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This paper searches for empirical evidence for convergence in real GDP per capita between the U.S., Canada, and Mexico. The results of the paper are based on two different concepts of convergence. First, some simple descriptive statistics are calculated that characterize convergence from a static cross-country perspective. Second, based on the concepts of cointegration and common trends, the paper estimates the dynamic (long run) relationships in per capita income between the three countries and then tests for convergence. Different subgroups of countries as well as the entire sample are considered. Both the static as well as the dynamic statistics indicate that there is little evidence for convergence in per capita income.

I. Introduction

This paper searches for empirical evidence for convergence in real GDP per capita between the U.S.A., Canada, and Mexico. Over the last decades, the three countries in general, and the U.S. and Canada in particular, have strengthened their economic ties by continuously reducing barriers to trade, a development that culminated in the signing and ratification of the North American Free Trade Agreement (NAFTA). The question then arises whether closer economic ties through increased trade, transfer payments or better policy coordination will help to reduce income differentials over time, as was the case with the European Community/Union (Ben-David, 1993).

This question is of substantial relevance for the three NAFTA countries since one of the arguments of the proponents of NAFTA has been that free trade will lessen the income gap between the U.S. and Mexico which, in turn, will reduce the level of migration of Mexican workers to the United States. While this expectation is certainly correct from the perspective of the European Community/Union, it remains an open question at this point whether NAFTA will have a similar effect on income differentials, in particular since the relative income gap between the U.S. and Canada on the one side, and Mexico on the other, is substantially larger than the difference in relative income between the high and the low income countries in Europe in 1982, the year when Spain, Portugal and Greece joined the European Community.

Nevertheless, it seems interesting to test whether closer economic ties in the decades before NAFTA had any effect on the relative income performance among the three countries. If such a result can be established, it can be interpreted as evidence that NAFTA will

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speed up the process of convergence in income levels proclaimed by the proponents of the free trade agreement.

II. Empirical Literature

The question whether countries converge in income levels has stimulated a large body of empirical research. So far, there is support for both convergence and non-convergence. Support for the non-convergence result is based on the observed differences in today's real per capita income among countries (Romer, 1987). In addition, simple cross-country regressions of average growth rates on initial income levels could not reject the null-hypothesis of zero correlation between the two variables whereas convergence would predict a negative correlation (DeLong (1988), Barro (1991)).

There is also empirical evidence in favor of the convergence hypothesis (Mankiw, Romer & Weil, 1992). These findings suggest that cross country regressions that contain a proxy for human capital are able to explain most of the observed cross-country differences in real per capita income. Furthermore, estimations of this type show the expected negative correlation between initial income levels and subsequent average growth rates. This result, however, may be spurious due to the problem of regression towards the mean (Quah, 1993).

Recently, Bernard (1991) and Bernard and Durlauf (1991, 1993) proposed an alternative approach to test for convergence in income across countries. Their approach focuses on the longrun or asymptotic behavior of the income series. We will therefore refer to their definition as 'asymptotic convergence'.[1]

The advantages of the Bernard and Durlauf approach are as follows. First, it avoids the pitfall of regression towards the mean that devalues the standard cross-country growth regressions described above. Second, in the case that income levels among countries follow a common trend, we can determine whether income differentials are temporary or permanent. Finally, even if the hypothesis of asymptotic convergence is rejected for the entire sample, we can still look for asymptotic convergence among subgroups of countries.

III. Cointegration and Convergence

Following Bernard (1991) we test for convergence in income levels using stochastic definitions of both common trends in time series data (cointegration) and a common long run response to shocks. In particular, by imposing restrictions on the rank and the parameter values of the cointegrating matrix, we derive a definition of asymptotic convergence.[2]

1. Using time series data from 1900 to 1987, Bernard and Durlauf test for cointegration and asymptotic convergence in GDP per capita for 15 OECD countries. Their findings suggest two or nine common trends depending on the VAR lag length. Since their definition of convergence requires that countries share only one common trend, they reject the convergence hypothesis for the entire sample.
2. Definition 3.1 corresponds to definition 2.5 in Bernard (1991).

