Intranational and International Trade, the “L Curve,”

Trade Barriers, and Growth

by

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Abstract

This paper provides an empirical analysis of the comparative evolution of intranational and international trade and of their effect on regional growth in the Canadian provinces since 1981. First, we establish a striking empirical fact, the “L curve,” that characterizes the comparative evolution of intranational (interprovincial) and international trade shares to GDP between 1981 and 2000. In the 1980s, interprovincial trade share was falling while the international trade was constant. A sharp break occurred around 1991, and throughout the 1990s, the international trade share expanded rapidly while the interprovincial trade share was constant. The analysis casts doubt regarding the pure diversion model that is often used in trade models such as the structural gravity model of Anderson and van Wincoop (2003), used recently to revisit the Canada-U.S. border effect. Second, we use a conditional-convergence growth model to estimate the respective long-run effect of interprovincial trade and international trade on Canadian regional economies. It appears that international trade creates jobs and higher productivity while interprovincial trade creates only jobs. A 10 per cent increase in international trade share translates, in the long run, into an increase in per capita relative GDP and labour productivity of 6.7 per cent and 5.1 per cent respectively. The long-run effect of a 10 per cent increase in interprovincial trade is 5.5 per cent on per capita GDP but virtually zero on labour productivity.

Keywords: Regional economic integration, trade and growth, conditional convergence, FTA, border effect

JEL classification: F15, F43, O51, R11

Acknowledgements: The author is grateful to Jean Mercenier, Gabriel Rodriguez, participants in seminars given at Industry Canada, the International Conference on Policy Modeling held at the Université Libre de Bruxelles, the Université de Poitiers, to two anonymous referees for their helpful suggestions on the research paper version, and to Patricia Buchanan for the English editing.
1. Introduction

The orientation of regional trade links in Canada has undergone a major shift in the last 15 years when north-south trade with its U.S. neighbour started to boom and grew at a much faster pace than the traditional east-west interprovincial trade channel. This fact has already been noted in the border-effect literature that scrutinized Canadian trade data, following McCallum’s (1995) empirical analysis of the detailed data on Canadian interprovincial and province-state trade. Between 1988 and 2000, the Canada-U.S. border effect had decreased from an initial 22 number to around 8 (Coulombe 2002).

In this paper we document the change in orientation of Canadian international and intranational trade and investigate the relationships between the two trade channels and regional growth. The approach is essentially empirical and will focus on the 1981–2000 period in order to capture time-series evolution. The period under study is rich in innovation regarding the comparative dynamic evolution of intranational and international trade institutional contexts. On the one hand, it is characterized by a sharp increase in international trade worldwide following the fall of the Berlin Wall and the opening of China. The overall decrease in international trade barriers for Canada was accentuated in 1989 by the Canada–U.S. Free Trade Agreement (FTA). On the other hand, the existence of interprovincial trade barriers—and the frequent and spontaneous erection of new barriers—has been recognized for some time as a serious problem in the Canadian federation. From the institutional point of view, there was no tangible progress in efforts to remove interprovincial barriers until 1995 with the Agreement on Internal Trade (AIT).1 Knox’s (2001) analysis, however, casts serious doubts on the real effectiveness of the AIT. Consequently, the 1990s have been marked by a sharp decline of international trade barriers relative to intranational trade barriers. These developments, coupled with the availability of detailed Canadian regional data, permit the testing of two important economic issues related to trade and growth, using a relatively homogenous set of regional economies. The 10 Canadian provinces share many common social, political, and institutional characteristics and the heterogeneity problems that are encountered in many empirical cross-country growth analyses are mainly avoided.2

The paper contributes to original research in two different ways. First, time-series evidence reveals an important structural shock that occurred around 1991 in provincial trade patterns. The analysis allows a new perspective on the FTA’s effect on the relationship between interprovincial and international trade in Canada. The relative decline of Canadian interprovincial trade’s contribution to GDP is a phenomenon that preceded the expansion of north-south international trade between Canada and the United States. The share of interprovincial trade to GDP was decreasing steadily and significantly all through the 1981–1991 period, whereas the share of Canadian international trade to GDP was roughly steady. A significant structural break in the relationship between interprovincial and international trade occurred in 1991–1992. Since 1991, Canadian international trade has boomed and the value of interprovincial trade has started to grow at the same long-run rate as the GDP. These facts are collected in a single scatter diagram, highlighted as the L curve in Section 2. Furthermore, the changes in trade patterns were not spread evenly across Canadian provinces. We will maximize the use of this cross-sectional information in a pooled time-series cross-sectional framework that will be first employed in Section 3 for testing the relationship between interprovincial trade and international trade. The results indicate the diversion hypothesis—that interprovincial trade is a substitute for international trade—that Anderson and van Wincoop (2003) used

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1 A number of studies dealing with the AIT and Canadian interprovincial trade barriers can be found in C.D. Howe (1995).

2 For example, in cross-country analyses, it is often difficult to find a synthetic measure to capture trade openness. For a discussion of the heterogeneity problem in growth empirics, refer to Temple (1999).
as the underlying framework in the structural gravity model of trade to revisit the Canada–U.S. border
effect literature is clearly rejected by facts.

Second, the paper contributes to the voluminous literature on trade and growth, one of the oldest research
topics in economic literature. In recent years, with the development of international cross-country data
banks, this literature had focused on the empirical relationship between economic growth and openness to
trade.3 To our knowledge, this paper is the first analysis of the relationship between intranational trade
and international trade that uses official comparable data and their connection to economic growth. One
of the key results of Section 4 is that the two trade patterns, east-west interprovincial and north-south
international trade for the Canadian case, do not produce the same results for the relative regional
economic performances. The underlying theoretical framework for the empirical analysis is the well-
known conditional-convergence model of neoclassical growth (Mankiw, Romer, and Weil 1992). This
conditional-convergence framework has been used recently by Vamvakidis (2002) to estimate the effect
of openness on economic growth at the cross-country level. In this study, the empirical methodology
testing for the growth-openness relationship follows the conditional-convergence approach used by
Coulombe (2000; 2003) to study long-run disparities across the Canadian provinces. We will find that
international openness has a positive and significant effect on regional GDP per capita and productivity.
The quantitative effect, measured by combining time-series and cross-sectional information in the
Canadian regional data set, is comparable to the elasticity estimated recently by Frankel and Romer
(1999) with a completely different methodology in a wide cross-section of countries. The long-run
regional effect of interprovincial trade is positive for GDP per capita and employment but is null for
labour productivity.

