIN, 1991; and MANKIW, ROMER and VEIL, 1992, a number of influential empirical studies have centered in the 1990s on the concept of convergence. Convergence, a key feature of the neo-classical growth framework, is said to be *conditional* when the economies converge to different steady states, and *absolute* if they have the same level of per capita output in steady state.[1]

Empirical studies strongly support the hypothesis of conditional convergence across a broad group of developed and under-developed countries in the post WW II period (BARRO, 1997). Most empirical studies on regional convergence within countries have focused on absolute convergence. The reason is that most variables used in cross-country empirical studies to account for different steady states can reasonably be assumed to be constant across regions of the same countries. The absolute convergence hypothesis was supported by studies of regional data sets for U.S. states, Japanese prefectures, and European regions (BARRO and SALA-I-MARTIN, 1991,1995), Canadian provinces (COULOMBE and LEE, 1995), Australian states (CASHIN, 1995), and Austrian regions (HOFER and WÖRGÖTTER, 1997). However, CHATTERJI and DEWHURST, 1996; and SIRIOPOULOS and ASTERIOU, 1998, found no evidence of regional convergence in Great Britain and Greece, respectively and BUTTON and PENTECOST, 1995, found mixed evidence of convergence across EU regional economies.

The convergence of a variety of economic indicators (per-capita income, earned income output, and labor productivity) across the Canadian provinces since WW II is now a well established fact (COULOMBE and LEE, 1993, 1995, 1998; HELLIWELL and CHUNG, 1991; HELLIWELL, 1994; LEE and COULOMBE 1995; LEFEBVRE 1994). The poor provinces have tended to growth faster than the rich ones (beta-convergence) and the dispersion of economic indicators have shown a tendency to decrease over time (sigma-convergence). Recent studies have focused on conditional

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[1] We adopt here the taxonomy of BARRO and SALA-I-MARTIN, 1995, who provide a detailed theoretical analysis of convergence in neo-classical growth models.

convergence (LEE, 1997), on comparative analyses with US border states (COULOMBE and DAY, 1998, 1999), and on the role of human capital (COULOMBE and TREMBLAY, 1999). The new Canadian empirical growth studies are reviewed and synthesized in COULOMBE, 1999.

Two factors explain the fascination of Canadian economists with the convergence debate. First, at the turn of WW II, regional disparities across the Canadian provinces were extremely high and, in 1949, Newfoundland, joined the Canadian federation to become its poorest province. Not surprisingly, WILLIAMSON, 1965, showed that levels of regional disparities were higher in Canada than in other industrialized nations at the time. Second, since the late 1950s and the birth of the welfare state, Canada has become a highly decentralized federation in which a large proportion of public services such as health, education, and social security are provided and financed by provincial governments. With the substantial regional disparities then prevailing, decentralization was made possible with huge interregional redistribution efforts by the federal government. In this context, the existence of regional disparities raises the issue of vertical and horizontal equilibrium in federal and provincial public finances.

In this paper, we use the well-known conditional convergence model of Barro and Sala-I-Martin (1995) for explaining the relative evolution of per capita income across the ten provinces of the Canadian federation between 1950 and 1996. In a previous conditional empirical study on Canadian provinces, LEE's (1997) found support for the conditional convergence hypothesis using human capital, migration, and industrial structure variables as proxies for long-run steady states. The innovation in this paper is the inclusion of an urbanization variable to obtain relatively robust estimates of the relative per capita income steady state for each of the ten provinces. Furthermore, we use structural shocks to the long-run equilibrium for the oil-producing province (Alberta) and the French-speaking province (Québec) to account for departures from their respective transitory paths toward the steady state in the 1970s. The paper also highlights the role of interregional redistribution in the convergence process with the comparative analysis of two alternative income concepts. Finally, we try to see how far the conditional convergence model can go in explaining the relative evolution of per-capita income measures of the ten provinces since the early 1950s with a dynamic simulation using only actual data prior to 1954. The predicted data from the conditional convergence model are confronted with the actual data up to 1996.

Many interesting findings emerge from this analysis. Among others, since the early 1980s, most of the provinces appear to have converged in the neighborhood of their respective long-run steady state. This important finding raises important issues regarding the desirability of sustaining the interregional redistribution effort in Canada, and provides a potential explanation for the slow-down of cross-sectional dispersion convergence (sigma-convergence) observed in recent studies in many regional and country data sets.

2 - Empirical Methodology

2.1 - The Data Set

We use annual data for the 1950-1996 sample from the CANSIM series D11701-D11710 and those for government transfers from various series in Statistics Canada catalogue No. 13-213. The basic data used in this paper are the ratios of per capita income for individual provinces to the un-weighted provincial average. Two income concepts are used: Personal income, and personal income less government transfers. Comparing those two economic indicators is a way of accounting for the incidence of interregional redistribution operated by fiscal federalism and the tax-transfer system in Canada. As shown by COULOMBE and LEE 1995, the choice of income/output indicators matters for the analysis of regional convergence in Canada since an important part of personal income disparities across Canadian provinces is alleviated by interregional redistribution. This fact clearly emerges from Figure 1, where the series for personal income per capita ratios (RPIC) and the personal income per capita net of transfers ratios (RPIT) are depicted for the period 1950-1996.

Insert Figure 1 here

The dispersion of the two sets of regional economic indicators shows a clear tendency to decrease through the sample study (sigma-convergence). For the RPIC series, the standard deviation of the natural logarithm decreases from above 30 percent in the early 1950s to 10.8 percent in 1996. For RPIT series, the relative dispersion index decreases from more than 36 percent in 1953 to 16.8 percent in 1996.

The urbanization variable was computed from census data on rural and urban populations. "Urban" refers to the population living within census metropolitan areas and census agglomerations over 10 000 inhabitants.[2] The cross-section variable used in regressions is the ratio between the percentage of the population living in urban areas in province *i* to the provincial average. Data are presented in Table 1 and are computed from the average ratio of the last three censuses of 1986, 1991, and 1996. Although the Canadian economy has gone through a process of increased urbanization at least since WWII, relative rankings of provinces have not change very much in recent years. For this reason, we think that the relative index of urbanization is a good candidate to reflect long-run regional economic structures.

Insert Table 1 Here

2.2 - Conditional Convergence methodology

During the transition toward the steady state, the evolution of the logarithm of per-capita output or income y_i in economy *i*, measured in efficiency units of labor, is determined by its initial level $y_{i,0}$ and its long-run equilibrium y^*_i (BARRO and SALA-i-MARTIN, 1995). For periods of unit length, like years, this relationship can be written as:

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

Here, β is the annual speed of convergence toward the steady-state. If β equals 0, $log(y_{i,\,t})$ is determined by $log(y_{i,\,t-1})$ only and the economy does not converge to y^*_i . The economy converges to y^*_i when β is a positive fraction. With an additive error term $\varepsilon_{i,\,t}$, equation (1) can be tested using

[2] The data were computed from the censuses of population by Ray Bollman from Statistics Canada.

pooled time-series cross-section observations for a sample of T periods across N economic units. Testing equation (1) directly requires the explicitly modeling of any structural breaks having affected the evolution of regional economies during the period under study, that is from 1950 to 1996. The world-wide productivity slowdown observed across most developed countries and usually associated with the 1973 oil shock, is certainly an example of a structural break that has affected the regional economies in Canada. Following COULOMBE and LEE 1995, one could abstract from national shocks for the purpose of testing the convergence hypothesis by measuring provincial economic indicators as deviations from the mean. For this reason, the basic equation tested in this paper is the following modified version of (1):

$$\log RY_{i,t} = e^{-\beta} \log RY_{i,t-1} + (1 - e^{-\beta}) \log RY^*_i \qquad (2)$$

where RY_i stands for the relative per capita income of province *i*, which is the ratio between province *i* per capita income to the un-weighted provincial average. Similarly, RY^*_i is the relative per capita income concept steady state of province *i* to the provincial average.

