Regional Wage Convergence in Canada: An Error-Correction Approach

Bakhtiar Moazzami
Department of Economics
Lakehead University
Thunder Bay, ON P7B 5E1

Regional economic disparity and geographic variations in economic opportunities have been part and parcel of economic growth and development in Canada (Anderson 1988). Regional variation exists not only with respect to the availability of employment but also with respect to the level of wages and earnings. A narrowing of the gaps in both wages per employed person and gross domestic product has occurred over the past twenty-five years, but the gaps still exist, especially for the Atlantic provinces (Swan and Serjak 1991). The Prairie region has traditionally had per capita incomes which are below the Canadian average and fluctuate with the agricultural market. Quebec has been slightly below the average while Ontario and B.C. have been above it.

A number of studies using Canadian and American data have tried to test whether there has been a tendency for interregional per capita income differences to decline over time. In their recent study, Coulombe and Lee (1995) found evidence of convergence in Canada for six different measurements of per capita income and output since the early 1960s. They also found that since 1968, there is evidence of convergence in living standards and labour productivity in Canada. The convergence hypothesis is based on the premise that market adjustment forces will lead to convergence of per capita income measures among regions. This means that relatively poor regions will tend to grow faster than relatively rich regions. The main mechanisms for convergence are the flexibility in prices and wages and mobility and substitutability of capital and labour. For example, high unemployment in a region will lead to lower wages. This induces labour to leave the region for higher wage destinations and capital to flow in to take advantage of the lower wages there. This process will simultaneously increase income

© Canadian Journal of Regional Science/Revue canadienne des sciences régionales, XX:3 (Autumn/automne 1997), 341-350.
ISSN: 0705-4580 Printed in Canada/Imprimé au Canada

in the poor region and lower income in the rich region. In the long run, this process results in equalization of income between the two regions. In this context, regional disparity can exist due to the failure of market forces caused primarily by government interferences. Evidence for Canada shows that this adjustment mechanism correctly predicts labour flows away from low wage provinces towards high wage provinces (Courchene 1970; Marr and Whitney 1983). However, some argue that such things as federal transfer payments, including generous unemployment insurance benefits, and government and union imposed wage parity across the country with little consideration to the local labour market conditions impede market adjustment and wage convergence in Canada (Courchene 1981, 1986). This is because the working of the convergence mechanism relies on the mobility of labour and capital and on the flexibility of wages and prices. For instance, Blanchard and Katz (1992) in their study of differential growth rates of the states in the U.S. over forty years conclude that the dominant adjustment mechanism is labour mobility in response to unemployment changes.

The objective of the present study is to test the hypothesis of convergence for ten provinces and two regions of Canada using wages per unit of paid labour as the economic indicator. We employ a time-series approach based on the error-correction methodology which not only allows for testing the convergence hypothesis as a long run proposition, but also allows for short-run disparities to take place.

The paper proceeds as follows. The first section provides a brief review of the literature. The second presents an error-correction model designed to test the convergence hypothesis as a long-run proposition while allowing for short-run disparities or deviations from the long-run equilibrium to take place. The data and estimation results are discussed in the third section, and the final section provides a brief summary.

Review of Literature

In their recent study, Barro and Sala-I-Martin (1992) outlined the convergence mechanism across regions using a transitional dynamics of output per unit of labour, *Y*, approximated as:

$$\ln[Y(t)] = \ln[Y(0)]e^{-\beta t} + \ln(Y^*)(1-e^{-\beta t}) \qquad (1)$$

where Y^* is the steady state level of output per unit of labour and â is the rate of convergence to the steady state. The average rate of growth over an interval 0 to *T* is:

$$\frac{1}{T}\ln\frac{Y(T)}{Y(0)} = \mu + \frac{(1-e^{-\beta t})}{T}\ln\frac{Y^*}{Y(0)} \qquad (2)$$

where μ is the rate of exogenous labour augmenting technological progress. The higher the coefficient â, the more responsive the average growth rate to the gap between ln(Y^*) and ln[Y(0)], and the faster the convergence to the steady state. Applying equation (2) to a region I for discrete time periods and including a random disturbance term u_{it} results in:

$$\ln \frac{Y_{it}}{Y_{i,t-1}} = \delta i - (1 - e^{-\beta t}) \ln (Y_{i,t-1}) + u_{it} \qquad (3)$$

where $ä_i = \mu_i + (1 - e^{-âT}) \ln(Y_i^*)$.

