Interprovincial Trade, International Trade, and Growth

by

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Abstract

This paper provides an empirical analysis of the relationship between interprovincial and international trade flows of the Canadian provinces by the pooling of annual time series and cross-sectional information in the 1981-2000 sample. 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 has a significative and substantial effect on regional productivity while the positive effect of interprovincial trade is limited to regional employment. A 10 per cent increase in international trade share translates, in the long run, into an increase in per capita relative GDP and labor productivity of 6.7 per cent and 5.1 per cent respectively. The corresponding long-run effect of an increase in interprovincial trade is 5.5 per cent on per capita GDP but virtually zero on labor productivity.

Keywords: Regional economic integration, trade and growth, conditional convergence
JEL classification: F15, F43, O51, R11

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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. neighbor started to boom and grew at a much faster pace than the traditional east-west interprovincial trade channel.¹ As is the case in many countries confronted with globalization, the spectacular development of international trade links has raised a number of concerns with the Canadian public and policymakers. It has brought some important issues regarding the effects of increased international trade on employment, standards of living, and welfare to the forefront of the economic policy scene. In this paper we investigate the relationships between the two international and interprovincial 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 interprovincial 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).² 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 the relationship between the intranational and international trade channels and economic 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.³

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¹ See Beine and Coulombe (2003) for a comparative analysis of the evolution of interprovincial and international trade links of the Canadian provinces since 1981.

² A number of studies dealing with the AIT and Canadian interprovincial trade barriers can be found in C.D. Howe (1995).

³ 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).
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.\textsuperscript{4} To our knowledge, this paper is the first analysis of the relationship between intranational trade, international trade, and economic growth that uses official comparable data for the two trade channels. One of the key results of the paper 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 labor productivity.

2. Evolution of trade shares

The openness indicators used in the empirical analysis of this paper are the international and interprovincial trade shares to GDP (\textit{INTS} and \textit{IPTS} respectively):\textsuperscript{5}

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

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

The evolution of the two trade shares for the ten Canadian provinces are depicted in Figures 1 and 2 in the 1981-2000 sample.

\textsuperscript{4} See, for example, Frankel and Romer (1999) and Vamvakidis (2002).

\textsuperscript{5} See appendix for data sources.
The notable point that comes out of Figures 1 and 2 is that there is a lot of information contained in the cross-sectional variance and the time series evolution of both the IPTS and the INTS openness variables. The sharp increase in international openness after 1991 for all provinces with the exception of British Columbia is the striking point from a time series perspective. For the overall Canadian economy, the INTS increased steadily from 0.51 to 0.86 in the 1991-2000 period. This sharp expansion follows the gradual elimination and reduction of tariff (and nontariff) trade barriers between Canada and the United States from January 1, 1989 to January 1, 1998 according to the Canada–U.S. Free Trade Agreement. Furthermore, the interprovincial trade shares were decreasing for Ontario, Quebec and the four Atlantic provinces (Newfoundland, Prince Edward Island (PEI), Nova Scotia, and New Brunswick) in the 1980s. From a cross-sectional perspective, Ontario, the largest and one of the richest Canadian provinces displayed continuously the largest international openness and the smallest interprovincial openness. The interprovincial trade shares are the largest for PEI and New Brunswick.

In the remaining of the paper, we use this cross-sectional and time-series information to analyse the relationship between trade and growth across the Canadian provinces.

3. Theoretical foundations and empirical methodology
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.6

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6 Vamvakidis (2002) provides a short, updated synthesis on the vast and growing empirical literature on the growth-openness connection.
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).

The underlying theoretical framework for the empirical analysis 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 $y_{i,t}$ 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

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

In this equation, $\beta$ is the annual speed of convergence toward the steady state and the additive error term $\varepsilon_{i,t}$ 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 $y_{i,t}^*$ 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 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-

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7 See, for example, the discussion on this topic in Temple (1999).
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 variables $x_{i,t}$ (like $y_{i,t}$ and $y^*$) are 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

$$y_{i,t} = \gamma_1 y_{i,t-1} + \gamma_2 RU_i + \gamma_3 DA_{i,t} + \gamma_4 DQ_{i,t} + \epsilon_{i,t}.$$
The convergence parameter \( \alpha \) is equal to \( e^{-\delta} \) 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 \( y^*_i \).

