HUMAN CAPITAL AND CONVERGENCE IN CANADA

by

Giuseppe Ruggeri

and

Haifang Huang

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Giuseppe Ruggeri and Haifang Huang

University of New Brunswick

Abstract

Abstract

The BMS model predicts the same speed of convergence for human capital and output per effective labour. Coulombe and Tremblay (1999) applied the model to the Canadian provincial economies during the 1961-1996 period and found support to this prediction. This paper tests the convergence of human capital in Canada during the 1976-1999 period following the same theoretical framework. The results show no evidence of convergence on the favoured indicators. Moreover, the test on the relationship between the human capital indicator and the labour productivity indicator suggests persisting interprovincial differences in labour productivity that have not been reduced either by the relative accumulation of human capital or by exogenous factors operating through time.

Department of Economics, University of New Brunswick, P.O. Box 4400, Fredericton, N.B. E3B 5A3; Phone (506) 453-4828, Fax (506) 453-4514; Email ruggeri@unb.ca

HUMAN CAPITAL AND CONVERGENCE IN CANADA

I. INTRODUCTION

A major unresolved issue in the study of comparative growth is the reconciliation between empirical estimates of the speed of convergence and the values predicted by neo-classical models of growth. According to the traditional neo-classical model where capital is confined to physical assets, diminishing returns to capital accumulation assure that poorer countries or regions will grow faster than richer countries or regions, thus leading to convergence of output per worker. Empirical studies have estimated speeds of convergence of about .02 (2 percent) per year for both cross-country and cross-region samples (see, for example, Barro (1991), Barro and Sala-i-Martin (199,1992), Levine and Rennet (1992), Mankiew, Romer and Weil (1992)). As pointed out by Barro, Mankiw and Sala-i-Martin (1995), hereafter called BMS, "the neoclassical growth model can explain the observed rate of conditional convergence if economies are closed and the capital share is about 0.8" (p. 103). Since the share of physical capital is in the neighborhood of 0.3, the neo-classical model implies annual speeds of convergence considerably higher than the observed 2 percent. For example, Barro and Sala-i-Martin (1992) incorporated a set of baseline values to the neo-classical model and predicted a speed of convergence of .13 per year.

Initial efforts at reconciling the above differences were focused on finding ways to raise the

share of capital from the low value associated with physical capital only. This adjustment was achieved by including human capital in the definition of capital, as suggested by Mankiw et al. (1992). This adjustment did not eliminate a major shortcoming of the neo-classical model of convergence, namely, the assumption of a closed economy. This assumption is difficult to justify in comparisons among countries in a world of expanding globalization of economic activity. It is nearly impossible to justify in studies of regions within a country. As shown by Helliwell and McKitrick (1999), national borders may affect the mobility of capital internationally, but internal borders within a federation do not impede interprovincial capital flows. In the extreme case of a small open economy, which can be realistically assumed ro represent a region within a country, perfect capital mobility will ensure instantaneous convergence. As pointed out by BMS, "the model predicts that a small open economy will jump instantaneously to its steady-stated level of output, physical capital, and human capital per effective worker and remain there forever" (p.109)

In an effort to explain the difference between the theoretically rapid rate of convergence in open economies and the low speeds of convergence observed in empirical studies, economists searched for special factors that would reduce the mobility of human capital. The solution suggested by BMS was to introduce two asymmetries between human and physical capital. First, they assume perfect mobility of physical capital and immobility of human capital through the lack of labour migration. This means that convergence of human capital can occur only through differential rates of its accumulation in each country. Second, they assume that physical capital can be used as collateral for international borrowing, but human capital cannot. As the authors

point out " the important assumption is that domestic residents cannot borrow with human capital or raw labour as collateral and that foreigners cannot own domestic human capital or raw labour" (p. 110). They show that, under these assumptions and for realistic parameter values, " open economies will converge only slightly faster than closed economies" (p.114).