There are two concepts of convergence which have their roots in equation (3). Convergence whereby poor regions grow faster than rich regions corresponding to the coefficient â greater than zero (if $ä_i$ and μ_i are the same for each region). This is referred to as â-convergence. Convergence whereby the cross-regional variance of ln(Y_{it}) follows a monotonic path as it converges to its long-run equilibrium value. This is called ó-convergence. If one is interested in the rate and extent of catching up by a particular region to the average across regions, then â-convergence is the relevant concept (Barro and Sala-I-Martin 1991, 1995; Sala-I-Martin 1996).

Using the above model, researchers have tried to examine the hypothesis of convergence among regions and countries. For example, Barro (1991) looked at data for 98 countries from 1960 to 1985 and found that the simple correlation between per capita growth in output and the initial level of output (1960 GDP) to be not significantly different from zero. In fact, the convergence coefficient had the wrong sign, meaning that was a tendency for rich countries to grow faster than poor ones after 1960.[1] Barro and Sala-I-Martin (1991, 1992) examined â-convergence in per capita personal income from 1880 to 1988 and in per capita gross state product from 1963 to 1988 for 47 U.S. states. Similarly, they examined â-convergence in per capita gross domestic product from 1950 to 1985 for 73 regions of seven European countries. In all cases they found the rate of â-convergence to be positive, supporting the hypothesis that poor regions grow faster than rich ones.[2] Coulombe and Lee (1995) examined convergence between the Canadian provinces. They looked at â-convergence over the ten provinces for

1. This picture changed when a proxy for human capital was included in the model suggesting that whether a poor country tends to grow faster than a rich country depends on its level of human capital relative to its level of per capita income at the beginning of the time interval being examined.
2. Other studies also found evidence of convergence. For example see Mankiw et al (1992), Baumol (1986) and Abromovitz (1986).

six measures of per capita income or output for three ten-year subperiods from 1961 to 1991. They found evidence of convergence in Canada similar to those observed for regions in other countries. However, convergence patterns differed depending on the measure of the economic indicator used.[3] They also examined ó-convergence, a measure of the cross-sectional dispersion of income from 1926 to 1991 and concluded that convergence in economic indicators is not necessarily the rule in Canada.

Much of the existing literature relies on the cross-section approach. In the case of Canada, simple cross-section approaches are not very reliable since there are only ten provinces and therefore relatively few degrees of freedom. To rectify this problem, Coulombe and Lee (1995) used a panel data approach by generating a sample of ten cross-section and three time series for ten provinces during 1961 to 1991. In the present study, we examine the convergence hypothesis using time series approach based on error-correction methodology.

The Model

To examine the hypothesis of convergence of wages among various regions in Canada, we consider the following error-correction model:

$$W_{i,t} - W_{i,t-1} = \alpha + \delta(P_{i,t} - P_{i,t-1}) + \lambda(RW_{i,t-1} - \Theta_i WCA_{t-1}) + \phi Z_{it} + \omega_t \quad (4)$$

where $W_{i,t}$, and $RW_{i,t}$ are the nominal and real wages in region i at time t, $P_{i,t}$ is the level of prices in region i at time t, WCA is the average real wages in Canada, Θ_i measures the long-run response of real wages in region i to changes in the average real wages in Canada, Z_{it} is a vector of other relevant variables in region i at time t and ω_t is a random disturbance term. All variables are in log form.

