45

Convergence in Per Capita Income across Regions in Bangladesh

by

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This paper examines per capita income convergence across six divisions—Dhaka, Chittagong, Rajshahi, Khulna, Sylhet, and Barisal—in Bangladesh using annual data during 1977-2000. The methodology uses ordinary least squares as well as time series approach, specifically unit root and cointegration techniques. The findings, however, do not provide enough evidence in favour of the convergence hypothesis even though the regions have similar socio-economic background and physical infrastructure, and access to the same financial system, administrative institutions, and technology. The series of income deviations from the benchmark fail to reject the null of non-stationarity in most cases. However, the presence of cointegration between various economic factors and the leading regions suggests the presence of long-run equilibrium relationship among them. Therefore, proper attention in terms of providing infrastructural as well as technological and financial supports to the lagging regions may be intensified. It may be worth mentioning, in this regard, that the current strategy of pro-poor growth seems to be a proper way of expediting per capital income convergence across regions in Bangladesh.

I. INTRODUCTION

The doctrine of income convergence led by Solow asserts that economically lagging regions will grow faster than the advanced ones and ultimately will catch up overtime. The neoclassical growth models have some special properties that ultimately ensure the convergence in per capita output (Solow 1956). Exogenous

technological change, diminishing returns to capital accumulation (supported by '*Inada Conditions*'), and concave production possibilities are certain features that lead to the convergence in the neoclassical model. On the other hand, new growth theorists strongly dispute the possibility of any convergence in per capita output (e.g. Romer 1986, Lucas 1988). The framework of the models developed in this tradition has some particular features that prevent any convergence in income per capita.

The empirical evidence on the issue of income convergence is mixed, depending upon model characteristics, underlying assumptions, and the nature of data (e.g. cross section or time series). Studies using cross-section data generally provide evidence in support of the convergence hypothesis across nations (see, Baumol 1986, Dowrick and Nguyen 1989, Barro and Sala-I-Martin 1991, 1992, 1995, Mankiw, Romer and Weil 1992, Cashin *et al.* 1996, Taylor 1999, Hossain 2006, Rahman 2006). On the other hand, studies based on time series data usually do not support convergence (Bernard and Durlauf 1995, Quah 1992, Alvi and Rahman 2005).

This paper tests the existence of per capita income convergence across six divisions i.e. Dhaka, Chittagong, Rajshahi, Khulna, Sylhet, and Barisal of Bangladesh using annual data during 1977-2000. The simple OLS as well as sophisticated unit-root and co-integration approaches have been applied to test the convergence hypothesis. In this context, testing the convergence hypothesis across regions rather than across nations is more appropriate because there are smaller differences in technology, tastes, culture, and institutions across regions within a country than across nations. Although the findings of this paper do not support the convergence hypothesis, it suggests the existence of a common deterministic trend across the leading regions.

II. LITERATURE REVIEW

The existing literature on the issue of income convergence falls into two broad groups. One group reports the existence of convergence basically using cross section investigation, while the other group finds no convergence mainly based on time series data.

Baumol (1986) used Madison's data covering the period 1870-1979 to test the convergence among 16 industrialised countries. He regressed output growth on a constant and an initial income that ended up with very strong evidence of convergence. His findings were questioned by De Long (1988). He showed that Baumol's findings were mostly spurious due to sample selection bias and measurement error. Dowrick and Nguyen (1989) investigated the convergence condition for OECD countries and examined if such convergence could be

explained by differences in the rate of growth of factor intensities or by total factor productivity (TFP). They used the cross sectional definition of convergence (β-convergence) and found evidence of income convergence among the OECD economies dominantly accounted by the differences in TFP catch-up and, in some cases, by differences in the rate of growth of factor intensities. The study ended up with convincing evidence in favour of convergence.

Barro and Sala-I-Martin (1992, 1995), in their significant empirical studies based on the cross section approach of convergence ended up with findings in favour of convergence. They tested convergence across different states of the United States, the prefectures of Japan, and across the regions of eight European countries. They found evidence of absolute β-convergence is the norm for these regional economies. They reported their findings as an evidence of absolute convergence by saying that,

> "…… *poor regions of these countries tend to grow faster per capita than the rich ones. The convergence is absolute because it applies when no explanatory variables other than the initial value of per capita product or income is held constant.*"

They also analysed the trends in net migration along with the convergence tendency and found some evidence, although not definite, that net migration has some role in the convergence story.