2. The L curve

Trade data for interprovincial and international trade are available from Statistics Canada on an annual
time-series basis for the 10 Canadian provinces for the 1981–2000 period.4 In this section, we focus on
the comparative evolution of two international and interprovincial trade shares to GDP (INTS and IPTS
respectively):

\[
INTS = \frac{\text{international imports + international exports}}{\text{GDP}}
\]
\[
IPTS = \frac{\text{interprovincial imports + interprovincial exports}}{\text{GDP}}
\]

The idiosyncratic relative evolution of the two time series for Canada as a whole is best illustrated by the
following scatter diagram (Figure 1) that links interprovincial and international trade shares.

Insert Figure 1 here

The scatter observations are linked by a line to illustrate the evolution over time. The historical evolution
starts at the south-east of the diagram and ends at the north-west. The evolution of the two trade shares in
the scatter clearly exemplifies two different periods: (1) between 1981 and 1991, the share of
interprovincial trade to GDP falls continuously and (relatively) steadily and slowly while the share of
international trade to GDP is roughly constant; (2) between 1992 and 2000, the share of interprovincial
trade to GDP is roughly constant while the share of international trade to GDP increases continuously and

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3 See, for example, Frankel and Romer (1999) and Vamvakidis (2002).

4 We use trade data of goods and services in this section. Data are presented and discussed in Appendix 1.
steadily. Obviously it appears that the relationship between the two trade share variables has been disrupted around 1991–1992 by an important structural break. We call this stylized fact the L curve to describe the L shape of the scatter.

Analysis of the scatter of the 10 provinces’ trade shares\(^5\) indicates that the typical L shape characterizing the aggregate relationship between interprovincial and international openness appears to be driven by the two big central provinces of Quebec and Ontario. In the two core provinces, trade patterns evolve similarly and mimic the Canadian pattern. The comparative evolution of trade links is different in the periphery. In Atlantic Canada, both international and interprovincial trade shares decrease substantially during the 1981–1991 period. Thereafter, the international trade share expands and the interprovincial trade share grows roughly at the same rate as GDP. There are few common patterns in trade link evolution across the four Western provinces. Saskatchewan and British Columbia are the only two Canadian provinces that did not experience a noticeable decrease in their interprovincial trade share during the 1981–1990 period. After 1992 for Manitoba, and 1993 for Saskatchewan and British Columbia, both international and interprovincial trade shares increase. During the whole period, the decrease in interprovincial trade shares is not substantial in these three provinces.

The overall picture is different for Alberta. The major oil-producing province is the only province for which the scatter suggests a negative relationship between the evolution of the international and interprovincial trade shares. In fact, Alberta is the only province for which the time-series evolution of the two trade shares is negatively correlated (-0.11) in first difference during the whole period. For the other provinces, correlations are positive and vary from 0.20 for Ontario to 0.61 and 0.72 for Quebec and Newfoundland, respectively. This key information illustrates clearly that, from a time-series basis, the trade diversion hypothesis (that the increase in international trade might have been at the expense of interprovincial trade) might be valuable only for Alberta. We return to this point below.

Furthermore, analysis of the comparative evolution of international and interprovincial trade share indicators differs strikingly for goods and for services. The relationship between international and interprovincial trade shares of goods follows the same L curve shape as total trade. The scatter for trade in services is completely different. Overall, both international and interprovincial trade in services tend to grow at a faster rate than GDP for the whole period. However, the expansion of interprovincial trade in services occurs in the 1994–2000 period while the expansion of international trade in services is mainly in the 1981–1994 period.

To summarize, the L curve is shaped by the evolution of the trade of goods in the two big central provinces of Ontario and Quebec. In 2000, these two provinces account for 70 per cent of Canada’s total international trade.

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\(^5\) To save space, the scatters for the 10 Canadian provinces and for the disaggregation between goods and services are not shown in this paper. They can be found in the research paper version that will be downloadable from the Industry Canada web site.
3. Intranational and international trade: substitute or complement?

3.1 The border effect, the FTA, and the diversion hypothesis

The L curve raises many questions regarding the economics of Canadian trade patterns. Why was the interprovincial trade share falling in the 1980s? Why was interprovincial trade constant in the 1990s while international trade was rising? Why did a sharp break in trade patterns occur in the early 1990s? What is the role of FTA in shaping the L curve? Answering all the questions requires the use of detailed sectorial data and econometric testing of alternative structural models of trade. Of course this task goes well beyond the scope of this paper. In this section, we focus on one single important economic issue that appear to be in conflict with the most straightforward message that emerges from the L shape curve: the diversion hypothesis. In the problem under study, the diversion hypothesis implies that intranational trade is a substitute for international trade. For example, if interprovincial trade was artificially stimulated by the Canadian tariff structure with a resulting trade diversion, removing tariffs (as has been the case in the period under study) will generate an increase in international trade at the expense of interprovincial trade.

Empirical testing of trade diversion versus trade creation following changes in trade barriers has been a subject of study in economics for a long time (Balassa 1967). The diversion hypothesis plays an important role in recent economic analyses of Canadian trade patterns. Pure trade diversion (one for one) between interprovincial trade and province-state trade is a central hypothesis in the structural gravity model of trade of Anderson and van Wincoop (2003), used recently to revisit the Canada–U.S. border effect literature. The model of Anderson and van Wincoop (2003) is based on the theoretical gravity model of trade that was first developed by Anderson (1979). One of the key elements of the modelling, also at the centre of many trade models, is the assumption that each regional economy is endowed with a fixed supply of a differentiated good. This good is either traded intranationally or internationally. Naturally, the effect of trade barriers in this framework is to divert international trade toward the national market.

The key finding of Anderson and van Wincoop (2003) is that McCallum-type border effect estimates are non-symmetrical. McCallum’s (1995) finding, that typical weighted (by size and distance) trade between two Canadian provinces was 22 times larger than weighted trade between a Canadian province and a U.S. state, was recognized by Obstfeld and Rogoff (2000) as one of the trade puzzles. Anderson and van Wincoop (2003) demonstrate that, for a given degree of trade diversion generated by the common border, a McCallum-type border effect is about 10 times greater when measured from Canadian interprovincial trade data than from U.S. interstate trade data. According to Anderson and van Wincoop (2003), this important bias follows mainly from the small size of the Canadian economy compared with that of the United States.

In this section, by pooling time-series and cross-section information contained in the evolution of provincial trade patterns since 1980, we show that the underlying pure trade diversion hypothesis used in the modelling of Anderson and van Wincoop (2003) is clearly rejected by Canadian facts. This point is important for the border effect literature since Canadian trade regional data banks have been from the start at the centre of border effect studies using official intranational trade data.