Equation (4) is based on the premise that market adjustment forces (price and wage flexibility and mobility and substitutability of capital and labour) will reduce wage differentials between different regions. The steady state solution of model (4) is $RW_i = \Theta_i WCA$, which implies that there exists a long-run steady state equilibrium relationship between real wages across various regions. The hypothesis of Θ_i being identical to unity implies that real wages across various

3. This is expected in some cases. In particular, with mobile capital one might expect to see greater convergence in regional product than in regional income since capital-rich residents of the high income/slow growth region can invest in the low income/high growth region, thereby maintaining a high growth rate of personal income.

regions are equal in the long run. We refer to this hypothesis as the strong form of convergence. However, $\grave{E}_i$ can be different from unity since the initial endowment, the rate of technological progress and industrial composition may vary from region to region. The hypothesis of $\grave{E}_i$ being greater than zero but different from unity is referred to as the weak form of convergence. Deviation from the long-run equilibrium relationship results in short-term adjustments. The speed of adjustment is measured by ë. The adjustment process is convergent if ë is negative. For example, if real wages in region *i* are below their long-run equilibrium relationship with other regions, out-migration of workers reduces the supply of labour and thus increase wages in that region. Equation (4) shows that it is the nominal wage that, in the short run, responds to changes in the supply and demand for labour. Therefore, market adjustment forces ensure that nominal wages in low wage regions continue to rise until real wages in that region have reached their long-run steady state equilibrium level. Therefore, the convergence hypothesis can be tested by testing whether the coefficient ë is negative and significantly different from zero. Inclusion of the price variable in equation (4) follows Sargan's (1964) specification of wage adjustment in the U.K. and suggests that workers, at least in the long run, are interested in their real wages. In the short run, however, money illusion can exist if the coefficient ä is significantly smaller than unity.

Data and Estimation Results

Before discussing the estimation method and the results, a few words about the data used in this study is in order. We employed annual observations for ten provinces plus two regions, namely, Atlantic and the Prairie regions for which consistent data could be assembled. Data used for the Atlantic region, the Prairie region, Ontario, Quebec and British Columbia cover the period of 1960-94. For Newfoundland, Nova Scotia, New Brunswick, Manitoba, Saskatchewan and Alberta data were available for the 1966-94 period. For P.E.I. the data allowed analysis from 1975 to 1994 only. We used nominal wages, salaries and supplementary labour income per paid worker as the basic measure of per capita income.[4] The price level is measured by the consumer price index.[5] Real wages

4. The wages, salaries and supplementary income data are available for the provinces but not for the Atlantic and Prairie regions and thus had to be generated. To save space, we have not presented the detailed discussion of data sources. However, they are available upon request.
5. Provincial Consumer Price Indices are available from 1979 onward only and there is no CPI for the Prairie and Atlantic regions. However, price indices are available for Census Metropolitan Areas (CMA). Therefore,

were constructed by dividing nominal measures by the CPI.

To estimate equation (4) we need to specify variables in *Z*. This vector should include all labour market specific variables which influence wages in different regions. We considered a number of such variables, namely regional unemployment rate, regional unionization rate, level of education, proportion of employment in manufacturing as a proxy for sectoral composition, a time trend to capture the effect of productivity and technological changes, and the proportion of the population in the age group 35-49 years as a proxy for experience.[6] Except for the regional unemployment rates and time trend, all other variables were statistically insignificant and therefore omitted from the final estimates.

Our preliminary estimates revealed that wage equations for Newfoundland, Nova Scotia, Atlantic region, Quebec, Ontario, Alberta and B.C. have undergone a structural break during the mid to late 1970s. Timing of these breaks coincides with the Anti-Inflationary Board (AIB) wage inflation restraint program which was in place for eleven quarters from 1975:4 to 1978:2. Research has shown that the direct wage restraint impact of the AIB was significant and that the total effect was to reduce newly negotiated wage gains in Canada by ten percent below what they would have been when the program ended (Walsh and Schaafsma 1989). Therefore, in order to capture the effect of the structural break we included a dummy variable in model (4).[7]

To allow for the presence of lags in the response of nominal wages to changes in price and unemployment rate variables, we included three lags of the dependent variable, changes in prices and the unemployment rates among our explanatory variables. Following Gilbert (1986), we used a series of F-tests along with the Akaike's final prediction error (Akaike 1970) to reduce the number of lags appearing in the estimated equations. We found that only the first lag of the dependent variable was statistically significant in the regression for Ontario, New Brunswick, and Saskatchewan. In all other cases, none of the lagged variables were significant. The estimation of model (4) was carried out using maximum likelihood (ML) estimation technique. The starting values for the ML iterations were set equal to the estimated parameters from the OLS regression of the unrestricted model.