The assumption of binding borrowing constraints, which is essential for achieving slow convergence, has been challenged by Duczynsky (2000). Noting that "a credit-constrained economy receives negative factor income from abroad and exhibits a current-account deficit" (p. 688), Duczinsky challenged the above assumption by calculating indicators of net external assets, measured by the cumulated current account, for 113 countries and 51 U.S. states. He concluded that "borrowing constraints are binding only for a relatively small portion of countries" (p.690) and between two and six states. Duczinky starts with the BMS model and replaces the borrowing constraint, which was found to be generally non-binding, with another mechanism for slowing down the accumulation of human capital. Following Kramer and Thomson (1998), Druczinsky argues that, because young and old workers are imperfect substitutes, there may be large adjustment costs in the process of human capital accumulation. He shows that a BMS model with large adjustment costs for human capital and a total capital share of 0.95 yields the 2 percent annual speed of convergence found in empirical studies.

The BMS model was tested with Canadian data by Coulombe and Tremblay (1999). Instead of evaluating the validity of the mechanism of human capital convergence incorporated into the BMS model, these authors estimated the speed of convergence of human capital and compared it

to the speed of convergence of per capita output. Through this comparison, they provided empirical support to the prediction of the BMS model that human capital converges at the same speed as per capita output.

The introduction of human capital in models of growth raises a variety of issues. On the empirical side, the major issue involves the selection of the human capital indicators. As pointed out by Coulombe (1999), "it is difficult to obtain a precise and appropriate indicator of human capital at the aggregate level" (p. 14). Yet, one must be careful not to select human capital indicators that are either unreliable or inconsistent with the theoretical framework that is being tested. We will show in this paper how sensitive the results can be to different indicators of human capital. This paper follows the BMS framework as applied to Canada by Coulombe and Tremblay (1999) in order to facilitate the direct comparison with previous studies. It makes two main adjustments. First, it extends the sample period to 1999 in order to capture the effects of the initial stages of the technological revolution driving the new economy. Second, it uses indicators of human capital that are more consistent with the BMS theoretical framework. The methodology is explained in section II and the results for human capital convergence are presented in section III. Section IV explores the relationship between human capital indicators and real output per worker and the final section concludes.

II. METHODOLOGY

Empirical studies on regional convergence in Canada have involved tests of the BMS neo-

classical model (see, for example, Coulombe and Lee (1995), Coulombe and Day (1999), Coulombe and Tremblay (1999) and Coulombe (1999,2000). By following Coulombe and Tremblay (1999)'s methodology in our paper, it will be possible to test the BMS model for differences in sample periods and different definitions of the relevant variables.

A. Measures of Convergence

Empirical studies often present two measures of convergence. The first measure describes the time-path of the dispersion of the selected economic indicator. It is called σ- *convergence,* it is measured by the standard deviation of the selected economic indicator and is usually presented as a graph which measures time on the horizontal axis and the degree of dispersion on the vertical axis. A downward sloping pattern of dispersion provides indication of convergence. The second measure, called β - *convergence*, captures the speed at which the growth rates of individual economies converge to the national average *(absolute convergence)* or to different steady-state growth rates *(conditional convergence).* The estimates of σ- and β - convergence are related. A higher speed of convergence will necessarily result in a faster reduction in the degree of dispersion. Therefore, a higher value of the measure of β-convergence is associated with a steeper slope of the line representing σ-convergence. This paper is confined to the analysis of absolute convergence and shows estimates of both σ- and β - convergence. The method used for estimating β - convergence is explained in more detail below.

BMS have shown that, for economic unit i, the speed of convergence to the steady-state level of

income may be derived from the following expression

$$(1)\ Ln(y_{i,t}) = e^{-\beta} Ln(y_{i,t-1}) + (1 - e^{-\beta}) Ln(y_i^*)$$

where $y_{i,t}$ is income per effective unit of labour in economic jurisdiction i at time t, y_i* is the steady-state value of y_i and β measures the speed of convergence per unit of t. Since $(lny_t - lny_{t-1})$ is approximately $(y_t - y_{t-1})/y_{t-1}$ and that $lny^* - lny_{t-1}$ is approximately $(y^* - y_{t-1})/y^*$ and realizing that the Taylor series expansion for $e^{-\beta}$ is just $1-\beta$, it emerges that β is the ratio of the proportional one year change in y to the proportion by which y* exceeds y_{t-1}.