The diversion hypothesis is also an important element of the interpretation of the effects of FTA on Canadian trade patterns. The FTA is the obvious institutional change that was likely to affect the orientation of provincial trade patterns in Canada. The FTA gradually eliminated and reduced tariff (and nontariff) trade barriers between Canada and the United States from January 1, 1989 to January 1, 1998. The Canada–U.S. Free Trade Agreement was extended to Mexico on January 1, 1994 with the North
American Free Trade Agreement (NAFTA). During this period, Canada experienced a spectacular increase in its trade with its southern neighbour. A decrease in the relative importance of interprovincial trade in the 1988–1996 period has been documented and analyzed in Helliwell, Lee, and Messinger (1999). Based on evidence from industry-level data on commodity trade and tariffs, they conclude that part of the relative decline in interprovincial trade might be attributed to FTA. We will show in this section that the underlying time-series and cross-sectional information contained in Canadian provincial data casts doubt on this interpretation of the effect of FTA.

3.2 Empirical investigation

Even though the L curve gives a clear hint about the rejection of the diversion hypothesis, the curve’s idiosyncratic profile is not a sufficient argument. The information contained in the L curve deals only with the time-series evolution of aggregate trade flows. In this section, we test the prediction of trade diversion by making the best use of the information contained in the pooled time-series and cross-sectional data for the interprovincial and international trade share of the 10 Canadian provinces in the 1981–2000 sample.

On a time-series basis, for one single province, trade diversion implies that an increase in the international trade share is accompanied by a decrease in the interprovincial trade share. We will test for the contemporaneous relationship between the two trade variables and look at a possible Granger causality between the two. From a cross-sectional point of view, the diversion hypothesis implies that provinces with a higher international trade share have a lower interprovincial trade share. This is a key prediction of the endowment economy of Anderson and van Wincoop (2003) in which international trade is a substitute one-for-one for intranational trade. We pool both types of information in an empirical set-up where appropriate measures are gradually taken into account in order to tackle the econometric problems encountered with this type of analysis: various forms of heteroscedasticity, fixed effects, structural breaks, and auto-correlation.

The analysis is carried out in two steps. First, we combine the pooled time-series cross-sectional (across provinces) information for the 10 Canadian provinces in the 1981–2000 sample to analyze the contemporaneous relationship between international and interprovincial trade shares. Second, we will test the Granger causality between these two variables to determine if there is a causal relationship between them.

The results of five diversion regressions are displayed in Table 1. In the first two regressions, the hypothesis is tested on the levels of the \( IPTS \) and \( INTS \) variables. In the last three regressions, the hypothesis is tested on the first difference \( d(IPTS) \) and \( d(INTS) \). Interprovincial trade shares are used as the dependent variable. The diversion hypothesis implies that the expansion of international trade has a negative and significant effect, on average, on the interprovincial trade shares for the 10 Canadian provinces. In all five regressions, we used fixed effects to model the fact that the Canadian provinces follow different trends in the evolution of interprovincial trade shares.

Insert Table 1 around here

In the first three regressions, we estimated the system using seemingly unrelated regression (SUR), which is the least restricted framework here as it corrects for both contemporaneous correlation and cross-sectional heteroscedasticity. For the last two regressions with subsamples, it was not possible to use SUR
due to the limited number of time-series observations. For these two subsample regressions, we used iterated feasible generalized least squares (IFGLS) to account for cross-sectional heteroscedasticity. They produced estimates that were consistent with the ones produced with SUR for the first difference set-up in the whole sample.

In the first column, the diversion hypothesis is tested in level following a straightforward approach that mimics a cross-section econometric approach by abstracting from time-series consideration. For this first econometric set-up, we ignore the important structural break that occurred around 1991 in the relationship between international and interprovincial trade shares, depicted in the L curve, and do not correct for auto-correlation. The effect of international trade on interprovincial trade shares is negative, substantial, and extremely significant (at the 1 per cent level) and the regression has a high R-squared of 0.87. This exercise illustrates the danger of testing the diversion hypothesis by comparing interprovincial and international trade for two dates (such as 1988 before FTA and 1996 after FTA as in Helliwell, Lee, and Messinger [1999]) without taking the 1991 structural brake into consideration.

Due to the time-series dimension of the actual analysis, the results depicted for the first regression post an important warning. The very low Durbin-Watson statistic (0.32) is clear evidence of positive serial correlation in the residuals. As documented and explained in Granger and Newbold (1974) and Phillips (1986), the use of non-stationary data in econometrics might result in spurious regressions. A spurious regression will typically produce a very high R-squared and a very low Durbin-Watson. As a practical rule of thumb, a Durbin-Watson statistic that is lower than the R-squared is evidence of a spurious regression.

The next four regressions use two alternative approaches to tackle the econometric problems of the first diversion regression. In the second regression, we continue to estimate the diversion hypothesis with the levels of the \textit{IPTS} and \textit{INTS} variables. However, we explicitly model the structural brake by introducing for the 10 provinces a time dummy \textit{BR91} that takes the value zero prior to 1991 and one thereafter.\footnote{The general direction of the results (rejection of the diversion hypothesis) is not altered if the time dummy is modelled as a shock to the parameter of the \textit{INTS} variable.} We also correct for serial correlation with a common (for all provinces) AR(1) in the regression. The result regarding the diversion hypothesis is reversed! International openness now has a positive and significant effect (at the 5 per cent level) on interprovincial trade shares. The \textit{BR91} break variable is negative and significant at the 1 per cent level. The standard error of regression is much lower than in the first regression, the R-squared is 0.98, and the Durbin-Watson is close to 2. Obviously regression (2) provides a much better fit than regression (1).

Two supplementary points are worth mentioning regarding the econometric results of regression (2). First, the negative value of the 1991 break does not imply that FTA had a negative effect on interprovincial trade. The reason for the negative value is that the \textit{INTS} variable grows faster after 1991 and the effect of \textit{INTS} on interprovincial trade is positive. The total effect of the changing trade patterns after 1991 on interprovincial trade shares will be best viewed with the following three regressions in first differences. Second, the parameter estimates for the fixed effects are indicators of the relative interprovincial trade shares across the Canadian provinces. It is interesting that the three provinces with a lower dependence on interprovincial openness are Ontario, British Columbia, and Quebec. In Beine and Coulombe’s study (2003), those three provinces show a business cycle that is more correlated with the U.S. business cycle.
In regressions (3), (4), and (5), we use a straightforward approach to tackle the issue of nonstationarity by taking the first difference of both trade variables. In regression (3), the system is estimated for the entire 1981–2000 period. We repeated the same regression setting for the two subsamples 1981–1991 and 1991–2000, which are divided by the date of the structural break for the relationship between the levels of the two trade variables.