The key contribution of this paper is to estimate long-run equilibrium ratios of per capita income RY^*_i by using a variable based on urbanization ratios in order to account for different economic structures across the Canadian provinces. The purpose of this modeling is to capture agglomeration economies as propose by KRUGMAN's (1991) core-periphery structure. CARLINO and VOITH (1992) find that the percentage of the population living in metropolitan area is an important determinant of aggregate state productivity differentials in the U.S.. Canada is a huge country with a sparsely distributed population and urbanization rates vary considerably across provinces. Industrial activity is concentrated in a narrow band of land close to the US border from the Saint-Lawrence Valley River to the southern shore of Lake Huron. Sixty-two percent of Canada's population resides in the urbanized provinces of Ontario and Québec, which are also home to 71 percent of the country's manufacturing jobs. The highly urbanized Toronto-Windsor corridor connects up with a broader industrial core on the US side of the Great Lakes. To the east of Montréal, urban centers are smaller and a larger proportion of the population lives in rural areas. To the west of Ontario, in Manitoba and Saskatchewan, where extensive farming is a key economic activity, a higher proportion of the population lives in rural area. In

Alberta and British Columbia, both economic activity and population are concentrated in the urban areas of Edmonton, Calgary and Vancouver.

The empirical results on convergence in this paper come from the following regression equation which is a modified form of equation (2):

$$\log RY_{i,t} = \gamma_1 \log RY_{i,t-1} + \gamma_2 \log UR_i + \gamma_3 A_{i,t} + \gamma_4 Q_{i,t} \\ \gamma_{5,i} AR(1) + \gamma_{6,i} AR(2) + e_{i,t} \tag{3}$$

with: $A_{i,t} = 0$, for all i but Alberta,
$A_{Alberta,t} = 0$, for all $t<1973$,
$A_{Alberta,t} = 1$, for all $t \geq 1973$.

And: $Q_{i,t} = 0$, for all i but Québec,
$Q_{Québec,t} = 0$, for all $t<1970$,
$Q_{Québec,t} = 1$, for all $t \geq 1970$.

The convergence parameter γ_1 (which is equal to $e^{-\beta}$ of equation (2)) is assumed to be the same for all cross-sectional (provinces) variables.

The variables UR_i, $A_{i,t}$, and $Q_{i,t}$ determine the relative long-run steady states. If their associated parameters γ_2, γ_3, and γ_4 are all equal to zero, then absolute convergence is said to occur. UR_i is the cross-section relative urbanization variable presented in Table 1. With this set-up, provinces are allowed to converge, at the same speed, to different long-run steady states depending upon their degree of urbanization and their initial level of income.

$A_{i,t}$ and $Q_{i,t}$ are regional dummy for Alberta and Québec respectively, for structural breaks in the level of their respective long-run relative steady states. As shown in section 3.1 below, Alberta's economy, a major oil producer, is a good candidate for a structural break in 1973. Furthermore, it is for this year that the t ratio for the γ_3 parameter is maximized. We retain this well-known criterion for the determination of the exact date of Québec's structural break which was found to be 1970. We have tested for structural breaks for all other provinces at different dates but did not find one that was significant.

The $\gamma_{5,i}$, and $\gamma_{6,i}$ parameters are respectively the first-order and the second-order serial correlation coefficients of the residuals $g_{i,t}$. With annual data series for provincial per capita income, low-order serial correlation could be interpreted as provincial economies adjustment to their regional business cycles. If we do not correct for serial correlation, the estimated speed of convergence will be too high since it reflects in part this short-run adjustment.[3] It is well known that serial correlation is hard to detect in pooled time series-cross-section estimation. Our approach to deal with this problem was first to include common (across pool members) AR(1), AR(2), and AR(3) terms in the specification (3), and to test if the last AR process is significant at 5 percent. Since the AR(3) process was not significant for RPIT and RPIC, it was dropped. Secondly, we estimated the (3) specification with only common AR(1) and AR(2) terms. Both AR terms were significant at the 1 percent level. We then decided to estimate separate AR(1) and AR(2) processes for each pool member.[4]

We have tested for alternative specifications for the determinants of relative steady states. First, we have tested for fixed effects for individual provinces and for groups of provinces (Atlantic, Saskatchewan and Alberta, Atlantic and Québec). We have not found any significant fixed effects indicating that the urbanization variable captures most of the long-run differences across provinces. When the urbanization variable is excluded from the specification, fixed effects are significant for all provinces with the exception of Saskatchewan which indicates that the other nine provinces converge to steady states that differ from the provincial average. Our empirical work indicates that this alternative way of estimating conditional convergence produces non-robust estimates of the convergence speed and of long-run steady-states. The results are likely to change considerably when the time period is reduced to 1960-1996, for example. Secondly, other variables were used in conjunction with the

[3] DE LA FUENTE, 1998, analyses the problem of empirically separating short-term fluctuations around trend from long-term growth dynamics using data for the Spanish regions.

[4] The reported results are robust to many alternative AR specifications. For example, inclusion of AR(3) terms does not change the nature of the results. Furthermore, the results remain roughly the same when a common AR structure is estimated instead of a separate one for each pool member. The choice of presenting the results for the separate AR process is based on the fact that in section 7 below, we present dynamic simulations for each of the ten provinces of the estimated model. We thought that the separate approach was then preferable in order to reflect each province own intrinsic estimated short-run dynamic adjustment.

urbanization variable as determinant of relative steady state. No one was found significant. Specifically, the variables used by LEE, 1997, in its conditional convergence analysis for the Canadian provinces, such as net migration flows, and human capital dotations were not significant when the urbanization variable was included in the specification regression equation (3).[5]

3 - Empirical Results

3.1 - Trends and Unit Roots

In this section, results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests for the twenty RPIC and RPIT time series under study are presented. The purpose of the analysis is two-fold. First, if the null hypothesis of a unit root can not be rejected, then the data generating processes for the relative regional growth indicators can not be represented by the simple convergence-growth model. Second, the time trend variable embodied in these unit root tests provides some important preliminary information on convergence. The tests are performed on the level of the natural logarithm of both RPIC and RPIT since, following the underlying theoretical model, these variables should follow a log-linear time trend in their convergence process toward steady-states.

Unit root tests are based on least-squares estimates of the following regression equation:

$$\Delta y_{i,t} = \beta_1 + \beta_2 t + \beta_3 y_{i,t-1} + \varepsilon_{i,t} \qquad (4)$$

Here, y_t is the logarithm of the relative income indicators RPIC or RPIT, $\beta_1 + \beta_2 t$ is the trend path, and $\varepsilon_{i,t}$ is the disturbance. For ADF tests, autoregressive processes of order k are added to the right-hand side of this equation to account for serial correlation. For PP tests, the correction for autocorrelation is non-parametric. For unit root tests, the null hypothesis is $\beta_3 = 0$. If the null hypothesis is rejected and β_2 is significantly different from 0, then y_t is trend stationary. If the null hypothesis is rejected and β_2 is not significatively different from 0, y_t is stationary. The underlying

[5]The other candidate independent variables were measured as deviation from the provincial mean. The human capital stock variable, taken from COULOMBE and TREMBLAY 1999, was measure form the percentage of the population 15 years and over with at least a University degree. The migration variable was the net interprovincial migration per capita from 1950 to 1996.

convergence model implies that the y_{it} series are either trend stationary or stationary. If the y_{it} series is not on steady state and convergence is occurring, the series should be trend stationary and $\$_2$ should be negative (positive) for the relative income indicator of a rich (poor) province. If the y_t series is on steady state, the series should be stationary and $\$_2$ should equal zero. As pointed out previously, the usefulness of unit root tests on relative income indicators comes from two points: First they are a way of testing a necessary condition for the underlying modeling of the conditional convergence regression equation, and second, they provide some preliminary results regarding the convergence process through a careful analysis of the sign and significance of the $\$_2$ parameters.