Taylor (1999) found convergence pattern in his sample of a group of seven countries in an alternative setting of neoclassical model termed as "open-economy factor accumulation model" that allows capital and labour migration. In another paper, Mankiw *et al.* (1992) found evidence of conditional convergence in the sense that such convergence is evident for all sample groups when they controlled for investment, growth of the working age population, and school enrollment. One recent paper by Martin and Mitra (2001) used panel data in their study of testing convergence that also ended up with findings in favour of convergence.

Time series studies, however, have different conclusions where convergence is harder to come by. Bernard and Durlauf (1995, 1996) and Quah (1992) suggest that time series data do not support convergence. Bernard and Durlauf (1995) used Johansen's co-integration method to test the convergence of per capita income across 15 OECD countries. They argue that cross-sectional convergence is a weaker notion because such tests tend to spuriously reject the non-convergence hypothesis when economies have different long run steady states. Unlike the findings of cross-section studies, their investigation fails to reject the null hypothesis of no convergence across 15 OECD countries. However, they do find

evidence of substantial cointegration, indicating the presence of some common long-run factors that jointly determine output growth.

A recent study by Alvi and Rahman (2005) examines income convergence across U.S. regions for the period 1929-2002 using unit root and cointegration techniques. Their findings also suggest non-convergence in per capita incomes across U.S. regions even when endogenous breakpoints are included. Interestingly, they find evidence of cointegration between technology and incomes in the leading regions, but not in the lagging ones, identifying technology as a factor that contributes to the lack of convergence. There are only a few studies (e.g. Hossain 2006, Rahman 2006) that attempt to investigate the issue of per capita income convergence across regions of Bangladesh. While Hossain (2006) tests for β or conditional β convergences across the regions based on single country (Bangladesh) data during 1982-1997, Rahman (2006) tests only conditional β convergence across regions for a group of countries including Bangladesh based on panel data during 1960-2000. Both the studies find convincing evidence of either β or conditional β convergences across regions in Bangladesh.

III. THEORETICAL BACKGROUND AND METHODOLOGY

III.1 The Neoclassical Framework

A production function of the following form is usually used to represent a typical neoclassical growth model:

$$Y_t = A_t F(K_t, L_t) \tag{1}$$

where,

Y_t = output at time t,
A_t = technology at time t,
K_t = level of physical capital at time t, and
L_t = level of labour at time t.

The neoclassical theorists assume the following properties for the above production function.

1. $F(\bullet)$ is concave in K and L that implies a positive and diminishing marginal productivity of each input.

    $F_k(\bullet) > 0$ and $F_{kk}(\bullet) < 0$ for all K>0 and L>0;
    $F_L(\bullet) > 0$ and $F_{LL}(\bullet) < 0$ for all K>0 and L>0.

2. $F(\bullet)$ exhibits constant returns to scale.
    $F(\delta K, \delta L_t) = \delta.F(K_t, L_t)$ for all δ>0.

3. $F(\bullet)$ satisfies *Inada Conditions*:

$$\text{Lim}_{k \to 0} (F_k) => \text{Lim}_{L \to 0} (F_L) => \propto$$
$$\text{Lim}_{k \to \propto} (F_k) => \text{Lim}_{L \to \propto} (F_L) => 0$$

III.2 The Convergence Hypothesis

The conditional convergence hypothesis of the neoclassical model stipulates that in the long run all economies will converge to their path of steady state growth conditioned by savings and population. So, the prediction of this hypothesis is that other things being equal, the lagging poor economies would tend to grow faster than the rich economies and hence catch up in the long run.

The concept of convergence has two interpretations:

β-Convergence: The concept of β-convergence is related to studies with cross section samples. A group of countries is said to be consistent with β-convergence if there exists a negative relationship between per capita income and subsequent growth rate in per capita income over the next several years.