If β is a positive fraction, y_i will converge to y_i*. Incorporating an additive error term allows the testing of (1) with time series data for a single economic jurisdiction or with cross-section data for cross-country comparisons or comparisons of different regions within a country.

For human capital convergence, Coulombe and Tremblay (1999), hereafter called CT, followed the BMS model and started with a Cobb-Douglas production function incorporating a broad concept of capital

$$(2)\quad Y = AK^a H^n (Le^{gt})^{1-a-n}$$

where a is the elasticity of output Y with respect to physical capital K, n is the elasticity of output with respect to human capital H, g is the growth rate of labour L in efficiency units and A is an

exogenous technological variable. Expressing (2) in units of effective labour by dividing all terms by Le^{gt} transforms the production function into

(3) $$y = k^a h^n$$

In the open economy, the net return to physical capital equals the world interest rate because this form of capital can be used as collateral. As a result, the *k/y* ratio remains constant during the transition to the steady-state. As shown by BMS, the above result transforms the production function into

(4) $$y = Bh^{n/1-a}$$

where *B* is a constant term dependent on a variety of exogenous variables unrelated to the capital/labour ratio.

Combining (4) and (1) yields the equation that describes the time-path of the human capital indicator (the ratio of human capital to labour measured in efficiency units).

(5) $$Ln(h_t) = e^{-\beta t} Ln(h_0) + (1 - e^{-\beta t}) Ln(h^*)$$

CT used a variant of equation (5) in order to accommodate the pooling of time series and cross-section data necessary to obtain sufficient degrees of freedom in a country with only ten cross-

section observations (provinces). They estimated the speed of convergence of human capital during the 1951-96 period through the following equation

$$(6) \qquad \frac{1}{P} Ln\left(\frac{HI_{i,t+p} / \overline{HI}_{t+p}}{HI_{i,t} / \overline{HI}_{t}}\right) = -\left(\frac{1 - e^{-M\beta}}{M}\right) Ln\left(\frac{HI_{i,t}}{\overline{HI}_{t}}\right)$$

where HI_i is the human capital indicator of individual provinces, bar indicates the unweighted provincial averages, P is the length of each sub-period and M is the average length of the sub-periods. CT used census data on the educational attainment of the population, therefore, their observations follow the time-period associated with the taking of the national census. Thus, P equals 10 for the period from 1951 to 1981 and 5 for the remaining years, M is set at 9.

In our analysis we also used expression (6) to measure the speed of convergence of human capital indicators over the 1976-99 period. The end year of our sample period contains the latest information available at the time of writing while the initial year marks the beginning of consistent labour force statistics by province, which are used in the derivation of our selected human capital indicators. In order to have a consistent comparison with the CT (1999), we transform our annual data into the 5 year averages. P equals to 5 in the first four periods and equals to 4 in the last period, M is set at 4.8.

B. Indicators

As indicators of human capital, CT used the percentage of selected groups of the population (15 years and over, 15 to 24 years and 25 years and over, for males and females separately and for the total) who achieved either grade nine education (indicator 1) or a university degree (indicator 2). Coulombe (2000) narrowed the list of human capital indicators to the "percentage of males and of the population of both sexes in the population 15 years and over, and 25 years and over, who have achieved at least one university degree " (p. 5).