Insert Table 2 here

The key results of the ADF and PP unit root tests for the two relative income indicators RPIC and RPIT and the ten provinces are displayed in Table 2. Two sets of results emerge from the analysis of Table 2.

The first set of results deals with the stationarity issue. Overall, there is some evidence, sometimes strong, sometimes weaker, that the null hypothesis of a unit root can be rejected for eight of the ten provinces, Alberta and Ontario being the two notable exceptions. This result might appear surprising as it is well known since PERRON (1989) that unit root tests are biased toward not rejecting the null when a trend stationary series is characterized by a structural break. As mentioned before, abstraction from common structural breaks, like the productivity slowdown, is made by working with data expressed as deviation from the mean . Consequently, this first finding implies that in most cases, the relative evolution of regional economies in Canada since 1950 has not been affected by regional structural breaks. Since Alberta is Canada's major oil producing province, one should not be surprised by the result as the 1973 oil shock would certainly have affected its relative economic evolution differently from most other provinces. The oil shock regional dummy variable for Alberta was introduced in the conditional convergence equation to model this change in the relative evolution of Alberta's economy compared with the other Canadian provinces. The case of Ontario, the most important and industrialized province, is more troubling. We have looked for a structural break for Ontario in the framework of the conditional convergence equation, but have not been able to find any significant one. Since Ontario's relative income indicators start to go up in 1981 and to go back down in 1988, we could have looked for two structural breaks, but we were limited by the number of degrees of freedom for the cross-section variables. Evidence of trend stationarity is much stronger for the minus-transfer income concept in Newfoundland which makes it an interesting case. An explanation for this might be that the increased effort in interregional redistribution operated by fiscal federalism and the tax transfer system in the period under study has caused a structural break in the LRPIC series, which includes transfers.

The second set of results deals with the estimates of the time trend variable $\$_2$ in equation (3). For New Brunswick, Newfoundland, Nova Scotia, and Prince Edward Island, the four 'poor' provinces in 1950, the estimated $\$_2$ are positive and significantly different from zero. For British Columbia, Manitoba, and Ontario, three rich provinces in 1950, the estimated $\$_2$ are negative but statistical significant is relatively weaker. For Alberta, an initially rich province, the fact that its $\$_2$ parameter is not significant is another indication that a structural break might have occurred during the period under study since the null hypothesis of a unit root could not be rejected. For Québec and Saskatchewan, the combined results on unit root tests involving stationarity and no time trend indicate that these two provinces might have evolved around a steady-state equilibrium since 1950. Québec's income indicators clearly show an upward trend for the first part of the sample, which is an indication that a structural break might have occurred. Consequently, the log-linear time trend assumption underlying the unit root tests is not the proper assumption to make regarding the shape of the time trend. That might explain why the $\$_1 + \$_2\, t$ log-linear time trend is not significant.

To sum up, these first results indicate three points worthy of consideration. First the underlying trend stationarity assumption for conditional convergence equation is, relatively speaking, practical and not so unrealistic. Even though unit root test results do not clearly indicate stationarity, one should note that unit root tests are known not to be very powerful when comes the time to reject the null. Should we have opted to wipe out Ontario from the cross-section set of observations,[6] non-reported results indicate that the analysis would have been roughly the same in the convergence model with only nine cross-sectional observations. Second, preliminary results for the time trend variable β_2 in equation (3) clearly indicate that the convergence hypothesis is promising for explaining the relative evolution of regional economies in Canada since 1950. Third, structural breaks should be considered for modeling the relative evolution of some of the regional economies.

3.2 - Convergence Results

Results for the estimations of the key parameters of regression equations (3) are presented in Table 3. For details regarding estimation techniques, refer to the notes to Tables 3. The reported results for the *t*-ratios of the estimated speed of convergence β come from the linear regression of the following modification of equation (3):

$$\log(RY_{i,t} / RY_{i,t-1}) = (1-\gamma_1)\log RY_{i,t-1} + \gamma_2 \log UR_i + \gamma_3 A_{i,t} + \gamma_4 Q_{i,t} + \gamma_{5,i} AR(1) + \gamma_{6,i} AR(2) + e_{i,t} \tag{3'}$$

The parameter (1- γ_1), which is equal to (1- $e^{-\beta}$), converges to zero as β converges to zero. Since β is a small fraction, (1- $e^{-\beta}$) $\approx$ β. The reported t ratios for the parameter (1- $e^{-\beta}$) are then very close to the t ratios of β. Estimations of equations (3) and (3') lead to the same estimates for the γ parameters.

Many interesting findings, both qualitative and quantitative, emerge from an analysis of the results.

Insert Table 3 here

The estimated speeds of convergence (1- γ_1) are significant and substantially higher, around 5 percent per year, than the 2 to 3 percent typically reported in previous absolute convergence Canadian

[6] This, clearly, is an unpalatable exercise from the point of view of the author who is an economics professor working in an Ontario university.

studies. However, this result should not be surprising for two reasons. First, as illustrated by the dynamic simulation presented in the next section, the initially poorer (richer) provinces appeared to have converged to steady states that are below (above) the provincial average. Then, when the provinces were allowed to converge to different steady states (conditional convergence) closer to their initial situation, they would converge faster than when they are constrained to converge to identical steady states (absolute convergence). Second, on theoretical grounds, convergence speeds of around 5 percent per year are consistent with neo-classical growth models with endogenous saving rates, as shown in ROMER, 1996, section 2.6. Investment rates are then predicted to be higher in regions that are further back from steady state.

The estimated convergence speeds for the two income concepts are almost equal. This result seems to contradict one of the findings of COULOMBE and LEE, 1995, and COULOMBE and TREMBLAY, 1999, regarding the fact that the estimated speed of convergence was significantly higher for the income concept that includes government transfers. This apparent contradiction is explained by the fact that in these two studies, the convergence speed is estimated under the assumption of absolute convergence. As the dynamic simulation of the next section will show, the long-run equilibrium dispersion for relative per capita income is much smaller than for the relative per capita income minus transfers. So, with respect to the previous studies, the story is different, but the principle remains regarding the incidence of interregional redistribution on the convergence process in Canada. In an absolute convergence scheme, interregional redistribution increases the convergence speed to identical steady states. In the conditional convergence scheme, interregional redistribution decreases the long-run relative dispersion across steady states. In both cases, *ex post*, interregional redistribution appears to have helped the convergence process at the regional level in Canada.

Parameter γ_2 of the first determinant of relative long-run steady states, the urbanization variable, is highly significant with a positive sign for both income concepts. Interestingly, the estimated γ_2 parameter is 43 percent higher[7] (with a higher statistical significance) for RPIT than for RPIC. This

[7] Note that the null hypothesis that parameter estimates for RPIC and RPIT are equal could not be rejected at a 5 percent level from a Wald test. Here and thereafter in the text, percentage

percentage could be considered as a measure of the long-run effect of interregional redistribution, essentially the difference between RPIC and RPIT, on long-run relative per capita income across the Canadian provinces. Forty-three percent of the differences between steady state relative per capita income is eliminated by interregional redistribution operated through fiscal federalism and the tax transfer system. Similarly, the other determinants of relative long-run steady states, the structural breaks for Alberta and Québec, are affected by interregional redistribution. Both structural breaks are significant at the 5 percent level for RPIT but only at the 10 percent level for RPIC. These γ_3 and γ_4 parameter estimates are also much smaller for RPIC than for RPIT, 48 percent in the case of Alberta and 62 percent for Québec.