---

provincial and regional price indices were constructed by using a weighted average of the CMA Consumer Price Indices. Detailed discussion of these indices are available upon request.

6. Data on some of these variables are not available for the entire period under consideration. In those cases, we estimated the convergence model for the period for which data were available.

7. Data suggests the presence of structural breaks during the following years: Newfoundland 1973; Nova Scotia 1977; Atlantic Region 1976; Quebec 1978; Ontario 1977; Alberta 1976; B.C. 1977.

To ensure the validity of the estimated results for statistical inference, the estimated models were subjected to a series of diagnostic tests. The augmented Dickey Fuller (ADF) test is used to test for the presence of a unit root in the residuals. All values of the ADF test are below the critical limit rejecting the presence of non-stationarity in the residuals. The m-test proposed by Durbin (1970) is used to test for the presence of first-order autocorrelation in the residuals. All t-statistics reported in the row labeled t(ñ) are below the critical value and therefore we cannot reject the null of no autocorrelation.

Turning to the results, Table 1 presents the maximum likelihood estimates of model (4) for various regions of Canada. We first concentrated on the long-run steady state equilibrium relationship between real wages in different regions and the overall real wage in Canada. Table 1 shows that the error correction coefficient È, which measures the long-run response of real wages in various

TABLE 1 Maximum Likelihood Estimates of Model (4)

				Atlantic Region					Prairie region			
Coefficient	ON	QP	BC	NF	PE	NS	NB	Atl.	AL	SK	MN	Prarie
Constant	0.19 (1.35)	0.16 (1.19)	0.42 (2.45)	0.41 (0.94)	0.93 (2.56)	0.48 (1.23)	1.11 (1.54)	0.75 (2.85)	0.68 (2.24)	0.49 (1.10)	0.38 (1.23)	0.87 (1.23)
$W_{t-1} - W_{t-2}$	0.15 (2.12)	--	--	--	--	--	0.23 (2.29)	--	--	0.19 (2.93)	--	--
$P_t - P_{t-1}$	0.61 (5.32)	0.85 (4.85)	1.22 (7.83)	0.41 (1.64)	0.75 (2.56)	0.74 (3.23)	0.32 (1.21)	0.56 (3.45)	0.94 (4.32)	1.05 (2.56)	0.63 (2.91)	1.06 (6.87)
λ	-0.16 (1.96)	-0.14 (1.74)	-0.34 (2.65)	-0.27 (4.23)	-0.38 (4.21)	-0.31 (4.98)	-0.36 (2.34)	-0.31 (4.35)	-0.31 (4.29)	-0.35 (3.95)	-0.15 (1.21)	-0.33 (3.94)
Θ	1.02 (1.95)	0.92 (5.84)	0.97 (10.21)	0.68 (4.96)	0.71 (6.32)	0.73 (6.21)	0.82 (7.46)	0.81 (9.39)	0.96 (6.54)	0.58 (4.57)	0.36 (0.87)	0.84 (8.23)
Time Trend	0.003 (3.21)	--	0.003 (2.95)	0.004 (2.57)	0.004 (1.58)	0.008 (3.21)	0.005 (1.84)	0.003 (1.78)	0.008 (3.47)	0.007 (3.21)	--	--
Unemp. rate	-0.03 (3.47)	0.01 (0.53)	-0.01 (1.25)	-0 03 (1.32)	-0.03 (2.36)	-0.02 (1.98)	0.06 (1.47)	-0.05 (2.92)	-0.03 (1.78)	-0.05 (1.95)	-0.02 (1.56)	-0.025 (1.67)
Dummy	-0.04 (4.01)	-0.04 (2.63)	-0.04 (2.67)	0.06 (2.35)	--	-0.08 (4.32)	--	-0.06 (4.74)	-0.07 (3.57)	--	--	--
R^2	0.83	0.75	0.89	0.75	0.85	0.73	0.53	0.86	0.75	0.71	0.51	0.82
D.W.	1.97	2.03	1.98	1.96	1.99	2.08	2.01	1.98	2.05	2.01	2.09	2.01
$t(\rho)$	0.01	0.12	0.31	0.37	0.06	0 .21	0.05	0.38	0.09	0.18	0.48	0.41
H_0: δ =1	3.40	0.85	1.41	2.36	0.85	1.13	2.57	2.71	0.28	0.12	1.71	0.39