Definition 3.1 Asymptotic convergence in multivariate per capita output: *Per capita outputs in countries 1, ..., p converge if Y_{it}, ..., Y_{pt} contain stochastic trends and if*

$$\lim_{k\to\infty} E(\beta' Y_{t+k} \mid \Omega_t) = 0 \text{ and } \beta' = [I_{p-1}, -\bar{e}_{p-1}] \quad (1)$$

where Y_{it} is income per capita in country i at time t, Ω is the information set at time t, β is the cointegrating matrix, and $\bar{e}_{p-1}$ is a (p-1) vector of ones.

Definition 2.1 adds two qualifications to the definition of cointegration. Convergence among time series data requires that the cointegrating matrix must be of rank $p - 1$. Furthermore the $p - 1$ independent column vectors of β must take the form of the identity matrix with an additional first row of (minus) ones. Definition 2.1 requires that the system of time series contains only one common trend or, equivalently, that there are $p - 1$ cointegrating vectors. If, in addition, all countries have the same (long run) response to a shock at time t income disparities between countries will eventually disappear.

We will apply this definition of asymptotic convergence to income data from the U.S., Canada, and Mexico in section V.

IV. Data and Simple Descriptive Statistics

In order to test for convergence in income levels we use annual data on per capita GDP (in 1985 international dollars). The sample period is 1950 to 1990. The GDP data are taken from an updated version of Summers and Heston (1988).

Figure 1 shows the three income series over the entire sample period. The figure shows that, in absolute terms, the income gap between Mexico and either the U.S. or Canada became larger during the sample period while it became somewhat smaller between the U.S. and Canada. The more important question is, though, whether there has been any major change in relative per capita income between the three countries.

Some descriptive statistics which are reported in Table 1 and 2 shed some light on this question. Table 1 shows that Mexico has, on average, a lower investment share but higher GDP and population growth than the U.S. or Canada.

Despite the higher GDP growth rate, Mexico could not catch up with its neighbor countries in terms of per capita GDP due to the higher population growth rate. This fact can be seen from Table 2. The coefficient of variation of per capita GDP drops only slightly from .57 in 1950 to .53 in 1990 despite a temporary decline to .44 at the beginning of the eighties. The descriptive statistics in Table 1 and 2 thus indicate that stronger economic ties through more trade in goods and services had, at best, a minor influence in the reduction of the relative income gap between the NAFTA countries. In the next section we investigate whether the corresponding long-run relationships in per capita GDP between the three countries point to a similar conclusion.

V. Econometric Methodology and Empirical Results

In order to test for cointegration, one first has to determine whether each time series in the sample contains a unit root. Table 3 summarizes the values of the augmented Dickey-Fuller test for each country and two different lag lengths. Independent of the lag length, none of the reported "t-statistics" is higher than the critical value at the 5%-level of the cor-

responding Dickey-Fuller table (*see* Harvey (1990), p. 368).[3] Therefore, we cannot reject the null hypothesis of a unit root for any of the three GDP series.

We test for cointegration using the method of Johansen (Johansen (1988), Johansen and Juselius (1990)). We calculate a likelihood ratio statistic (the trace statistic) in order to determine the rank of the cointegrating matrix.[4] Furthermore, we use another likelihood ratio statistic to test constraints on the parameter values of the cointegrating matrix provided that the time series in question share exactly one common trend. Under the null hypothesis of convergence, test statistics that are larger than the critical value at the 5% level are taken as strong evidence against asymptotic convergence.

The test results for cointegration and asymptotic convergence for the entire sample as well as for all subgroups are presented in Tables 4 and 5. The likelihood ratio statistic in Table 4 indicates the existence of one cointegrating vector which, in turn, implies that the three countries share at least two common trends. Since a necessary condition for asymptotic convergence is that there exist only one common trend, the result implies that there is no evidence for asymptotic convergence in GDP between the U.S.A., Canada, and Mexico. This result confirms our interpretation of the descriptive statistics in the previous section.