Consider the following equation:

$$\hat{y}_{i,t} = \alpha + \beta y_{i,0} + \varepsilon_{i,t} \tag{2}$$

where,

$\hat{y}_{i,t}$ = Average per capita income growth rate of ith economy over period 0-t, and

$y_{i,0}$ = Initial per capita income in ith economy.

Any negative value of β in the above regression equation confirms the presence of income convergence across the nations under consideration.

σ-Convergence: This is related to studies of time series samples. A group of economies is said to be consistent with σ-convergence if the per capita income deviations among the economies in that group tend to decline or approach zero over time.

Between the two versions of convergence, as defined above, this paper intends to pursue σ-convergence test based on the following definitions of convergence and common trends provided by Bernard and Durlauf (1995, p.99):

(i) Convergence in multivariate output

Countries i= 1, 2,……,n are said to converge in output if the long-run forecasts of output differences tend to zero as forecasting time horizon tends to infinity.

$$\lim_{s \to \infty} E_t (y_{1,t+s} - y_{i,t+s}) = 0 \quad \text{for all i} \neq 1 \tag{3}$$

where,

$$y_{1,t+s} = \text{Income per capita in the reference economy, and}$$

$$y_{i,t+s} = \text{Income per capita in the ith economy.}$$

In terms of cointegration literature, the above definition of convergence will be satisfied if the series of income deviations from a benchmark is a mean zero stationary process. Bernard and Durlauf (1995, p.99) put the above definition in the following way: "*In order for countries i and j to converge ……… their outputs must be cointegrated with cointegrating vector [1, -1]. Additionally, if the output series are trend stationary, then the definitions imply that the time trends for each country must be the same.*" Therefore, per capita income in two regions are said to be converged if and only if the deviation between the series is stationary.

(ii) Common trends in multivariate output

The per capita income in countries i= 1, 2,……,n is said to have a common trend if we fail to reject the null of unit root in deviations and they are cointegrated in levels.

Note that the above definition of convergence in output is quite different than that of cross section case. In this respect, we could refer to Bernard and Durlauf (1995, p.100),

> "… definition of convergence is substantially different from that employed by Baumol et al. who have defined convergence to mean that there is a negative cross section correlation between initial income and growth, thereby inferring long-run output behavior from cross-section behavior."

They also mentioned that the studies of convergence by directly examining the time-series properties of various output series place the convergence hypothesis in an explicitly dynamic and stochastic environment.

IV. DATA AND METHODOLOGY

The annual data on personal per capita income (i.e. total personal income divided by total mid year population) at current factor cost from the *Statistical Year Book of Bangladesh* Bureau of Statistics (BBS) for the period 1977-2000 have been used in this study. The data on divisional per capita income during the period indicate that Chittagong[1] division ranks top with mean per capita income of Tk.

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[1] Excludes Chittagong Hill Tracts, considered as an outlier in the present study because of very high per capita income.

6.43 thousand followed by Barisal, Khulna, Sylhet, Dhaka and Rajshahi with mean per capita incomes of Tk. 5.97 thousand, Tk. 5.96 thousand, Tk. 5.69 thousand, Tk. 5.54 thousand, and Tk. 4.98 thousand respectively. Given that the average per capita income during 1977-2000 for all divisions is Tk. 5.76 thousand, three divisions namely Chittagong, Barisal, and Khulna are considered to be the leaders while the remaining three divisions namely Sylhet, Dhaka, and Rajshahi are treated as laggers (Table I). Accordingly, it has been observed that divisional per capita income deviations from the benchmarks (i.e. average income) remain mostly positive for the leaders and mostly negative for the laggers (Figure 1).

TABLE I
RANKING OF DIVISION/REGION USING PER CAPITA INCOME

Division/region	Mean (000 Tk.)	Rank	Remarks
Chittagong	6.43	1	
Barisal	5.97	2	Leaders
Khulna	5.96	3	
Average (benchmark)	5.76		
Sylhet	5.69	4	
Dhaka	5.54	5	Laggers
Rajshahi	4.98	6	

The data on factors affecting per capita income convergence, namely, private sector credit as a per cent of GDP, use of agricultural machinery and tractors, electric power consumption, fertiliser consumption, adult literacy rate, gross capital formation as per cent of GDP, and value added in agriculture, industry and services sectors as shares of GDP have been taken from *World Development Indicators* of World Bank.