The elasticity of the urbanization variable on the long-run relative steady state of province *i* could be computed from the following expression taken from equation (2):

$$\frac{\Delta \log(RY*_i)}{\Delta \log(UR_i)} = \frac{\gamma_2}{1-\gamma_1}$$

This estimated elasticity is 0.78 and 0.51 for RPIT and RPIC, respectively. In a poor province with an urbanization rate 10 percent lower than the average, at steady state, per capita income and per capita income minus transfers would be lower than the provincial average, 5.1 percent and 7.8 percent respectively. Based on the reported value of the urbanization variable shown on Table 1 and these two estimated elasticities, the relative steady-state level of RPIC and RPIT were computed and are reported in Table 4. For Québec and Alberta, values before and after the structural breaks are reported for each income concept. Alberta's structural break is positive and generates an increase of 9.7 percent and 15.4 percent of its relative long-run per capita income and per capita income minus transfers, respectively. In the case of Québec however, the structural break is negative and translates into a decrease of its long-run relative per capita income and per capita income minus transfers of 5.7 percent and 10.3 percent, respectively. Again, interregional redistribution appears to smooth regional

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changes are always calculated from logarithmic mean, which in this case is:
43 percent = 100Å log(0.0393/0.0255).

differences effectively. Almost one-half of the positive long-run effect of the oil shock on the Alberta economy is redistributed to other provinces. Similarly, almost one-half of Québec's economic decline after 1970 is buffered by interregional redistribution.

Insert Table 4 here

As one could have anticipated from the previous discussion, the long-run relative per capita incomes are in general closer to the provincial average when transfers are included. The only exception is post-1970 for Québec, but the reason for this apparent anachronism is simple. Relative to the provincial average, Québec post-1970 is, by a short margin, slightly above. But, relative to the national average, the average of the provinces weighted by their economic size, Québec is a relatively poorer province and thus gains, very slightly, through interregional redistribution. It is interesting to note that if Québec would have continued to evolve along its pre-1970 path, it would have remained in the group of rich provinces in Canada, thanks to its high urbanization level, and would have been a net contributor to interregional redistribution in steady state.

It is interesting to note that the methodology used to determine the exact date of Alberta's structural shock, namely searching the date that maximizes the *t* ratio of the structural break variable, identifies the year 1973. This should not be a surprise since this date coincides with the first world oil shock. Certainly, Alberta, the only major oil producer among Canadian provinces, should have been affected differently than the other provinces by this structural change. The year 1970, which marks the beginning of Québec's relative economic decline with respect to the evolution of the two per capita income concepts considered, might appear somewhat surprising to some Canadian political and economics observers. However, this date coincides somewhat with the 'exodus' of the highly educated Anglophone minority which, according to POLÈSE 1990, remains the primary explanation of the relative decline of Montreal with respect with Toronto.[8] Montreal was Canadian's financial and administrative metropolis from the nineteenth century to early post-WWII but Toronto had always been

[8]We thank Pierre Fortin for directing us to this explanation.

a close contender. In Polèse's analysis, the Anglophone exodus is associated with the shift from Montreal to Toronto of high level tertiary activities. Québec's society was deeply transformed with the "Quiet Revolution" of the 1960s which resulted in an increased use of the French language in business activities and everyday life. This, coupled with the rise of the independent movement, contributed to a decrease in the comparative advantage of Montreal for attracting the extremely mobile well-educated Anglophone elite. A simple look at the evolution of the relative average wages between Québec and Ontario by language groups illustrates this point. Between 1961 and 1991, the relative wage of Québec's Francophone males increased from 80% to 86% of Ontario's average male wage.[9] During the same period, the average wage of Québec's Anglophone males decreased from 124% to 100% of Ontario's average. Note that this explanation of Québec's decline is consistent with the basic notion of conditional convergence presented in this paper. Because of the importance of urbanization, the long-run relative position of the Québec economy will likely be affected by a change in the relative importance of its metropolis.

It might appear unnecessary, from a modeling point of view, to know if the transformation of Montreal's role in the Canadian economy, from a national financial center to a more regional one, occurred precisely in the year 1970. Remember that the negative break in the empirical analysis was significant at the 5 percent level at any date between 1968 and 1976. However the choice of the exact date matters if one is interested in identifying the event that ultimately triggered the Anglophone exodus. For example, the year 1970 coincides with the intervention of the Canadian army during Québec's "October Crisis" when the FLQ kidnaped a British diplomat and Québec's labour minister. Whether the break occurred in 1968, 1970 or 1976 might be extremely sensitive for Canadian political observers. The importance of using appropriate techniques for determining the exact date of structural breaks is highlighted by the fact that many things happened in Québec during this period, and several factors might have reinforced each other. However, the methodology chosen here, as intuitively appealing and simple as it is, does not have a solid theoretical foundation. Further research is needed in

[9]These numbers on relative wages were taken from the 1961 and 1991 Statistics Canada Census.

order to offer a better theoretical foundation for the determination of the date of structural breaks in pooled time series-cross section models.[10]

3.3 - Dynamic Simulations Results

At the outset, the meaning of the structure of a conditional convergence model with structural breaks and urbanization effects for provincial dynamic adjustments is worth considering. With the exception of Alberta and Québec, the conditional convergence model predicts that provinces should converge to their long-run equilibrium based on their relative urbanization rate at a speed of about 5 percent per year. For Alberta and Québec, the convergence process was disturbed in 1973 for the former and in 1970 for the latter, by a permanent level shock to their long-run steady states. Again, following those shocks, these two provinces should converge to their new long-run equilibrium at an annual speed of 5 percent. In this section, these predictions are evaluated by comparing the observed evolutions of the Canadian provinces since 1950 to the path predicted by the conditional convergence model based on the parameters estimated with the 1950-1996 sample.

We proceed to a dynamic simulation of the conditional convergence model using only historical data up to 1954.[11] Given the existence of second-order serial correlation, 1951 is the first year for which the simulation exercise could be performed for the ten provinces since Newfoundland entered the Confederation in 1949. Overall results do not change much when different years are chosen for the first period of the simulation. For an individual province, however, this choice matters since at the beginning of the simulation, a given province might be experiencing a temporary boom or slow-down. The level of the transitory path toward the steady state for a given province is solely determined by its relative initial situation at the year arbitrarily chosen to begin the simulation. Based partly on historical

[10]PERRON and RODRIGUEZ (1998) for example demonstrate that maximizing the *t* ratio of the structural break variable is not always the most efficient way of determining the date of a structural break in the case of univarate GLS detrending.

[11] Dynamic simulations were performed using EViews 3.1 with the dynamic solution multi-step forecasts option.

considerations, the year 1954 was somehow, arbitrarily chosen as the first year of the simulation.[12]

Some results obtained from these dynamic simulations are depicted in Figures 2A to 2L for both RPIC and RPIT for Newfoundland (2I and 2J) and Québec (2K and 2L) and for RPIC or RPIT for the eight other provinces.[13] In each Figure, the predicted path is confronted with actual data for the 1954-1996 period. The long-run relative income concepts computed from the estimated parameters of equation (3) and reported in Table 3 are added to each of the twelve Figures.

Given the intrinsic challenge of trying to forecast 42 years of relative regional evolution, one might be surprised by the general fit between the predicted path and the actual data in most cases. We will discuss the results by first analyzing the relationship between actual paths and steady states, before turning to the adjustment speed. The notable (apparent) exception of Saskatchewan (2H) will then be discussed and finally; we will analyze the adjustment to structural breaks for both Alberta (2A) and Québec (2K and L).