regions to changes in the overall wages in Canada, is statistically significant for all regions except for Manitoba. In other words, except for Manitoba, there exists a long-run equilibrium relationship between real wage per paid worker in various regions of Canada. The long-run hypothesis of real wage equality can be examined by testing whether the long-run coefficient È is equal to unity. If È is equal to unity for all regions, then in the long run, steady state real wages will be equal across the country. The t-test reported in the last row of Table 1 shows that the strong form of convergence or the real wage equality hypothesis is accepted for Ontario, Quebec, B.C., the Prairie region, New Brunswick and Alberta. The long-run equilibrium real wage in the Atlantic region, Newfoundland, Nova Scotia, Saskatchewan and P.E.I has been significantly smaller than the overall real wages in Canada. In other words, a weak form of convergence is supported for these regions.

The adjustment coefficient on the error correction term is negative and highly significant for all regions, except for Quebec and Manitoba. For Quebec, the adjustment coefficient is significant at the 10% level and for Manitoba it is insignificant. This suggests that, in the short run, nominal wages in various regions of Canada (except for Manitoba) respond to inter-regional wage disparity. The adjustment coefficients are relatively large suggesting that changes in nominal wages in the short run close a significant part of the gap between the current real wages and their long run equilibrium levels. In other words, if the real wage income per paid worker in a region is below (above) its long-run equilibrium level, then market adjustment mechanism works so that nominal wages in that region increase (decrease) such that a part of this disequilibrium gap is closed each year. The adjustment coefficient is negative ensuring that this adjustment process is stable and convergent.

The hypothesis of no money illusion in the short run can be examined by testing whether the coefficient of change in the price level is identical to unity. Acceptance of this hypothesis implies that workers see through the money veil and therefore respond to variations in the real wages across different regions. Table 1 shows that the change in the price level is significant for all regions except for Newfoundland and New Brunswick. The hypothesis of no money illusion is accepted for all regions except for Ontario, the Atlantic region, Newfoundland and New Brunswick. The unemployment rate is negative and significant for Ontario, the Atlantic region, Nova Scotia, P.E.I. and Saskatchewan. The time trend variable has a positive sign and is significantly different from zero for Ontario, B.C., Newfoundland, Nova Scotia, New Brunswick, Alberta and Saskatchewan. The time trend picks up the effect of variables such as technology and productivity, which are positively correlated with the wage levels in these regions. Finally, the dummy variable is statistically significant for Ontario, Quebec, B.C., the Atlantic region, Newfoundland, Nova Scotia and Alberta suggesting that wages experienced a significant break during the mid to late 1970s.

Conclusion

In this paper, we used an error correction approach for testing the hypothesis of convergence of wages among various regions. Error correction methodology not only enabled us to find the long-run relationships between wage incomes per paid worker across different regions, but also provided a convenient way of testing whether deviations of wages from their long-run relationships are corrected for in the short run.

Using data on ten provinces and two regions in Canada, we found support for the strong form of convergence of wage income per paid workers for Ontario, Quebec, B.C., the Prairie region, New Brunswick and Alberta. A weak form of convergence is supported for the Atlantic region, Newfoundland, Nova Scotia, Saskatchewan and P.E.I. We found that there exists a long-run equilibrium relationship between real wages across different regions. We also found that if a region's real wage income per paid worker deviates from that long-run equilibrium relationship, market adjustment forces work so that wages tend toward their long-run equilibrium levels.