It is interesting to see, however, whether we can find evidence for convergence in income for any subgroup of countries. Table 5 presents the results for the three subgroups. At the 5% level, the likelihood ratio statistic indicates one cointegrating relationship and hence one common trend for each subgroup. In this case, we can test parameter restrictions on the cointegrating matrix, i.e., we can test for asymptotic convergence.

In the case of the U.S. and Canada, the likelihood ratio test statistic rejects the constraints on the values of the cointegrating vector at the 5% level. We therefore reject the null hypothesis of asymptotic convergence. In the case of the U.S. and Mexico we can reject the imposed restrictions on the cointegrating vector at the 10% level but we cannot reject them at the 5% level. This result, however, cannot be interpreted as evidence for asymptotic convergence since the cointegrating equation for these two countries requires a constant. This means that even if the cointegrating vector happens to be equal to (1, -1), the two income series would not converge. Rather, the difference in income levels would neither increase nor decrease but remain constant over time and the value of the constant would be equal to the expected value of the income difference. Finally, we clearly reject the convergence null in the case of Canada and Mexico.

VI. Summary and Implications

Static descriptive statistics as well as estimates of the dynamic long-run relationship suggest little evidence in favor of convergence in per capita income between the U.S., Canada, and Mexico for the time period between 1950 and 1990. Relative income differences remain more or less constant over the sample period. This is true for the whole sam-

3. We also ran an augmented Dickey-Fuller test in first differences. The results of this test indicate that all three series are first difference stationary processes.
4. We also employed a non-parametric cointegration test developed by Bierens (1994). The results of this test indicate the same number of cointegration relationships as the Johansen test. The results of the non-parametric test for cointegration can be obtained from the author upon request.

ple as well as for all bivariate groups. We observe, however, that per capita GDP in all bivariate groups follows a common stochastic trend. If we look at all three countries together, we find evidence for at least two common trends.

Despite the fact that there is little evidence for convergence, the question arises whether there is a meaningful economic interpretation of the observed common long run movements in per capita GDP. Clearly, in order to transmit economic shocks from one country to the other, it is necessary that countries engage in trade with each other. All countries in the sample have strong trade relations with each other, which may explain why there is evidence for common trends among them. In this sense, strong economic ties may explain the comovement of economic time series such as GDP. These economic ties, however, may not be sufficient to overcome large historic income gaps. After all, the income gap between the U.S. and Canada in 1950 was just one third of the income gap between the U.S. and Mexico at the same time. Free trade agreements may therefore be just a first step towards a more equal income distribution among countries. To achieve real income convergence, stronger measures such as transfer payments from the high to the low income countries to finance infrastructure, investment in human capital, and small business loans may be necessary.

Appendix

TABLE 1: SUMMARY STATISTICS (TIME AVERAGE, 1950 TO 1990)

Country	Investment share	GDP growth	Population growth
U.S.A.	24.18%	3.4%	1.3%
Canada	25.84%	4.4%	1.7%
Mexico	17.58%	5.1%	2.8%

Source: Updated version of Summers and Heston (1988)

TABLE 2: COEFFICIENT OF INCOME VARIATION, 1950 TO 1990

1950	0.57
1954	0.56
1958	0.52
1962	0.54
1966	0.53
1970	0.50
1974	0.49
1978	0.50
1982	0.44
1986	0.53
1990	0.53

Source: Updated version of Summers and Heston (1988)

Table 3: Testing for unit roots (augmented Dickey-Fuller test)

Regression equation: $\Delta Y_{i,t} = c_i + \gamma_i Y_{i,t-1} + \sum_{j=1}^{p-1} b_{i,j} \Delta Y_{i,t-j} + \epsilon_{i,t}$

lag length	"t-statistic" for $\hat{\gamma}_i$			
q	U.S.A.	Canada	Mexico	5% Critical Value
1	.550	.812	-.827	-2.9378
2	.743	1.025	-.933	-2.9399