The first sticking point that emerges from an analysis of Figures 2 is that, by the end of the period under study, all provinces appear much closer to their respective steady state than at the beginning of the dynamic simulation. Since the early 1980s, the actual paths of all provinces with the exceptions of Prince Edward Island (2G) for both income concepts and of Nova Scotia for RPIC only (not shown), have crossed their relative steady states at least once. Prior to 1970, Saskatchewan (2H) is the only province to have crossed its steady state and that for both income concepts. This result dovetails with previous findings of COULOMBE and LEE, 1998, COULOMBE and DAY 1999, which were obtained using a completely different methodology. According to this study, the distribution of a variety of relative per capita income/output indicators across the Canadian provinces might have evolved around their long-run steady states since the mid-1980s. At the turn of WW II, the relative dispersion of regional disparities in Canada was much bigger than its long-run equilibrium and sigma-convergence occurred mainly from the early 1950s to the mid-1980s. COULOMBE and LEE,

[12] The Korean War ended in 1953.

[13] In the eight cases not shown, results of the dynamic simulations do not differ much between RPIC and RPIT.

1998 was based on a statistical analysis of the evolution of a variety of cross-section dispersion measures and COULOMBE and DAY, 1999 findings follow from a dynamic simulation exercise of the cross-section dispersion obtained with an absolute convergence model. Interestingly, whether convergence is absolute or conditional, empirical analyses indicate that relative per capita income/output indicators across the Canadian provinces are now close to their long-run equilibria. Being more disaggregated, the present analysis goes beyond previous works by highlighting the exceptions: Saskatchewan, which was around its steady state earlier than the others provinces; and Prince Edward Island and Nova Scotia who might still have some catching-up to do. Furthermore, the story regarding the determinants of relative steady states differs considerably from the interpretation of COULOMBE and DAY, 1999, where the long-run dispersion is determined by stochastic shocks to regional economies. Here, stochastic shocks still play a role, but the urbanization variable is a key non-stochastic determinant.

In most other cases, with the exception of Saskatchewan, the convergence model appears to provide a reasonable story regarding the relatively slow transitory adjustment toward the steady state. Some provinces however, like Ontario (2F) and Nova Scotia (2E), depart from their transitory path for long periods of time but eventually come back to it. Since the convergence-growth model is a long-run model, the specific nature of regional shocks determines departures from the transitory path toward the steady state. This long-run model is thus consistent with both types of adjustment toward the transitory path. Interestingly, Newfoundland appears to have overshot its long-run steady state in the mid-1980s for RPIC (2I) and few years latter for RPIT (2J). This might be the result of the massive transfers from the federal government to this province in order to offset temporarily the effects of the crisis in the fishing and fish-processing industries following the disastrous decrease in the stocks of northern cod in the end of the 1980s.

Saskatchewan is the main exception with regards to the predicted convergence speed. As seen in Figure 2H, this province appears to come back much faster to its steady state than the implicit 5 percent speed embodied in the slope of the predicted path following a regional shock. If the simulation is started in 1956, however, the predicted path is virtually equal to the steady state and the results of the dynamic simulation looks much better. As pointed out in COULOMBE, 1999, p.19, it is difficult to anticipate the relative evolution of a non-diversified peripheral economy whose fortunes are largely based on the evolution of changing world prices of its resources, wheat in the case of Saskatchewan. The price of wheat fluctuates much more than the price of a basket of goods and is subject to significant sudden movements.

Finally, it is interesting to note the different adjustment of Québec and Alberta, for which significant structural breaks were found in the econometric model. As shown in Figures 2A, 2K, and 2L, a once-and-for-all shock to the long-run steady state translates into a change in the slope of the transitory path. The economy then adjusts to its new long-run equilibrium by following a new transitory path that converges to a steady state at a speed of 5 percent per year. This transitory path with a structural break does an excellent job in tracking Québec's relative evolution since the 1950s. Québec's economy almost constantly evolves around its transitory path. Until 1970, Québec was converging to a steady state well above the provincial average, but since 1970, it converges from above to a lower steady state. A comparison of the two predicted paths for RPIC (2K) and RPIT (2L) highlights the role of interregional redistribution in smoothing: the post-1970 downward transitory path is much steeper for the income concept that exclude transfers. The convergence-growth model appears to track extremely well Alberta's relative evolution for RPIT before the first world oil shock. Alberta was converging from above to a steady-state closer to the provincial average. The oil shock appears to have generated a tremendous short-run boom until the mid-1980s, a period during which Alberta's economy overshot both its new upward-sloping transitory path and its new higher long-run steady state.

4- Conclusion

This paper provides more evidences in the usefulness of the convergence hypothesis in explaining the relative evolution of per capita income for most of the ten Canadian provinces during the last fifty years. When WW II came to a close and Newfoundland entered the Confederation in1949, regional disparities in per capita income in Canada were well above their long-run equilibrium value. Convergence occurred, and the provinces slowly approached their steady-state equilibrium. Since the mid-1980s, the provinces appear to be in the neighborhood of their respective steady states as determined by their relative rate of urbanization. This result provided an explanation to the slow-down of cross-sectional dispersion convergence observed in recent Canadian regional studies. When the provinces are closed to their steady states, the cross-sectional dispersion is in equilibrium. It could be useful in further research to test this explanation for other cross-country and regional data sets for which a slow-down in sigma-convergence was observed in recent years.

One of the key features of the model proposed in this paper is the way structural breaks, namely, Montreal's decline and Alberta's oil shocks, are represented. Structural breaks are modeled as level shocks to long-run equilibria and translate into a change in the slope of the adjustment path toward the steady state. This analysis differs from the usual way structural changes are modeled in macroeconomic time-series analysis: either a change in the slope of the deterministic time trend, or a once-and-for-all level shock to the trend, or a combination of the two, as in PERRON, 1989. In the proposed neo-classical growth model of the Canadian provinces, convergence again plays a key role in structural changes since it determines the relatively slow reaction of the economy to the long-run shocks.

This paper opens two questions that could be addressed in future research. First, we have used an ad hoc procedure for extracting short-run regional cycles from the long-run convergence trend. Without an economic model, separating trends from cycles is necessarily an arbitrary exercise. It would be an interesting exercise to derive a procedure from the analysis of a well specified stochastic economic growth model. Second, it could be possible to use a more efficient procedure for determining the date of unknown breaks in pooled time-series cross-section models. Whether the oil shock happened in 1973 or 1974 is not very important, but whether Montreal's decline started in 1968 or 1976 might be an extremely sensitive question for Canadian political and economics observers, since it could lead to alternative conclusions about the fundamental determinants of that province's economic decline.

From a policy point of view, this paper highlights the role of interregional redistribution in the convergence process across the Canadian provinces. Interregional redistribution is an important determinant of long-run relative standards of living in the Canadian provinces and it also plays a key role for determining the reaction of a province to a long-run shock. Canadian fiscal federalism provides an insurance against regional misfortunes and estimates of the extent of the insurance program were provided in this paper.

Bibliography

BARRO, R., 1991, "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics*, 106, 407-443.

_________, 1997, *Determinants of Economic Growth: A Cross-Country Empirical Study*, MIT Press, Cambridge.

BARRO, R. and X. SALA-I-MARTIN, 1991, "Convergence", *Journal of Political Economy*, 100, 223-251.

_________, 1995, *Economic Growth*, McGraw-Hill, New York.

BARRO, R., G. MANKIW, and X. SALA-I-MARTIN, 1995, "Capital Mobility in Neoclassical Models of Growth", *American Economic Review*, 85, 103-115.

BAUMOL, W.J., 1986, "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show", *American Economic Review*, 76, 1072-1085.

BUTTON, K.J. and E. PENTECOST, "Testing for Convergence of the EU Regional Economies", *Economic Inquiry*, 33, 664-671.