While recognizing the impossibility of selecting an indicator of human capital which is free of theoretical and measurement shortcomings, we suggest that the available data allows the selection of more meaningful indicators. What matters for economic growth is not the level of education of the population as a whole, but the level of education of those who are in the labour force and even more directly those who are employed. This information is available in labour force data published by Statistics Canada and we used them to determine whether they yield different conclusions about human capital convergence than the population ratios. Human capital indicators based on labour force statistics are more closely related to the BMS model, where the level of human capital is expressed as a ratio to the labour input, and allow a more direct test of that model. In our analysis of human capital convergence we used six indicators of human capital: the two indicators used by CT plus the proportion of the labour force with a university degree, the proportion of the labour force with at least one year of high school education, the proportion of employed workers with a university degree and the proportion of the proportion of

employed workers with at least one year of high school. The results are discussed in the following section.

Most of the data used in this study are found in sources developed by Statistics Canada. Details on the sources of data are found in the Appendix.

III. HUMAN CAPITAL AND CONVERGENCE

A. σ- Convergence for Indicator 1

The dispersion of the indicators related to the achievement of at least grade 9 education, measured by the standard deviation of the selected indicators, is shown in Figure III-1. Three variations of this indicator are shown: (a) the proportion of the population with at least one year of high school, (b) the proportion of the labour force with the same education level and (c) the proportion of employment with the same education level. It is evident that all three variants show steady convergence. The degree of dispersion fell between1976 and 1999 by 4.6 % for variant (a), 4.4 % for variant (b) and 4.9 % for variant (c). The achievement of at least one year of high school is a poor indicator of human capital in the age of the knowledge-based economy. This indicator includes potential members of the labour force that actually lack even the basic skills to function effectively in the new economy.

B. σ- Convergence for Indicator 2

A more meaningful indicator of human capital is the achievement of a university degree. The corresponding three variants for the human indicator measuring educational achievement to a university degree are shown in Figure III- 2. The variants of this indicator highlight the sensitivity of the results to the selection of the human capital indicator. Variant (a) exhibits a long-run trend towards convergence, but through a fluctuating pattern. The degree of dispersion fell from 1976 to 1984, increased from 1984 to 1990 (nearly reaching the 1976 level), fell again from 1990 to 1995 and remained roughly flat in the following four years. The proportion of the labour force with a university degree also shows a fluctuating pattern, but with no convergence at all. The degree of dispersion of this variant fell moderately from 1976 to 1984, increased steeply from 1984 to 1990, fell again from 1990 to 1995 and then embarked on a slow upward trend for the remaining four years. As a result, the degree of dispersion was slightly higher in 1999 than in 1976. A nearly identical pattern is evident for the proportion of employed workers with a university degree. We interpret these differences as indication that the convergence of human capital indicators found by other studies may result from (a) a sample period that excludes the initial years of the globalization and information revolution and (b) the selection of a poor indicator of human capital. A more formal analysis of human capital convergence is performed in the following sub-section which contains estimates of the speed of convergence.

Place figures III-1 and III-2 here

C. β - Convergence

Our estimates of the speed of convergence of regional human capital indicators are shown in table III-1. The following observations may be derived from this table.

When human capital is measured by the achievement of at least one year of high school, the data for 1976-99 shows convergence. The estimated β values are .038 for the proportion of the population with the above level of education, .060 for the proportion of the labour force and .065 for the proportion of employment. All three β values are statistically significant. These results confirm the estimates derived by CT (1999).

There is no convergence when human capital is measured by the achievement of a university degree. The estimates of the β values for this indicator are .011 for the proportion of the population with a university degree, .002 for the proportion of the labour force and .05 for the proportion of employment. All three values are statistically insignificant at the 5% level, although the first value is significant at the 10% level. We interpret the above results as indications of the lack of convergence of human capital in Canada during the 1976-99 period. CT found a statistically significant speed of convergence for the proportion of population with at least a university degree for 1951 to 1996, our estimates for the period 1976-1999 show no convergence for the same indicator and the other two indicators based on university degree achievement, we interpret the results as the indication that the convergence found by Coulombe and Tremblay (1999) and by Coulombe (2000) must have occurred during the 1951-75 period.