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 sigma-convergence in economic growth (Barro and Sala-i-Martin, 1991). Since the early 1980s, the relative dispersion appears to be in the neighborhood 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 \( y^*_{i,t} \) 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

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8 The results regarding the different effect of trade channels on growth are robust to specific modelling of Alberta and Quebec dummy variables. An Alberta fixed effect is generally positive and significative; the Quebec fixed effect is negative and non significative.
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):

\[ y_{i,t} = \gamma_1 y_{i,t-1} + \gamma_2 RU_i + \gamma_3 INTS_{i,t-1} + \gamma_4 IPTS_{i,t-1} + \varepsilon_{i,t}, (2) \]

As in Coulombe (2000), \( RU_i \) stands for the relative urbanization variable. It is a cross-sectional variable with just one observation per province. The key variables here are the \( INTS_{i,t} \) and \( IPTS_{i,t} \). The international and interprovincial trade shares (measured as deviations from the cross-sectional mean) are lagged one period in convergence regression equation (2) because of potential delays regarding the effects of these variables on productivity and per capita GDP growth. This lagging procedure is also a straightforward way to tackle the usual simultaneity problem that might occur if there were a two-way contemporaneous causality between these variables on the one hand and the dependent variable on the other hand. In a pure cross-sectional framework, such as in the cross-country analysis of Frankel and Romer (1999), instrumental variables have to be used for the trade variables in order to overcome this problem. In this dynamic set-up, if \( \gamma_3 \) and \( \gamma_4 \) are statistically significant and \( \gamma_1 \) smaller than one, shocks to \( INTS_{i,t} \) and \( IPTS_{i,t} \) disturb the steady-state relative values of variable \( y \).

4. The results

Convergence regression results for four specifications of equation (2) are displayed in Table 1. 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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\[^9\text{For a discussion of using cross-sectional fixed effects in this regression set-up, refer to Coulombe (2000).}\]

\[^{10}\text{If } \gamma_1 \text{ equals one, there is no steady-state growth path.}\]
present results when the \( INTS \) and \( IPTS \) variables are measured from the real and the nominal GDP database.\(^{11}\)

The conditional-convergence speeds were estimated using the first difference of \( y_{i,t} \) as the dependent variable in equation (2). This does not change the estimation of the other parameters reported in Table 1. 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 sigma-convergence of the 1950–1980 period is not taken into account in the conditional-convergence regression.

Insert Tables 1 and 2 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 2 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

\(^{11}\) See data appendix for a discussion of the two concepts of relative trade measures.
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.\(^\text{12}\) 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.

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

\(^{12}\) Refer to Appendix for a discussion of terms-of-trade effect in the nominal and real databases.
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 the key result 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.

5. 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).

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13 As shown in Appendix 2 of the Industry Canada Research paper version available to download from Industry Canada web site.
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 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

The analysis in this paper suggests that, overall or from an aggregate perspective, the vigorous increase in Canadian–U.S. trade that followed FTA 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 skeptical 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.

Bibliography


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


Figure 1. International trade shares - Canadian provinces

Note: Data from nominal data set (see Appendix)
Figure 2. Interprovincial trade shares - Canadian provinces

Note: Data from nominal data set (see Appendix)
Table 1. 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>
</tr>
<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>
</tr>
<tr>
<td>$INTS (-1)$ (nom)</td>
<td>0.031*** (0.009)</td>
<td></td>
<td>0.021*** (0.008)</td>
<td></td>
</tr>
<tr>
<td>$IPTS (-1)$ (nom)</td>
<td>0.026** (0.010)</td>
<td></td>
<td>0.003 (0.007)</td>
<td></td>
</tr>
<tr>
<td>$INTS (-1)$ (real)</td>
<td></td>
<td>0.024** (0.009)</td>
<td></td>
<td>0.018** (0.008)</td>
</tr>
<tr>
<td>$IPTS (-1)$ (real)</td>
<td></td>
<td>0.019* (0.01)</td>
<td></td>
<td>0.004 (0.007)</td>
</tr>
<tr>
<td>S.E. of regression R-squared</td>
<td>0.022</td>
<td>0.022</td>
<td>0.019</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>0.989</td>
<td>0.989</td>
<td>0.975</td>
<td>0.975</td>
</tr>
</tbody>
</table>

Notes: 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.
- No significative autocorrelation.
- White heteroscedasticity-consistent standard error (between brackets) (HCCME) allows for asymptotically valid inferences in the presence of heteroscedasticity.
- Adjusted sample 1982–2000; 190 panel observations.
- Estimations are done using EViews 4.1.
Table 2. Long-run elasticity of environmental variables

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>GDP per capita</th>
<th>Labour productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$RU$</td>
<td>0.67</td>
<td>–</td>
</tr>
<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>
</tr>
</tbody>
</table>

*Note:* Computed from Table 1, using long-run solution of equation (2).
Appendix

A Note on the Data

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. However, the very comparable results we get from the two real data bases illustrate the robustness of the empirical analysis.

In the econometric and descriptive analyses, the trade shares are measured by logarithmic deviations from the cross-sectional mean. 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.

For example, 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 partly eliminated from the data set based on real GDP as only real flows (volume of oil) are computed with this data bank.

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. This is because we want to purge the dependent variable (real income) from exogenous shifts in terms of trade determined in international markets. Both sets of data were used to compute alternative measures of international and interprovincial trade shares in the convergence regressions.

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.