For the three diversion regressions using first differences, the diversion hypothesis is strongly rejected with a positive, substantial, and significant (at the 1 per cent level) effect of the change in the international trade shares on the change of interprovincial trade shares. Interestingly, the effect is stronger after 1991 than before. A 100 per cent point increase in international trade translates into a 17.5 per cent and 26.4 per cent point increase in interprovincial trade before and after 1991, respectively.\(^7\)

In the first difference set-up, fixed-effect parameters estimate annual growth long-run trends in interprovincial trade shares, using the assumption that there is no change in international trade shares. The point estimates are not all statistically different from zero. They are, however, all negative and some of them are very significant. For Ontario and Quebec, the long-lasting decrease in interprovincial trade is significant at the 1 per cent level. For Newfoundland, the decrease is significant at the 5 per cent level. For Alberta, the decrease is significant at the 1 per cent level in the 1991–2000 period only.

Having now established a positive statistical relationship between international and interprovincial trade in light of the 1981–2000 cross-sectional and time-series information, we attempt in the last empirical step of this section to verify if there are causality links between the two trade channels. Of course, the following Granger causality exercise has to be viewed with great caution since the number of time-series observations at our disposal is very limited. We have to split the sample into two periods (1981–1991 and 1991–2000) because Granger causality tests would suffer from a serious bias if performed over a period during which a structural break in the relation was observed between the two variables under study. Given the limited number of time-series observations, we have to restrict our study to a one-year lag.

**Insert Table 2 around here**

Results for the 1991–2000 period are presented in Table 2 for Canada and the two big central provinces of Ontario and Quebec. Interestingly, the null hypothesis of non-Granger causality is rejected for both relationships (\(INTS\) not causing \(IPTS\), and the reverse) for the aggregate trade data of both Canada and Quebec. Evidence is mixed for Ontario since the null hypothesis cannot be rejected for one relationship. Overall, the results suggest there is some evidence of a simultaneous (and positive, given the results of Table 1) causality between international trade and interprovincial trade in Canada over the 1991–2000 sample.\(^8\)

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\(^7\) The word “translates” is appropriate here give the a-theoretical approach of the econometric analysis.

\(^8\) The results of Table 1 on the diversion hypothesis are robust to many alternative econometric set-ups. For example, following the Granger causality analysis, one could think of modelling the effect of international openness on interprovincial openness as \(ipts_{-1} = f(ipts_{-1}, ints_{-1}, 1991\text{break, ...})\). In this dynamic set-up, using correction for serial correlation and IFGLS estimation, the point estimate for the lagged international openness variable is positive and significant at the 1 per cent level.
4. Estimating the long-run effect of international and interprovincial trade on provincial growth

As pointed out in Aghion and Howitt (1998, section 11.6), it is very difficult in modern growth theory to isolate the effect of expanding trade links on an economy’s long-run income and welfare. Many different dynamic channels intervene, such as human and physical accumulation, factor price equalization, agglomeration effect and scale economies, and dynamic comparative advantage. For example, Ben-David and Loewy (1998) found that knowledge spillovers resulting from increased trade have a positive effect on economic growth during the transition process and in the long run. On empirical grounds, however, most modern research emphasizes the positive effect of increased international trade on economic growth. As Vamvakidis (2002) shows, this positive effect might be limited to recent decades since 1970. Prior to this, he finds no support for a positive relationship between economic growth and trade measures in a cross-section of countries.9

In this section, we use cross-sectional and time-series information contained in the asymmetric evolution of provincial trade patterns to estimate the long-run effect of trade on provincial GDP per capita and labour productivity in a conditional-convergence framework. This framework works well for testing the relationship between openness and growth, as was done in Vamvakidis (2002).

4.1 Theoretical foundations and empirical methodology

The underlying theoretical framework for the empirical analysis in this section is the conditional-convergence growth model of Mankiw, Romer, and Weil (1992) and of Barro and Sala-i-Martin (1995). In this framework, during the transition process toward the steady state, the evolution of the logarithm of per capita output or labour productivity \( y_{it} \) in the regional economy \( i \) at time \( t \) (for \( i = 1, \ldots, N \) and \( t = 1, \ldots, T \)) is a function of its initial level \( y_{i,t-1} \) and its steady-state value \( y^*_i \). This dynamic process can be written as

\[
y_{i,t} = e^{-\beta} y_{i,t-1} + (1 - e^{-\beta}) y^*_i + \epsilon_{i,t}. \quad (1)
\]

In this equation, \( \beta \) is the annual speed of convergence toward the steady state and the additive error term \( \epsilon_{i,t} \) captures the effect of regional shocks that temporarily affect the economy \( i \) at time \( t \). If \( \beta \) equals 0, \( y_{i,t} \) is determined only by \( y_{i,t-1} \); the economy does not converge to \( y^*_i \); and \( y_{i,t} \) is integrated of order one. The economy, however, converges to a steady state \( y^*_i \) when \( \beta \) is positive and smaller than one. The conditional-convergence hypothesis refers to the case when the \( N \) economic units converge to different steady-state values for \( y^*_i \).

The convergence equation was initially tested using the cross-sectional information that is contained only in cross-country or cross-state databases (Barro 1991; Barro and Sala-i-Martin 1992). The mean growth rate of \( y_i \) in the time interval 0-T was regressed on the initial level of \( y_{i,0} \). This approach, however, suffers from many drawbacks. Some economies might reach their steady state in the middle of the interval, which implies that the speed of convergence would be seriously underestimated. Structural shocks that affect the

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9 Vamvakidis (2002) provides a short, updated synthesis on the vast and growing empirical literature on the growth-openness connection.
steady state of an economy during the time interval are removed of the information in a cross-sectional framework. It is recognized that combining the time-series and cross-sectional information has several advantages over the cross-section approach. The pooling or panel data approach for testing the convergence equation maximizes the use of information since it takes into account the information contained in the time-series evolution of an economy toward its own steady state. The pooling of time-series and cross-sectional information in a convergence-growth framework has to be done very carefully, however, since the two types of information are not comparable in a straightforward manner.

For this reason, in equation (1) (following Coulombe and Lee [1995], and as will be the case for all variables used in the empirical analysis in this section), the regional economic variable \( x_{i,t} \) (like \( y_{i,t} \) and \( y^* \)) is measured as logarithmic deviation from the cross-sectional mean at time \( t \):

\[
x_{i,t} = \log \left( \frac{X_{i,t}}{\sum_{i=1}^{N} \frac{1}{N} X_{i,t}} \right),
\]

where \( X_{i,t} \) is the level of the logarithm \( x_{i,t} \). In this setting, \( y^* \) is the relative long-run gap between province \( i \) and the unweighted provinces’ mean value of economic indicator \( y \). The use of variables measured by deviation from their sample mean proved extremely useful in pooled time-series cross-sectional convergence regressions as it eliminates common factors such as the productivity slowdown that might bias the results. Time-series common trends and shocks have to be eliminated from the analysis in order to have comparable time-series and cross-sectional information.