In evaluating potential future trends and formulating appropriate policies to reduce regional disparities, the more recent developments may serve as a better guide than trends during the distant past. Given the major changes in the structure of the Canadian economy and of its regions, what happened in the 1950s and 1960s may have little relevance for what may be coming in the future. We suggest that greater insights in the process that leads to convergence across regions, or the lack of it, will be obtained by focusing the analysis on the more recent period which provides a better reflection of the new economic forces shaping comparative growth.

Table III-1. Speed of Convergence of Human Capital Indicators, 1976-99

	β	t-stat	R^2	# of Observations
1. Some High School Education				
% of population	.038	14.84	.85	40
% of labour Force	.060	15.22	.86	40
% of employment	.065	14.99	.85	40
2. University Degree				
% of population	.011	1.62*	.06	40
% of labour Force	.002	0.20*	.01	40
% of employment	.005	0.45*	.01	40

Note: All the estimations are done using Generalized Linear Least Square, β is calculated from the estimated coefficient.

*: statistically insignificant at the 5% level.

IV. Comparison of Labour Productivity Indicators and Human Capital Indicators.

CT compared the convergence speed of the per capita income indicator and the human capital indicator and estimated similar convergence speeds for both indicators. The results presented in this paper show no convergence of human capital indicators. Ruggeri and Yang (2001) found no convergence of real GDP per worker from 1966 to 1999. Both sets of findings are consistent with the BMS prediction that output per worker and human capital converge at the same rate. However, in CT consistency is associated with convergence whereas in the combination of our results and those of Ruggeri and Fang (2001) consistency is associated with the lack of convergence. Further insight into this issue can be obtained by relating directly the labour productivity indicator to the human capital indicator. According to the BMS model, as shown in equation (4), output per effective unit of labour, or labour productivity, is a function of the human capital/labour ratio. CT transformed equation (4) into

$$(4') \qquad \ln(\frac{y_{i,t}}{\bar{y}_t}) = (\frac{n}{1-a}) \ln(\frac{h_{i,t}}{\bar{h}_t})$$

where the bar indicates average values, and used it to estimate the share of human capital n. The left hand side of the equation can be interpreted as indicating province i's position relative to the provincial mean with respect to labour productivity. Similarly, the right hand

side indicates a province's relative position with respect to human capital. Equation (4'), therefore, can be used to test the relationship between labour productivity and human capital/labour ratio by adding the error term $u_{i,t}$. This relationship holds only under the assumption of homogeneous technology among provinces. To allow technologies to differ across provinces, we added a provincially-specific constant term to the model, as shown in equation (7). This modification indicates that productivity performance of each province is not totally determined by its relative accumulation of human capital. If a province has a higher constant term α_i, it has a higher productivity even if its human capital/labour ratio is the same as in other provinces. The difference in α_i may result from differences in human capital productivity which, in turn, may be caused by interprovincial difference in the application of technology. It may also result from differences in provincial economic structures which lead to unequal output per worker even in the presence of equal human capital intensities.

$$(7) \qquad \ln(\frac{y_{i,t}}{y_t}) = \alpha_i + \gamma * \ln(\frac{h_{i,t}}{h_t}) + u_{i,t}$$

Equation (7) was estimated by using real GDP per worker as the indicator of labour productivity and the percentage of employment with university degree as the indicator of human capital. Real GDP was calculated by deflating provincial nominal GDP with province-specific deflators. In order to maintain consistency with the analysis of β- convergence,

equation (7) was estimated with the average values within five-year periods from 1976 to 1999.

The results are shown in table IV-1, and lead to the following observations. First, six out of the ten constant terms are significantly different from zero. Among the three richer provinces, the constant term is positive and statistically significant for Alberta and Ontario, but is negative and statistically insignificant in the case of British Columbia. Among the less affluent provinces, the constant term is negative and statistically significant for the three Maritime provinces and for Manitoba. It is negative and statistically insignificant for Newfoundland and Quebec and positive and statistically insignificant for Saskatchewan. The implication is that human capital tends to be more productive in the richer provinces. Second, we found a negative but statistically insignificant γ. We tested for potential time trends by re-estimating Equation (7) with the inclusion of time and time square variables, but the coefficients were found to be very small and statistically insignificant.