CARLONO, G.A. and R. VOITH, 1992 "Accounting for Differences in Aggregate State Productivity", *Regional Science and Urban Economics*, 22, 587-617.

CASHIN, P., 1995, "Economic Growth and Convergence across the Seven Colonies of Australia", *Economic Record*, 71, 132-144.

CHATTERJI, M. and J. H. LL. DEWHURST, 1996, "Convergence Club and Relative Economic Performance in Great Britain", *Regional Studies* 30, 31-40.

COULOMBE, S., 1999, "Economic Growth and Provincial Disparity - A New View of an Old Canadian Problem", *Commentary No. 122*, March, the C.D. Howe Institute, Toronto, available to download from the WEB at www.cdhowe.org .

COULOMBE, S., and J.F. TREMBLAY, 1999, "Human Capital and Regional Convergence in Canada", University of Ottawa, Department of Economics Working Paper No. 9906E, November.

COULOMBE, S. and K. DAY, 1998, "Profils de croissance régionaux de part et d'autre du 49^{e}

parallèle”, *Études internationales*, 29, 365-390.

____________, 1999, “Economic Growth and Regional Income Disparities in Canada and the Northen United States”, *Canadian Public Policy/Analyse de politiques*, 25, 155-178.

COULOMBE, S. and F. LEE, 1995, “Convergence Across Canadian Provinces, 1961 to 1991”, *Canadian Journal of Economics*, 28, 886-898.

_____________________, 1998, “Évolution à long terme de la convergence régionale au Canada”, *L’Actualité économique - revue d’analyse économique*, 74, 5-27.

COULOMBE, S. and J.F. TREMBLAY, 1999, “Human Capital and Regional Growth in Canada”, Department of Economics, University of Ottawa, mimeo, January.

DE LA FUENTE, A., 1998, “ What Kind of Regional Convergence?” CEPR Discussion Paper No. 1924.

DOWRICK, S. and D.T. NGUYEN, 1992, “OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence”, *American Economic Review*, 79, 1010-1030.

HELLIWELL, J. F. and A. CHUNG, 1991, “Are Bigger Countries Better Off?”, in R. Boadway, T. Courchene and D. Purvis, eds., *Economic Dimensions of Constitutional Change*, John Deutsch Institute, Kingston, 345-367.

HELLIWELL, J., 1994, “Convergence and Migration among Provinces”, *PEAP Policy Study* 94-2, Institute for Policy Analysis, University of Toronto.

HOFER, H. and A. WÖRGÖTTER, 1997, “Regional Per Capita Income Convergence in Austria”, *Regional Studies*, 31, 1-12.

KRUGMAN, P. 1991, *Geography and Trade*, MIT Press, Cambridge..

LEE, F.C., 1997, “Conditional Labor Productivity Convergence in Canada”, *Seoul Journal of Economics*, 10, 57-82.

LEE, F. and S. COULOMBE, 1995, “Regional Productivity Convergence in Canada”, *Canadian Journal of Regional Science*, 18, 39-56.

LEFEBVRE, M.., 1994, “Les provinces canadiennes et la convergence: une évaluation empirique”, *Bank of Canada Research Paper* 94-10.

MANKIW, G., D. ROMER and D. WEIL, 1992, “A Contribution to the Empiric of Economic Growth”, *Quarterly Journal of Economics*, 107, 407-437.

PERRON, P., 1989, “The Great Crash, the Oil Price Shock and the Unit Root Hypothesis”, *Econometrica*, 57, 1361-1401.

__________, 1991, “Racines unitaires en macroéconomie : le cas d’une variable”, *L’Actualité économique - revue d’analyse économique*, 68, 325-356.

PERRON, P. and G. RODRIGUEZ, 1998, “GLS Detrending, Efficient Unit Root Tests and Structural Change”, Department of Economics, University of Montréal, mimeo, November.

POLÈSE, M., 1990, “La thèse du déclin économique de Montréal, revue et corrigée’, *L’Actualité économique - revue d’analyse économique*, 66, 133-146.

SIRIOPOULOS, C. and D. ASTERIOU, 1996, “Testing for Convergence Across the Greek Regions”, *Regional Studies*, 32, 537-546.

WILLIAMSON, J. G. 1965, “Regional Inequality and the Process of National Development: A Description of Patterns.” *Economic Development and Cultural Change*, 13, 3-45.

Table 1. The Urbanization Variable
(Provincial average = 1)

Alberta	1.132
British Columbia	1.291
Manitoba	1.023
New Brunswick	0.79
Newfoundland	0.685
Nova Scotia	0.913
Ontario	1.294
Prince Edward Island	0.845
Québec	1.184
Saskatchewan	0.844

Data sources: Data computed from the 1986, 1991, and 1996 censuses of population from Statistics Canada.

Table 2. Phillips-Perron (PP) and Augmented Dickey-Fuller Unit Root Tests for regional relative per capita income indicators

	LRPIC		LRPIT	
	PP test statistic $\$_2$	ADF test statistic $\$_2$	PP test statistic $\$_2$	ADF test statistic $\$_2$
Alberta	-2.32 -0.00026	-2.16 -0.00026	-2.42 0.00010	-2.27 0.00010
British Columbia	-3.05 -0.0017**	-3.52** -0.0031***	-3.25* -0.0015**	-4.25*** -0.0031***
Manitoba	-3.51** -0.0014***	-3.37* -0.0014***	-4.18*** -0.0018***	-3.73** -0.0030***
New Brunswick	-5.16*** 0.0026***	-4.70*** 0.0027***	-4.38*** 0.0019***	-1.90 0.0097*
Newfoundland	-2.89 0.0033***	-3.05 0.0033**	-3.60** 0.0030***	-4.74*** 0.0035***
Nova Scotia	-4.06** 0.0014***	-4.02** 0.0014***	-3.46* 0.00097**	-3.39* 0.00097**
Ontario	-2.14 -0.00086*	-2.84 -0.0014***	-2.27 -0.00083**	-2.97 -0.00120***
Prince Edward Island	-6.72*** 0.0085***	-6.67*** 0.0085***	-7.83*** 0.0092***	-7.84*** 0.0092***
Québec	-3.09** 0.00036	-4.12*** 0.00036	-3.14* 0.00018	-4.07*** 0.000
Saskatchewan	-4.94*** -0.0017*	-4.85*** -0.0017*	-4.68*** -0.0015	-4.08*** -0.0015

Notes: In each cell, the top number is the ADF or PP test statistic and the number below is the estimated linear time trend variable $\$_2$ in equation (3). The ***, **, and * indicate that the null hypothesis could be rejected at 1percent, 5 percent, and 10 percent critical levels, respectively. The unit root tests are performed with a trend ($\$_2$) and an intercept ($\$_1$). When the $\$_2$ variable is not significant at 10 percent, the reported results for the PP or ADF statistics are for regressions with an intercept and no trend. LRPIC is the logarithm of relative per capita personal income and LRPIT is the logarithm of relative per capita personal income minus government transfers. Data series are from the CANSIM data base. Annual data span the (unadjusted) sample 1950 to 1996. For PP tests, we followed the Newey-West suggestion for determining the lag truncation for Bartlett kernel, which is 3 in all cases. For ADF tests, we followed the procedure suggested by Perron (1991) for determining the number (not reported) for lagged differences. Estimations are done using EViews 3.1.