In this paper, we follow the empirical methodology employed by Coulombe (2000; 2003) to test equation (1) using annual pooled time-series cross-sectional observations. Coulombe’s analysis focuses on the relative evolution of the pre- and post-transfers measures of per capita income across the 10 Canadian provinces in the 1950–1996 sample where relative rates of urbanization across the provinces are used as instruments for the \( y^* \). The results indicate that the provinces have converged at a rate around 5 per cent per year to their relative long-run steady states. Furthermore, most provinces appeared to have been in the neighbourhood of their respective steady states since the mid-1980s. Coulombe (2000; 2003) also found significant structural shocks to the steady-state relative positions of Alberta and Quebec in the early 1970s that were associated with the oil shock and the relative decline of Montreal. The convergence regression used by Coulombe (2000) is

\[
y_{i,t} = \gamma_1 y_{i,t-1} + \gamma_2 RU_{i} + \gamma_3 DA_{i,t} + \gamma_4 DQ_{i,t} + \varepsilon_{i,t}.
\]

The convergence parameter \( \gamma_1 \) is equal to \( e^{-\gamma} \) of equation (1) and the variables \( UR_i, DA_{i,t} \), and \( DQ_{i,t} \) (the relative urbanization variable and the Alberta and Quebec dummies, respectively) determine the relative steady-state values \( y^* \).

In this paper, we want to test the hypothesis that the developments observed in interprovincial and international trade links in the 1981–2000 period might have affected long-run relative provincial key macroeconomic indicators such as GDP per capita and labour productivity. To this end, the methodology of Coulombe (2000) has to be adapted in three different ways to the problem under study in this paper. First, the sample used in Coulombe (2000) has to be restricted to the 1981–2000 period, given the
availability of comparable trade data at the regional level. Second, the whole series regarding international and interprovincial trade has to be used in the empirical analysis since provincial trade patterns have evolved asymmetrically during the period under study. Third, we ignore specific shocks to Quebec and Alberta since they occurred prior to the period under study. The first two of these modifications are important methodological changes and are discussed here.

First, restricting the study period to the 1981–2000 sample translates into a massive loss of information compared with Coulombe’s (2000) analysis. As shown in a number of studies published recently on convergence across Canadian provinces (e.g., Coulombe 2000, 2003), most of the evolution of the cross-sectional variance among Canadian provinces’ per capita income and related indicators occurred in the 1950–1980 period. During this period, the relative dispersion across provinces of per capita income and other related indicators showed a tendency to decrease over time, a phenomenon known as F-convergence in economic growth. Since the early 1980s, the relative dispersion appears to be in the neighbourhood of its steady-state level. Consequently, the cross-sectional variance is much smaller in the 1981–2000 sample than in the 1950–1996 sample used in Coulombe (2000). A convergence regression tested for the 1981–2000 sample would rely more on the information related to the time-series variance that emerged from the evolution of the variables $y_{ij}$ over time. It is important to bear this in mind when analyzing the results of the empirical analysis in this paper. Results might differ from the ones found in Coulombe (2000), and the parameter estimations might be less precise, since a great deal of information has been removed from the analysis due to the restrictions imposed on the period under study.

Second, we test if the evolution of relative interprovincial and international openness in the 1981–2000 sample has affected the steady-state relative values of labour productivity and GDP per capita of the Canadian provinces. The convergence regression equation used to test this hypothesis for both relative GDP per capita and relative labour productivity is the following variation of equation (1):

$$y_{ij} = \gamma_0 y_{i,j-1} + \gamma_2 R U_i + \gamma_3 INT_{i,j-1} + \gamma_4 I P T_{i,j-1} + \epsilon_{i,j}. \quad (2)$$

As in Coulombe (2000), $R U_i$ stands for the relative urbanization variable. It is a cross-sectional variable with just one observation per province. $I N T_{i,j}$ and $I P T_{i,j}$ are the measures of international and interprovincial trade shares respectively. The $I N T_{i,j}$ and $I P T_{i,j}$ are lagged one period in convergence regression equation (2) to avoid the simultaneity problem that might occur if there were a mutual contemporaneous causality between these variables and the dependent variable. In this dynamic set-up, if $\gamma_3$ and $\gamma_4$ are statistically significant and $\gamma_0$ smaller than one, shocks to $I N T_{i,j}$ and $I P T_{i,j}$ (measured as deviations from the cross-sectional mean) disturb the steady-state relative values of variable $y$.

4.2 The results

Convergence regression results for four specifications of equation (2) are displayed in Table 3. The results for the convergence regression of GDP per capita are depicted in columns (1) and (2) and the results for the convergence of productivity are shown in columns (3) and (4). For the two cases, we

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11 The results are robust to specific modelling of Alberta and Quebec dummy variables. An Alberta fixed effect is generally positive and significant; the Quebec fixed effect is negative and significant.

12 If $\gamma_0$ equals one, there is no steady-state growth path.
present results when the *INTS* and *IPTS* variables are measured from the real and the nominal GDP database.\(^{13}\)

The conditional-convergence speeds were estimated using the first difference of \(y_{it}\) as the dependent variable in equation (2). This does not change the estimation of the other parameters reported in Table 3. Convergence speeds are significant at the 1 per cent critical level for GDP per capita, and at the 5 per cent and 10 per cent level for labour productivity. Interestingly, the conditional-convergence speeds vary between 3.5 per cent and 4.7 per cent—very close to the estimates of 5.0 per cent and 5.1 per cent obtained in Coulombe (2000) for per capita income and per capita income minus government transfers in the 1951–1996 sample. However, the urbanization variable is significant at the 10 per cent level (with the expected positive sign) only for specification (1). Long-run differences in per capita GDP and labour productivity are not captured by the relative urbanization variable for the other three specifications. It appears that the long-run effect of the urbanization variable is harder to estimate when the cross-sectional and time-series information associated with the F-convergence of the 1950–1980 period is not taken into account in the conditional-convergence regression.

**Insert Tables 3 and 4 around here**

More importantly for the purpose of this paper, the analysis of the estimated coefficients for the international and interprovincial trade share variables is revealing. The various estimated coefficients for the international trade share variable are all positive and extremely significant with \(p\) value below 0.017 in the four cases. For the interprovincial trade share variable, however, the effect is significant (at the 5 per cent and 10 per cent level) only for GDP per capita. The long-run estimated effect of interprovincial trade on labour productivity is virtually zero.