Table 4: Multivariate tests for cointegration and convergence (All 3 countries)

	Likelihood ratio statistic		
$H^j(r)$:	$r(\beta) \leq 2$	$r(\beta) \leq 1$	$r(\beta) = 0$
USA, CAN, MEX	1.469	9.77	29.26*
5% Critical Value	3.84	12.53	24.31

*: null hypothesis rejected at 5% significance level

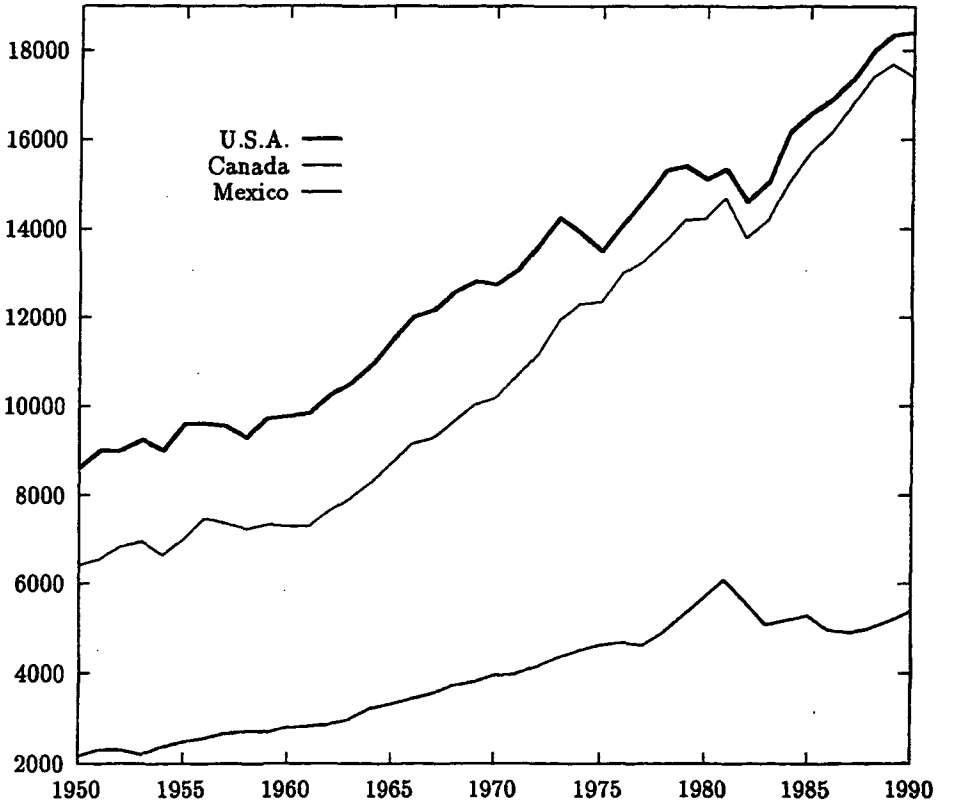
Table 5: Multivariate tests for cointegration and convergence (groups with 2 countries)

	likelihood ratio statistic			
$H^j(r)$:	$r(\beta) \leq 1$	$r(\beta) = 0$	Coint. vector	LR test of constraints on paramters**
USA,CAN	.37	13.40*	1 −.74	4.42
5% Critical Value	3.84	12.53		
USA,MEX	3.92	23.94*	1 −.36	3.41
5% Critical Value	9.24	19.96		
CAN,MEX	3.82	20.14*	1 −.29	6.88
5% Critical Value	9.24	19.96		

*: null hypothesis rejected at 5% significance level

** 5% critical value: 3.84; 10% critical value: 2.71

Figure 1: Per capita GDP from 1950 to 1990 (in 1985 international dollars)



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