Table 3. Estimation Results for Convergence Regression Equation (4)

	Income Concept for Dependant Variable			
	RPIC		RPIT	
$(_1$	0.950***	(76.3)	0.950***	(70.4)
$(1-(_1)$	0.050***	(4.02)	0.051***	(3.75)
$(_2$	0.0255**	(2.50)	0.0393***	(2.78)
$(_3$	0.00483*	(1.68)	0.00780**	(2.37)
$(_4$	-0.00279*	(-1.73)	-0.00519**	(-2.83)
	Total panel observations: 450 Sample 1950-1996 S.E. of regression: 0.0342 Adj. R-squared: 0.987, DW: 2.11		Total panel observations: 440[14] Adjusted sample 1951-1996 S.E. of regression: 0.0376 Adj. R-squared: 0.990, DW: 2.02	

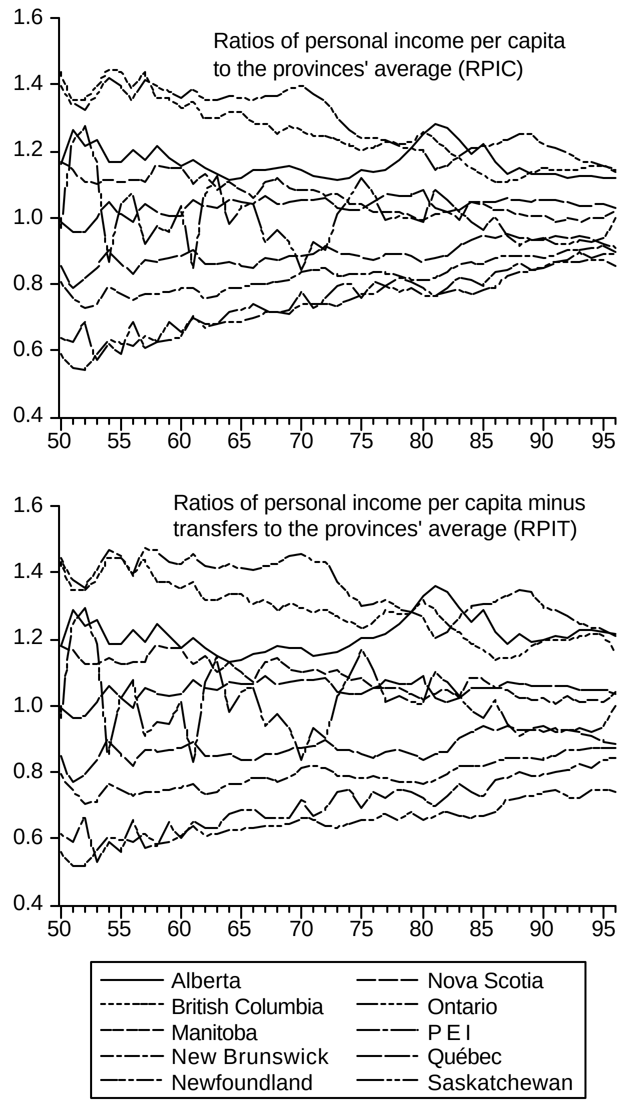
Notes: Generalized (linear) least-squares estimations using cross-section weighted regressions to account for cross-sectional heteroskedasticity. The null hypothesis of equality of variances between the residuals of the OLS convergence regressions for RPIC and RPIT is rejected well below the 1 percent level with Bartlett, Levene, and Brown-Forsythe tests. The *t*-ratios for the parameter $(1-(_1)$ are estimated from regression equation (3'). All other results come from regression equation (3). Regressions are performed with separate AR(1), and AR(2) processes for each pool member to deal with serial correlation. The ***, **, and * indicate that the null hypothesis could be rejected at 1 percent, 5 percent, and 10 percent critical levels, respectively. The *t*-ratios (between brackets) are based on the heteroskedasticity consistent covariance matrix estimator (HCCME), which allows for asymptotically valid inferences in the presence of heteroskedasticity. Estimations are done using EViews 3.1.

[14] The smaller number of time series observations for the RPIT estimations comes from the fact that consistent government transfers series are not available prior to 1950.

Table 4. Estimated Long-run Relative Per Capita Income
(Provincial average = 1)

	RPIC	RPIT
Alberta pre-1973	1.065	1.102
Alberta post-1973	1.173	1.285
British Columbia	1.139	1.22
Manitoba	1.012	1.018
New Brunswick	0.887	0.832
Newfoundland	0.825	0.744
Nova Scotia	0.955	0.931
Ontario	1.14	1.223
Prince Edward Island	0.918	0.878
Québec pre-1970	1.09	1.141
Québec post-1970	1.031	1.029
Saskatchewan	0.917	0.876

Figure 1 : Evolution of provincial relative incomes



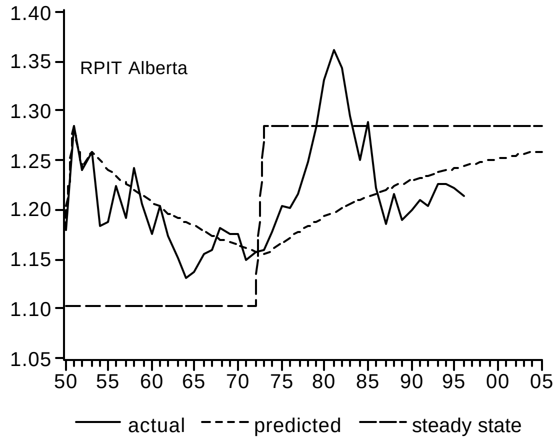
Figures 2 (A - L) : Dynamic simulation results

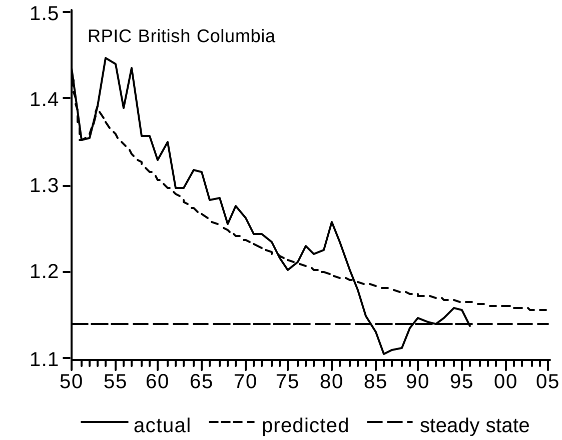
First page:

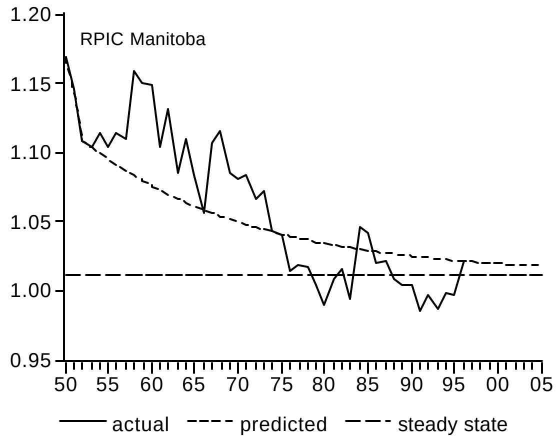
A	B
C	D
E	F

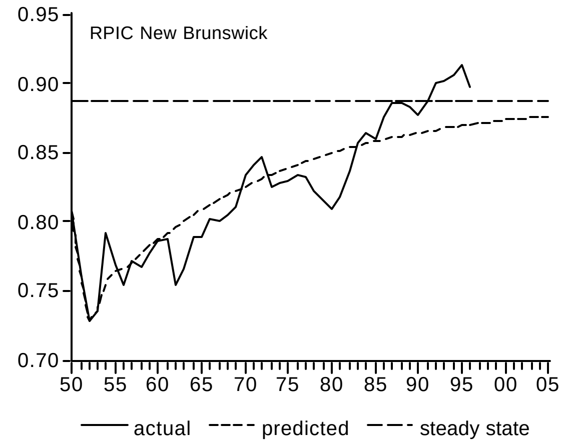
Second page

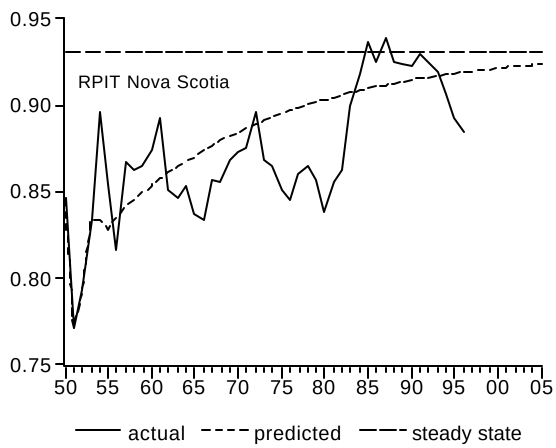
G	H
I	J
K	L

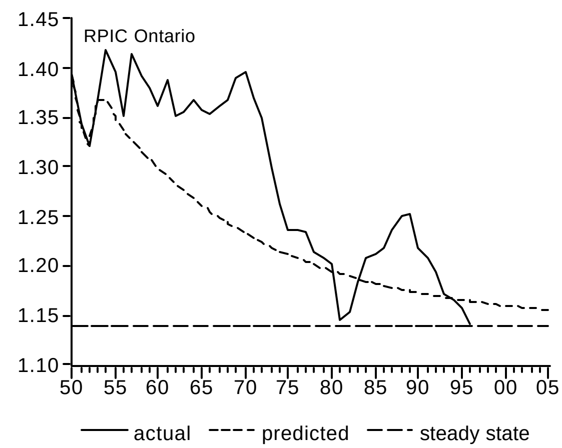

RPIT Alberta
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

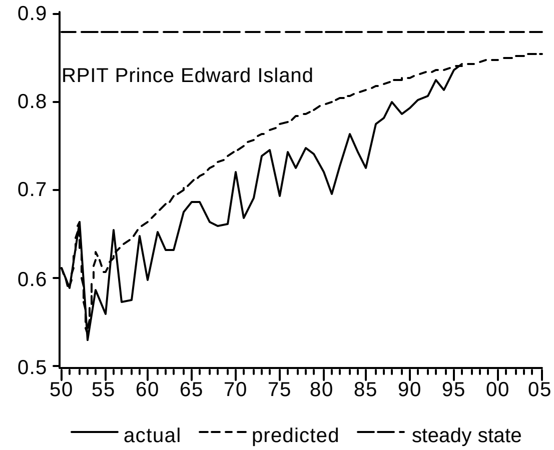

RPIC British Columbia
1.5
1.4
1.3
1.2
1.1
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

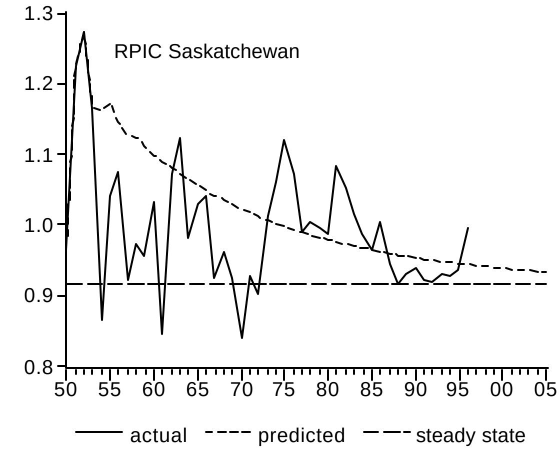

RPIC Manitoba
1.20
1.15
1.10
1.05
1.00
0.95
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

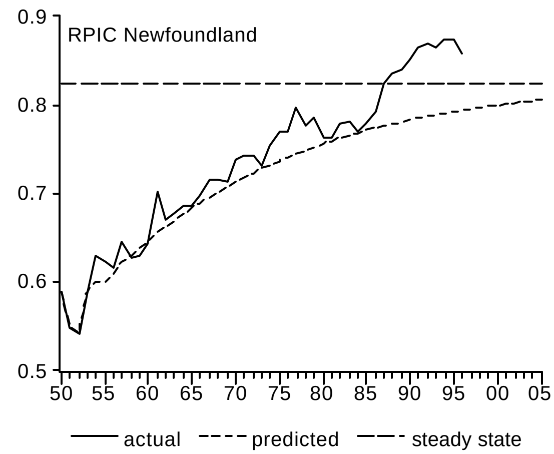

RPIC New Brunswick
0.95
0.90
0.85
0.80
0.75
0.70
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

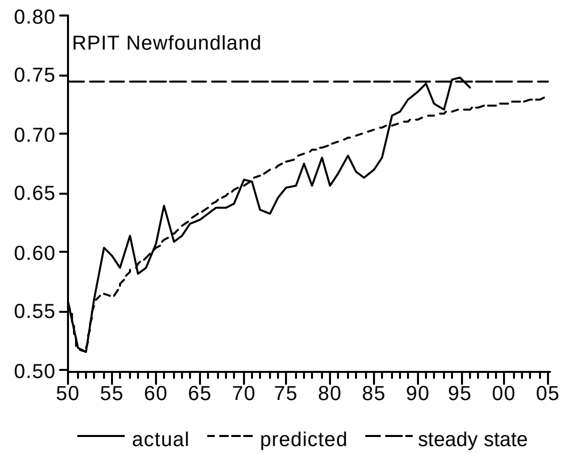

RPIT Nova Scotia
0.95
0.90
0.85
0.80
0.75
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

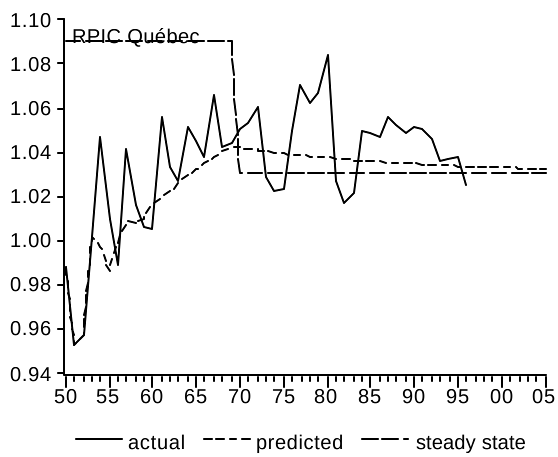

RPIC Ontario
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state

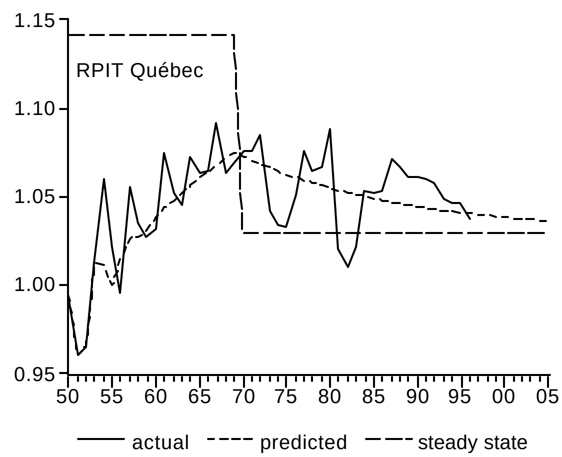

RPIT Prince Edward Island
0.9
0.8
0.7
0.6
0.5
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state


RPIC Saskatchewan
1.3
1.2
1.1
1.0
0.9
0.8
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state


RPIC Newfoundland
0.9
0.8
0.7
0.6
0.5
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state


RPIT Newfoundland
0.80
0.75
0.70
0.65
0.60
0.55
0.50
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state


RPIC Québec
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state


RPIT Québec
1.15
1.10
1.05
1.00
0.95
50 55 60 65 70 75 80 85 90 95 00 05
actual
predicted
steady state