These results imply that the pattern of human capital accumulation across provinces during the 1976-99 period had little effect on the time-path of inter-provincial differences in output per worker. This result is not surprising, given the lack of convergence of the human indicator based on achievement of a university degree. The combination of a statistically insignificant and statistically significant constant terms - positive for two out of the richer provinces and four out of the seven less affluent provinces - suggest that persistent regional economic disparities in Canada are associated with inter-provincial differences in output per

worker which remained unaffected by either human capital accumulation or exogenous factors operating through time.

Table IV-1 . Estimates for Equation (7)

Method: GLS (Cross-sectional Weighted)

Variable	Coefficient	t-Statistic	R^2
Human Capital	-0.1104	-1.2481*	0.960
NFLD--CONST	-0.0088	-0.5220*	
PEI--CONST	-0.2455	-16.278	
NS--CONST	-0.0683	-4.9695	
NB--CONST	-0.2097	-13.868	
Que--CONST	-0.0401	-1.7946*	
Ont--CONST	0.0998	5.1198	
Man--CONST	-0.0476	-33.744	
Sask--CONST	0.0459	1.394*	
Alb--CONST	0.3562	15.720	
BC--CONST	-0.0201	-0.329*	

* Statistically insignificant

V. CONCLUSION

This paper applies the neo-classical model of convergence developed by Barro, Mankiw and Sala-i-Martin (1995) and modified for Canada by Coulombe and Tremblay (1999) to test for the convergence of human across provinces in Canada. It presents estimates of speeds of convergence by using a more recent sample period than existing studies and using human capital

indicators more consistent with the theoretical model. A comparison with the results of existing studies will help determine the sensitivity of the speed of convergence to different sample periods and different indicators of human capital. Our results show that the speed of convergence is affected more by the sample period than by the measure of human capital. When human capital is measured by the achievement of at least grade nine, we found a statistically significant speed of convergence whether the target group (at least grade nine education) was expressed as a proportion of the population 15 years and over, the labour force or employment. Since our results are similar to those of Coulombe and Tremblay (1999), who used the first of the three indicators mentioned above and a sample period covering 1951 to 1996, we can conclude that, for a human capital measure based on achievement of grade nine, the results are little affected by the selected indicator or the sample period.

We argue that, in the age of the knowledge-based economy, such a low educational threshold for measuring human capital, especially in a country with compulsory secondary education, is a poor measure of human capital. When we use the more meaningful threshold of the achievement of a university degree, our results differ considerably from those of Coulombe and Tremblay. While they found a positive and statistically significant speed of convergence for the proportion of the population 15 and over with university degree, we found no statistical evidence of such convergence whether the target group is expressed as a proportion of the population 15 and over, the labour force or employment. The estimated speed of convergence is substantially higher for the first variant, but is statistically insignificant. We conclude that the convergence found by Coulombe and Tremblay must have occurred before 1976.

Our results on the relationship between labour productivity and human capital suggest that there are persistent differences in labour productivity across provinces. For a given percentage of employment with university degree, richer provinces have higher output per worker. Moreover, these differences have not been reduced over the sample period either by the relative accumulation of human capital or exogenous factors.

Empirical results from studies covering longer periods and including the 1950s and 1960s provided some comfort to policymakers by showing the presence of built-in mechanisms leading to absolute convergence. Our results indicate that, in the new economic environment, policymakers cannot be complacent about regional disparities in the belief that they will be eradicated automatically by market forces. In particular, they cannot count on market forces to generate convergence through differential rates of accumulation and utilization of human capital.