To complement this qualitative analysis, in Table 4 we present the long-run elasticities of per capita GDP and labour productivity to the different environmental variables. The estimated elasticity of the urbanization variable on the long-run relative per capita GDP is 0.67 when the openness variables are captured by the nominal data set. This number is consistent with the estimated elasticities of the urbanization variable in Coulombe (2000) of 0.78 and 0.51 for per capita income minus transfers and per capita income, respectively.

Regarding the impact of trade openness on per capita GDP, the effect is larger for the international trade share than for the interprovincial trade share for both the nominal and real measures of trade. The difference, however, is not significant using Wald tests. Not surprisingly, the long-run effect is greater for the nominal than the real measure as the effect of terms-of-trade changes is included in the former and excluded in the latter.\(^{14}\) A 10 per cent increase in trade shares, including the terms-of-trade effects, translates into an increase in per capita relative GDP of 6.5 per cent and 5.5 per cent for international trade and interprovincial trade, respectively. For the real measures of trade, the effect on per capita GDP is 5.9 per cent and 4.7 per cent for international trade and interprovincial trade, respectively. In this regional growth framework, increased relative (with respect with the other provinces) trade openness in a province produced a higher standard of living in the long run as measured by per capita GDP. The effect of international trade openness on labour productivity is a little smaller than for per capita GDP.

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\(^{13}\) See data appendix for a discussion of the two concepts of relative trade measures.

\(^{14}\) Refer to Appendix 1 for a discussion of terms-of-trade effect in the nominal and real databases.
On quantitative grounds, the estimated elasticities for the international trade shares are consistent with the empirical estimates of Frankel and Romer (1999) using a cross-country data set and a geographic adjustment in the spirit of gravity models to correct for size and distance. They estimated that an increase of 10 per cent in the trade share to GDP generates an increase of at least 5 per cent in income per capita. They also found a much smaller effect for within-country trade with a real GDP per worker elasticity to interior trade around 0.1. Their measure of within-country trade was based, however, on an artificial database.

Furthermore, the comparative analysis between the per capita GDP and labour productivity in this convergence-growth framework might reveal some interesting insights regarding the relative evolution of regional employment. The difference between the effect of trade openness (and the urbanization variable) on GDP per capita and labour productivity is explained by the evolution of provincial relative employment. Since the effect of interprovincial trade on labour productivity is null, the results suggest that interprovincial trade increases the long-run standard of living at the provincial level only by increasing employment. International trade, however, spurs both relative labour productivity and employment at the provincial level since its effect on GDP per capita is greater than on productivity.

To summarize, the effect of increased international openness on regional standards of living differs from that of interprovincial openness since the former enhances the level of regional labour productivity. This is one of the key results of this paper. The effect of interprovincial trade on regional standards of living comes exclusively from employment creation, whereas the effect of international trade comes mainly from productivity and, to a lesser extent, from employment.

Finally, the results are robust to alternative econometric techniques of combining cross-sectional and time-series information. The results discussed above are based on the same methodology as that used in Coulombe (2000). The approach is based on iterated feasible generalized least squares (IFGLS) estimations using cross-sectional weight regressions. This is to account for cross-sectional heteroscedasticity and the non-parametric White heteroscedasticity-consistent standard error approach for asymptotically valid inferences in the presence of the remaining time-series heteroscedasticity. Estimation results are robust to seemingly unrelated regression (SUR). This approach is designed to produce a feasible GLS estimator in the presence of both cross-sectional heteroscedasticity and contemporaneous correlation in the residuals. Even though the RU variable is not significant with SUR, the conditional-convergence model works well. The estimated long-run elasticities are close to the one estimated with IFGLS and the relative effect of interprovincial trade and international trade on per capita GDP and labour productivity is similar.

4.3 Theoretical interpretation of the results

The long-run relative differential effects of interprovincial and international trade on regional productivity can be interpreted in the framework of the neoclassical growth model of Solow-Cass-Koopman, coupled with an international trade model of Grossman and Helpman (1991) and Ben-David and Loewy (1998).

In the framework of the neoclassical convergence-growth equation (1), a shock to the relative \( y^{**} \) will affect the long-run relative level of labour productivity. This is what is captured by the estimated effect of

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15 As shown in Appendix 2 of the Industry Canada Research paper version.
international openness on labour productivity in this section. Many different theoretical channels have been developed in international trade theory to assess the effect of international trade openness on productivity. In the approach of Grossman and Helpman (1991), for example, the level of regional knowledge stock is positively related to the number of transactions in international markets. Trade with foreign agents creates a knowledge spillover at the regional level because it brings new ideas into the production process.

But this knowledge spillover will result from new trade links. If a set of regional economies—such as the Canadian provinces—have traded with each other for a long time period, there is no reason to assume there is a knowledge spillover positively related to the number of interprovincial transactions in a specific province. One can assume in a neoclassical growth framework that the relative evolution of trade flows across Canadian provinces is in the neighbourhood of a steady-state distribution and that the knowledge associated with this trade has already been diffused to the regions. The actual relative interprovincial trade shares do not capture the rate of learning of new ideas but rather reflect geographical locations, industrial structures, and natural resource endowments.

But this is not the case with international trade. Following FTA with a certain lag, the positive shock to international trade might be viewed as a shock to the relative steady-state position of the provinces since the expansion of international trade since 1991 has not been distributed evenly across the Canadian provinces (see Beine and Coulombe [2003]). In this framework, the central provinces of Quebec and Ontario appear most favourably positioned, given their geographical location and the spectacular expansion of their international trade since 1991.

5. Conclusion

Two separate conclusions, one dealing with trade theory and the other with the trade and growth literature, emerge from the analysis of the relationship between Canadian provincial trade data presented in this paper.

From a trade theory perspective, it appears that the pure trade diversion hypothesis—often used in structural gravity models of trade and other trade models to analyze the effect of trade barriers—is clearly rejected by facts. Consequently, the solution to the border effect puzzle proposed by Anderson and van Wincoop (2003) suffers from a serious setback since trade diversion is at the core of their insightful explanation of McCallum’s (1995) spectacular number. Our analysis suggests that more research is needed to provide a theoretical foundation for the gravity equation that could solve the Canada–U.S. border puzzle. The solution should take into account that, for Canadian regional economies, international trade appears rather to complement than substitute for interprovincial trade. One explanation for this might be that expansion of north-south trade increased the degree of specialization of Canadian regional economies. Given the core-periphery structure of the Canadian economy, this might stimulate trade between the periphery and the core provinces, especially for intermediate goods and primary products. This hypothesis appears consistent with the evolution of interprovincial and international trade for goods at the provincial level (contrary to services) in Section 2. Changes in the regional industrial structure as a result of decreased trade barriers are inconsistent with the starting point of Anderson and van Wincoop’s (2003) modelling. This modelling assumes each region is endowed with a fixed supply of a single differentiated final good.
As for the relationship between trade and growth, the analysis in this paper suggests that, overall or from an aggregate perspective, the vigorous increase in Canadian–U.S. trade that followed FTA (really starting in 1991) might have a positive (level) on productivity and, to a lesser extent, on employment. This conclusion is based on the comparative evolution of intranational and international trade patterns of a homogeneous group (from the institutional, political, and social point of views) of regional economies facing a common shock to their international trade barriers. To our knowledge, this experiment is new in the trade and growth literature. Interestingly, the estimated effects of international trade are relatively large (elasticities between 0.55 to 0.65 for GDP per capita and around 0.5 for labour productivity) and are consistent with estimates found by Frankel and Romer (1999) in a cross-section of countries.