The preliminary analysis of data used in the present study indicates that three divisional per capita income series (Chittagong, Sylhet, and Rajshahi) are purely non-stationary meaning to have unit root and the remaining three divisional per capita income series (Dhaka, Barisal, and Khulna) are trend stationary while factors affecting convergence series are all non-stationary with unit root (Table II).[2]

With a view to investigating the hypothesis of convergence in per capita income across regions in Bangladesh, empirical analysis of the study would, therefore, focus on:

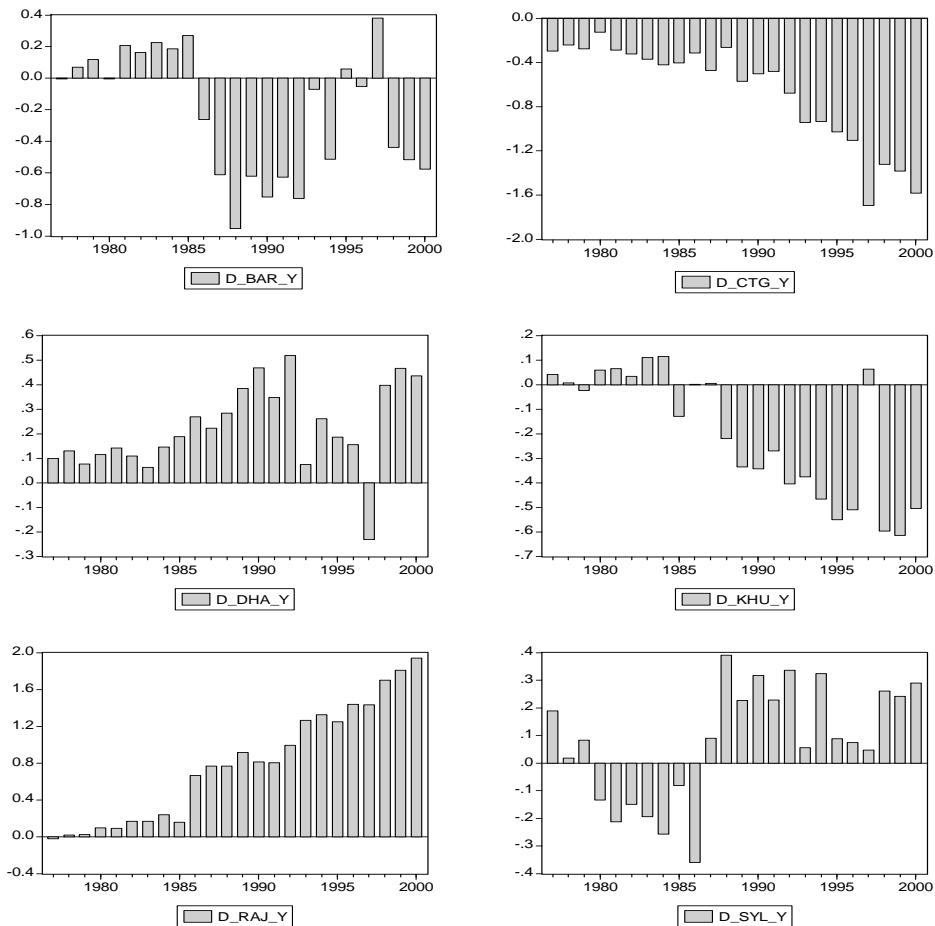(i)   Testing convergence (i.e. β-Convergence) using OLS method;

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[2] Three alternative unit root tests (ADF, PP, and KPSS) are used in deciding stationarity of the series.

(ii) Identifying ARIMA for all the series in levels as well as in deviations and testing convergence (i.e., σ-Convergence) based on unit root test; and

(iii) Testing cointegration among the series under consideration.