A brief comparison with the Coulombe and Lee studies may be interesting. Our results are similar to those of Coloumbe and Lee (1995) and Lee and Coloumbe (1995) in so far as the convergence hypothesis is concerned. This similarity is striking when we note the fact that our economic indicator and, more importantly, our testing methodology are quite different. However, the estimated speeds of adjustment in this study seem to be much faster than those found in their studies. In other words, wages per unit of paid worker seem to converge faster than various measures of per capita income and output used by them. The higher speed of adjustment of wages found in this study can be partly due to the fact that we have employed time series data while their study used panel data. Furthermore, the speed of convergence may be related to the economic indicator used. We used wages per unit of paid worker while they used various measures of per capita income and output. In their study, Lee and Coulombe (1995) found that the speed of convergence increased as they moved from a per capita basis to a per worker basis, and from a per worker basis to a per hour basis. Needless to say, further research is needed. Such work can combine time series and cross-section data to shed more light on the interregional wage and output adjustments in Canada.

References

Akaike, H. 1970. "Autoregressive Model Fitting for Control". *Annals of the Institute of Statistical Mathematics*, 22: 163-180.

Abramovitz, M. 1986. "Catching up, Forging Ahead and Falling Behind". *Journal of Economic History,* XLVI: 385-406.

Anderson, F.J. 1988. *Regional Economic Analysis: A Canadian Perspective*. Toronto: Harcourt Brace Jovanovich Canada Inc.

Barro, R.J. 1991. "Economic Growth in a Cross-Section of Countries". *The Quarterly Journal of Economics*, May: 407-443.

Barro, R.J. and X. Sala-i-Martin. 1991. "Convergence Across States and Regions". *Brookings Papers on Economic Activity*, 1: 107-158.

_____. 1992. "Convergence". *Journal of Political Economy*, 100: 223-251.

_____. 1995. *Economic Growth*, New York: McGraw-Hill.

Blanchard, O.J. and L.F. Katz. 1992. "Regional Evolutions". *Brookings Papers on Economic Activity*, 1: 1-61.

Baumol, W.J. 1986. "Productivity Growth and Convergence". *The American Economic Review*, December: 1073-1085.

Courchene, T. J. 1970. "Interprovincial Migration and Economic Adjustment". *Canadian Journal of Economics*, 3: 550-576.

_____. 1981. "A Market Perspective on Regional Disparities". *Canadian Public Policy*, 7: 506-518.

_____. 1986. "Avenues of Adjustment: The Transfer System and Regional Disparities", in D.J. Savoie (ed.). *The Canadian Economy: A Regional Perspective*. Toronto: Methuen.

Coulombe S., and F.C. Lee. 1995. "Convergence Across Canadian Provinces, 1961 to 1991". *Canadian Journal of Economics*, 28: 886-898.

Durbin, J. 1970. "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors Are Lagged Dependent Variables". *Econometrica*, 38: 410-421.

Gilbert, C.L. 1986. "Professor Hendry's Econometric Methodology". *Oxford Bulletin of Economics and Statistics*, 48: 283-307.

Lee F.C. and S. Coulombe. 1995. "Regional Productivity Convergence in Canada". *Canadian Journal of Regional Science*, 18: 39-56.

Mankiw, N.G., D. Romer and D.N. Weil. 1992. "A Contribution to the Em-pirics of Economic Growth". *The Quarterly Journal of Economics*, May: 407-437.

Marr, W. and W. Whitney. 1983. "The Changing Pattern of Differential Regional Growth in Canada 1951-61 and 1961-71". *Nebraska Journal of Economics and Business*, 22: 29-43.

Swan, N. and J. Serjak. 1991. "The Anatomy of Disparities". *Economic Council of Canada.* working paper, No. 16.

Sala-i-Martin, X. 1996. "The Classical Approach to Convergence Analysis". *The Economic Journal*, 106: 1019-1036.

Sargan, J.D. 1964. "Wages and Prices in the United Kingdom: A Study in Econometric Methodology", in D.F. Hendry and K.F. Wallis (eds.). *Econometrics and Quantitative Economics*. New York: Basil Black-well Inc.

Walsh, W.D. and J. Schaafsma. 1989. "An Empirical Analysis of the Impact of Canadian Wage Controls on Negotiated Wage Settlements, 1967-87". University of Victoria discussion paper, 89-10.