This finding is also interesting since modern growth theory is somewhat sceptical about the effect of increased trade openness and industrial specialization on long-run economic perspectives of economies that are concentrated in primary product exports. For example, Aghion and Howitt (1998, 391) point out that increased international trade might not be beneficial for all types of economies. Based on the argument of dynamic comparative advantages, they fear that a natural-resource–based economy might not capture the dynamic gains of increased specialization as would economies specializing in manufacturing. Our analysis indicates that opening to international trade has been good overall or on average for the Canadian regional economies even if many of them are still dependent on the exploitation of natural resources.

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16 See also Baldwin, Martin, and Ottavio (2001) for an asymmetric effect of trade related to the degree of industrialization.
Bibliography


Figure 1. The L curve

Interprovincial trade share

International trade share

FTA

NAFTA

1981

2000
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<tr>
<td>Estimation</td>
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<td>SUR</td>
<td>SUR</td>
<td>IFGLS</td>
<td>IFGLS</td>
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<td><strong>INTS</strong></td>
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<td>0.052**</td>
<td>0.223***</td>
<td>0.175***</td>
<td>0.264***</td>
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<tr>
<td></td>
<td>(0.011)</td>
<td>(0.024)</td>
<td>(0.027)</td>
<td>(0.060)</td>
<td>(0.050)</td>
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<td><strong>d(INTS)</strong></td>
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<td>0.036***</td>
<td></td>
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<td></td>
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<td></td>
<td>(0.008)</td>
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<td><strong>BR91</strong></td>
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<td>-0.036***</td>
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<td>-0.012</td>
<td>-0.020***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.008)</td>
<td></td>
<td></td>
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<tr>
<td><strong>AL-FE</strong></td>
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<td>0.51***</td>
<td>-0.015**</td>
<td>-0.012</td>
<td>-0.020***</td>
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</tr>
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<td><strong>BC-FE</strong></td>
<td>0.46***</td>
<td>0.35***</td>
<td>-0.003</td>
<td>-0.003**</td>
<td>-0.005*</td>
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<td><strong>MA-FE</strong></td>
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<td>0.59***</td>
<td>-0.005</td>
<td>-0.015***</td>
<td>-0.001</td>
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<td><strong>NB-FE</strong></td>
<td>0.84***</td>
<td>0.69***</td>
<td>-0.010*</td>
<td>-0.017*</td>
<td>-0.008</td>
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<td><strong>NF-FE</strong></td>
<td>0.68***</td>
<td>0.55***</td>
<td>-0.014**</td>
<td>-0.019**</td>
<td>-0.012**</td>
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<td><strong>NS-FE</strong></td>
<td>0.70***</td>
<td>0.57***</td>
<td>-0.014*</td>
<td>-0.024</td>
<td>-0.008</td>
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<td><strong>ON-FE</strong></td>
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<td>0.31***</td>
<td>-0.015***</td>
<td>-0.018***</td>
<td>-0.016***</td>
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<td><strong>PE-FE</strong></td>
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<td>0.80***</td>
<td>-0.018*</td>
<td>-0.033</td>
<td>-0.004</td>
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<td><strong>QU-FE</strong></td>
<td>0.53***</td>
<td>0.40***</td>
<td>-0.011***</td>
<td>-0.013***</td>
<td>-0.013***</td>
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<td><strong>SA-FE</strong></td>
<td>0.72***</td>
<td>0.62***</td>
<td>-0.004</td>
<td>-0.002</td>
<td>-0.011</td>
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<td>AR-correction</td>
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<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<td>0.022</td>
<td>0.026</td>
<td>0.031</td>
<td>0.018</td>
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<td>R-squared</td>
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<td>0.98</td>
<td>0.21</td>
<td>0.16</td>
<td>0.26</td>
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<td>Durbin-Watson</td>
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<td>1.75</td>
<td>1.84</td>
<td>1.97</td>
<td>1.77</td>
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<td>Panel observations</td>
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<td>190</td>
<td>190</td>
<td>100</td>
<td>100</td>
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Notes: See notes at end of Table 3 for details on estimation techniques.
### Table 2. Pairwise Granger causality tests: interprovincial and international openness

<table>
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<tr>
<th>Null hypothesis</th>
<th>F-Statistic</th>
<th>P-Value</th>
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<tbody>
<tr>
<td>INTS (Canada) does not Granger Cause IPTS (Canada)</td>
<td>6.8</td>
<td>0.035</td>
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<tr>
<td>IPTS (Canada) does not Granger Cause INTS (Canada)</td>
<td>14.02</td>
<td>0.007</td>
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<tr>
<td>INTS (Quebec) does not Granger Cause IPTS (Quebec)</td>
<td>7.08</td>
<td>0.032</td>
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<tr>
<td>IPTS (Quebec) does not Granger Cause INTS (Quebec)</td>
<td>11.57</td>
<td>0.011</td>
</tr>
<tr>
<td>INTS (Ontario) does not Granger Cause IPTS (Ontario)</td>
<td>1.3</td>
<td>0.292</td>
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<tr>
<td>IPTS (Ontario) does not Granger Cause INTS (Ontario)</td>
<td>8.82</td>
<td>0.021</td>
</tr>
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</table>

*Notes: Sample 1991–2000; 10 time-series observations, one lag; estimations are done using EViews 4.0.*
Table 3. Estimation results for per capita GDP and labour productivity convergence regression (equation 2 with IFGLS)