TABLE II
UNIT-ROOT TESTS FOR INDIVIDUAL SERIES

Series	without trend			with trend			Decision
	ADF	PP	KPSS	ADF	PP	KPSS	
Per-capita income							
(in current factor cost)							
Dhaka division (dha_y)	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)*
Chittagong division (ctg_y)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Khulna division (khu_y)	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)*
Rajshahi division (raj_y)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)
Barisal division (bar_y)	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)*
Sylhet division (syl_y)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)
Average (avg_y)	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)*
Factors affecting convergence							
Private sector credit (% of GDP)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Agricultural machinery, tractors	I(1)	I(0)	I(1)	I(1)	I(0)	I(1)	I(1)
Electric power consumption	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Fertiliser consumption	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Literacy rate, adult (%)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)
Agriculture, value added (% of GDP)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Industry, value added (% of GDP)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Services, value added (% of GDP)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Gross capital formation (% of GDP)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)

Notes: 1.   I (1) = unit-root, I(0) = stationary, and I(0)* = trend stationary.
2.   Lag length for ADF tests are decided based on Akaike's information criterion (AIC).
3.   Maximum bandwidths for PP and KPSS test are decided based on Newey-West (1994).
4.   All tests are performed on the basis of 5% significance level.

Figure 1: Divisional Per-capita Income Deviations from Benchmark

V. EMPIRICAL RESULTS

V.1 Testing Convergence (i.e. β-Convergence) Using OLS

The use of OLS is basically related to the concept of β-convergence where a group of countries is said to be consistent with β-convergence if there exists a negative relationship between per capita income and subsequent growth rate in per capita income over the next several years. The results from OLS confirm the negative relationship between log of initial per capita income and log of per capita

income growth over time meaning to have β-convergence among the various divisional per capita incomes in Bangladesh. But the weak level of statistical significance (8%) puts a question mark on the outcome of OLS results (Table III). With a view to having further investigation on per capita income convergence, more sophisticated and stronger version of testing convergence, such as unit root test has therefore been used.

Table III
RESULTS FROM OLS

Dependent Variable: Log of per-capita income growth (2000 over 1977)

Method: Least squares

Included observations: 7 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.95	0.06	109.35	0.00
LOG (Initial income=Y0)	-0.74	0.34	-2.20	0.08
R-squared	0.49	Mean dependent var.		6.84
Adjusted R-squared	0.39	S.D. dependent var.		0.13
S.E. of regression	0.10	Akaike's info criterion		-1.50
Sum squared residual	0.05	Schwarz criterion		-1.52
Log likelihood	7.25	F-statistic		4.84
Durbin-Watson stat	2.25	Prob. (F-statistic)		0.08

V.2 Testing Convergence (i.e. σ-Convergence) based on Unit Root Test

We need to identify each of the series in levels before conducting any stationarity and cointegration test required for examining the regional convergence and long-run equilibrium relationship behaviour. Box-Jenkins (1976) methodology has been used for initial identification. In order to get convergence in per capita income, we need to have stationarity in deviations for each of the series, which is calculated by deducting each series from the benchmark (average per capita income in this case).

The results of the stationarity tests fail to produce stationarity in any of the series in deviations except for Khulna division which trend stationary. Therefore, the decision about the convergence of per capita income of the six divisions/regions does not lend us much convincing evidence in favour of convergence. That is, when we consider average per capita income as benchmark,

we fail to reject the null hypothesis of convergence as a whole. The results of the ADF tests are reported in Table IV.

To ensure the robustness of the outcome test, three alternative techniques of unit root tests (ADF, PP, and KPSS) are used in deciding stationarity of the series. All three alternative tests generate the same result regarding the stationary property of the series under consideration. Therefore, the result of non-convergence across six divisional regions is very clear and robust. The economic implications of the above findings are straight forward in that these do not necessarily imply a region with initial low per capita income will grow faster and catch up the richer one in the long run. This means that a slow growing poor division may grow slowly and a fast growing rich division may grow faster forever.

TABLE IV
UNIT ROOT TESTS FOR SERIES AS DEVIATIONS FROM BENCHMARK

Series	without trend			with trend			Decision
	ADF	PP	KPSS	ADF	PP	KPSS	
Per-capita income deviation from avg.							
Dhaka Division (d_dha_y)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)	I(1)
Chittagong Division (d_ctg_y)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Khulna Division (d_khu_y)	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)*
Rajshahi Division (d_raj_y)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)
Barisal Division (d_bar_y)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)	I(1)
Sylhet Division (d_syl_y)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)	I(1)

Notes: 1. I(1) = unit-root, I(0) = stationary and I(0)* = trend stationary.
2. Lag length for ADF tests are decided based on Akaike's information criterion (AIC).
3. Maximum bandwidths for PP and KPSS test are decided based on Newey-West (1994).
4. All tests are performed on the basis of 5% significance level.