In concluding, it may be worth emphasizing that the dawn of the knowledge-based economy complicates the analysis of regional disparities. Economists have tried to incorporate human capital into the neoclassical model by assuming that the same convergence mechanism applies to physical and human capital. This simple adjustment may fail to capture the dynamics of the knowledge-based economy for a variety of reasons. First, human capital differs from physical capital with respect to inherent characteristics and mode of acquisition (see lroche, merette and Ruggeri (1999). Second, the factors determining the utilization of human capital, especially the factors determining geographical concentration, are different than those for physical capital. Finally, our understanding of the functioning of the knowledge-based is limited. For the above

reasons, the analysis of convergence of regional disparities using models that explained the past may not be a useful guide for future trends when the future involves a major paradigm shift in the way the economy operates. A better understanding of future trends in regional economic disparities may require a very different analytical apparatus than the one used for evaluating the past. In particular, we need models that provide insights into what appear to be incipient trends towards divergence in real output per worker and the proportion of employed workers with university degrees.

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APPENDIX

A: SOURCES OF DATA

Data on the educational attainment of population, labour force and employment is from Labour Force Survey. One set of data, which starts from 1976-1996, is from " Estimates for Educational Attainment ,Provinces, Annual Avg, 1976-1996", Labour Force Historical review, 1996. Another set of data is from "Estimate by Educ. Level, Age, Sex, Can/Prov, Annual Avg, 1990-1999", Labour Force Historical review, 1999.

GDP at factor cost was computed for each province by subtracting Indirect taxes net of subsidies from GDP at market price. Data on provincial GDP at market price for the period 1961-1980 were obtained from CANSIM: D46980-D45169. While Data on provincial GDP at market price for the period 1981-1999 were obtained from CANSIM: D28629-D28818. Data on Indirect taxes net of subsidies also came from CANSIM. For the period 1961-1980 we used the series of D12547-D12565. And for the period 1981-1999 we used the series of D24019-D24127.

Data on Provincial Deflator before 1980 were provided by Professor Serge Coulombe. They are originally compiled by the Conference Board. The data on Provincial Deflator for the period 1981-1999 were calculated from from CANSIM: D28628-D28817.

B. GRAPH

Figure III-1:

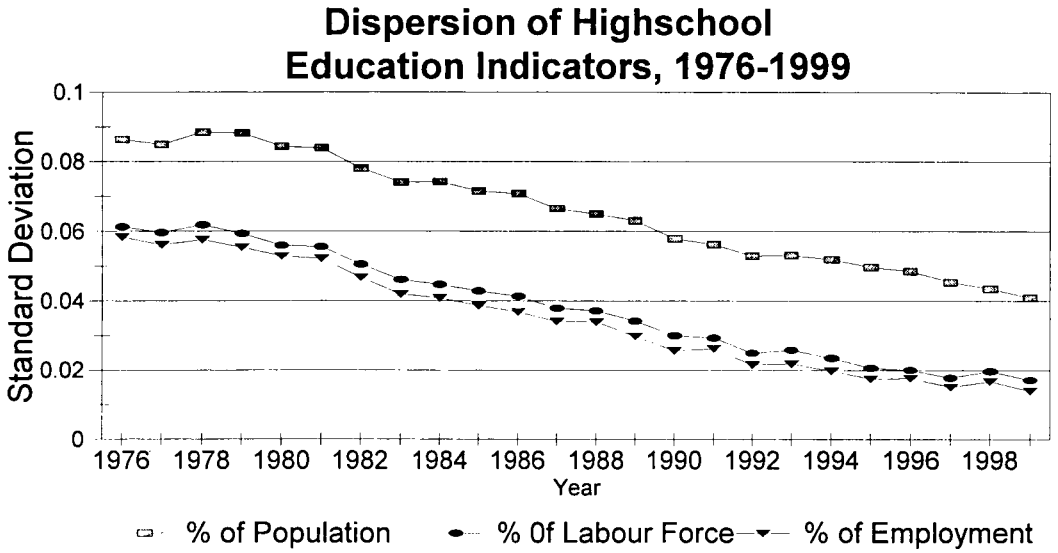

Figure III-2