<table>
<thead>
<tr>
<th>Dependent variable $y(-1)$</th>
<th>GDP per capita (1)</th>
<th>GDP per capita (2)</th>
<th>Labour productivity (3)</th>
<th>Labour productivity (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y(-1)$</td>
<td>0.953*** (0.013)</td>
<td>0.960*** (0.013)</td>
<td>0.960*** (0.020)</td>
<td>0.964*** (0.019)</td>
</tr>
<tr>
<td>Convergence speed (p value)</td>
<td>0.047 (0.0005)</td>
<td>0.040 (0.003)</td>
<td>0.040 (0.040)</td>
<td>0.035 (0.068)</td>
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<tr>
<td>$RU$</td>
<td>0.032* (0.018)</td>
<td>0.022 (0.018)</td>
<td>0.000 (0.009)</td>
<td>0.002 (0.008)</td>
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<tr>
<td>$INTS(-1)$ (nom)</td>
<td>0.031*** (0.009)</td>
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<td>0.021*** (0.008)</td>
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<td>$IPTS(-1)$ (nom)</td>
<td>0.026** (0.010)</td>
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<td>0.003 (0.007)</td>
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<td>$INTS(-1)$ (real)</td>
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<td>0.024** (0.009)</td>
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<td>0.018** (0.008)</td>
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<tr>
<td>$IPTS(-1)$ (real)</td>
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<td>0.019* (0.01)</td>
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<td>0.004 (0.007)</td>
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<tr>
<td>S.E. of regression</td>
<td>0.022</td>
<td>0.022</td>
<td>0.019</td>
<td>0.019</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.989</td>
<td>0.989</td>
<td>0.975</td>
<td>0.975</td>
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</table>

Notes (Tables 1 and 3): IFGLS are iterated feasible generalized (linear) least-squares estimations using cross-section weighted regressions to account for cross-sectional heteroscedasticity.
- 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 heteroscedasticity-consistent standard error (between brackets) (HCCME) allows for asymptotically valid inferences in the presence of heteroscedasticity.
- SUR is seemingly unrelated regression; standard error (between brackets) are not HCCME with SUR.
- Adjusted sample 1982–2000; 190 panel observations for Table 3.
- AR-correction is correction for autocorrelation. With the exception of the first regression in Table 1, no significant autocorrelation in Table 3.
- Estimations are done using EViews 4.0.
- The 10 Canadian provinces, and their associated fixed effects $FE$ (Table 1) are, from east to west: Newfoundland ($NF$), Nova Scotia ($NS$), Prince Edward Island ($PE$), New Brunswick ($NB$), Ontario ($ON$), Quebec ($QU$), Manitoba ($MA$), Saskatchewan ($SA$), Alberta ($AL$), and British Columbia ($BC$).
Table 4. Long-run elasticity of environmental variables

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>GDP per capita</th>
<th>Labour productivity</th>
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<tr>
<td>$RU$</td>
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<td>–</td>
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<tr>
<td>INTS (nominal)</td>
<td>0.65</td>
<td>0.51</td>
</tr>
<tr>
<td>IPTS (nominal)</td>
<td>0.55</td>
<td>–</td>
</tr>
<tr>
<td>INTS (real)</td>
<td>0.59</td>
<td>0.52</td>
</tr>
<tr>
<td>IPTS (real)</td>
<td>0.47</td>
<td>–</td>
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</tbody>
</table>

*Note:* Computed from Table 3, using long-run solution of equation (2).
Appendix

A Note on the Data

The appropriate choice of data is critical for the empirical analysis of this paper. It is important to point out that two sets of provincial GDP and trade data are used in the paper. The first set is nominal data and comes from the Gross Domestic Product, Expenditure-Based matrices (CANSIM I Matrix 9023 for Alberta and following numbers for the other provinces). The second set is real GDP data that are deflated using (chained) provincial GDP deflators from the Gross Domestic Product 1997 Prices table 3840002 (CANSIM II series v15855886, 965, 966, 968 and 969 for Alberta and corresponding number for the other provinces). In the research paper version, we used the Gross Domestic Product at 1992 Prices matrices (CANSIM I Matrix 9037 for Alberta and following numbers for the other provinces). This real GDP data bank was not extended beyond 1999 and we had to shift to the new chained real GDP data bank to update the data to year 2000. The changes in the real GDP data banks explain the slight differences in the growth regression results between the research paper version and this version.

In the econometric and descriptive analyses, the trade shares are measured as ratio to GDP (Section 2) or by logarithmic deviations from the cross-sectional mean (Section 3). Consequently, all variables are real variables, whether they come from the nominal or the real database. The difference between the two sets of variables is intrinsically related to regional terms of trade and to the specific composition of regional GDP. With the set of GDP and trade data computed from the nominal data bank, deviations from cross-sectional means and ratio of trade to GDP include variations in terms of trade; these variations, however, are excluded from variables computed from the real data set.

A good example to illustrate the difference is the effect of an oil shock on Alberta. An increase in the relative price of oil will expand the output and export measures of Alberta in the nominal GDP data set because the relative value of oil produced in Alberta and exported abroad has increased. This regional terms-of-trade effect will be eliminated from the data set based on real GDP as only real flows (volume of oil) are computed with this data bank. Consequently, if one wants to use a real regional relative GDP measure that is intrinsically related to the real regional relative income (and welfare), one has to use relative values computed from the nominal GDP data set. An increase in the price of oil increases real relative income and relative trade values of Alberta even though the production of oil does not increase. The two sets of data produced useful information and both sets have been employed. When we measured the long-run effect of a trade shock (in Section 3) on the relative per capita GDP, the regional GDP has to be measured from the real GDP data set. This is because we want to purge the dependent variable (real income) from exogenous shifts in terms of trade determined in international markets. However, if one is interested in measuring the relative evolution of trade links between regional economies, the data set based on nominal data is the appropriate one; it captures the change in the relative value of trade across the economies. Another example will illustrate this point. If the United States exports to Canada 10 times the number of computers in 2000 than in 1990, at one-tenth the price, measuring the expansion of U.S. trade in Canada from a nominal GDP data set will show that U.S. exports to Canada has not increased during the period since the value remains the same. However, from a real data set, the real relative value of computer exports to Canada have multiplied by 10 during the period. This is why relative trade data that are computed to illustrate the L curve in Section 2 and used in the econometric analysis in that section are computed from a nominal GDP data set and include the evolution of terms of trade.

Only the real data set (computed from provincial GDP deflators) was used to compute the GDP per capita and the labour productivity series used as dependent variables in the convergence regressions in Section 3.
Both sets of data were used to compute alternative measures of international and interprovincial trade shares in the convergence regressions in Section 3 (nominal versus real in Tables 3 and 4). The analysis in Section 2 focuses on the data set generated from the nominal GDP. The evolution of the ratio of exports plus imports over GDP then includes the evolution of terms of trade.

The employment data used to compute labour productivity from the real GDP data set are total employment (CANSIM I Matrix 9228 for Alberta and following numbers for the other provinces). The urbanization variable in Section 4 is borrowed from Coulombe (2000) and refers to the percentage of the population living within census metropolitan areas and census agglomerations over 10,000 inhabitants. The original data were computed from the population censuses by Ray Bollman at Statistics Canada.