V.3 Testing Cointegration

In order to identify if the series have any common factors in the long run, Johansen's cointegration test has been pursued. The results of the Johansen's cointegration test are reported in Tables Va and Vb respectively for three leading and three lagging regions. The cointegration tests are performed based on the assumptions that there is an intercept and a linear trend in the data with Max-Eigen value being the decider of the rejection of null hypothesis at 5 per cent level of

significance. The lag length in the model is decided based on Schwarz Information Criteria (SC). The results of cointegration tests, as reported in Tables Va and Vb, interestingly indicate that there are stable long-run relationship only among the three leading regions and the other selected factors influencing the convergence in the data.

TABLE VA
SUMMARY OF JOHANSEN COINTEGRATION TESTS FOR ALL LEADING DIVISIONS/REGIONS

Series	Lag length	Presence of cointegration
All leaders: Chittagong, Barisal, and Khulna	1	Yes (1)
All leading regional series plus private sector credit: (Chittagong, Barisal, Khulna, and psc)	2	Yes (1)
All leading regional series plus gross capital formation: (Chittagong, Barisal, Khulna, and gcap)	1	Yes (2)
All leading regional series plus agriculture machinery, tractors: (Chittagong, Barisal, Khulna, and ag_mac)	1	Yes (1)
All leading regional series plus electric power consumption: (Chittagong, Barisal, Khulna, and power)	1	Yes (2)
All leading regional series plus fertiliser consumption: (Chittagong, Barisal, Khulna, and fertiliser)	1	Yes (1)
All leading regional series plus literacy rate, adult: (Chittagong, Barisal, Khulna, and literacy)	1	Yes (1)
All leading regional series plus agriculture, value added: (Chittagong, Barisal, Khulna, and agri_va)	1	Yes (2)
All leading regional series plus industry, value added: (Chittagong, Barisal, Khulna, and ind_va)	1	Yes (2)
All leading regional series plus service, value added: (Chittagong, Barisal, Khulna, and ser_va)	1	Yes (1)

Note: 1.   Intercept and a linear trend in the data are assumed in all cases.
2.   Lag length is decided on the basis of Schwarz Information Criteria (SIC).
3.   Number in the parenthesis indicates the number of cointegrating relations under the Max-Eigen value test at 5% level.

TABLE VB
**SUMMARY OF JOHANSEN COINTEGRATION TESTS FOR ALL LAGGING
DIVISIONS/REGIONS**

Series	Lag length	Presence of cointegration
All laggers: Sylhet, Dhaka, and Rajshahi	1	No
All lagging regional series plus private sector credit: (Sylhet, Dhaka, Rajshahi, and psc)	1	No
All lagging regional series plus gross capital formation: (Sylhet, Dhaka, Rajshahi, and gcap)	1	No
All lagging regional series plus agriculture machinery, tractors: (Sylhet, Dhaka, Rajshahi, and ag_mac)	1	No
All lagging regional series plus electric power consumption: (Sylhet, Dhaka, Rajshahi, and power)	1	No
All lagging regional series plus fertiliser consumption: (Sylhet, Dhaka, Rajshahi, and fertiliser)	1	No
All lagging regional series plus literacy rate, adult: (Sylhet, Dhaka, Rajshahi, and literacy)	1	No
All lagging regional series plus agriculture, value added: (Sylhet, Dhaka, Rajshahi, and agri_va)	1	No
All lagging regional series plus industry, value added: (Sylhet, Dhaka, Rajshahi, and ind_va)	1	No
All lagging regional series plus service, value added: (Sylhet, Dhaka, Rajshahi, and ser_va)	1	No

Note: 1. Intercept and a linear trend in the data are assumed in all cases.
2. Lag length is decided on the basis of Schwarz Information Criteria (SC).
3. Number in the parenthesis indicates the number of cointegrating relations under the Max-Eigen value test at 5% level.

The findings of the co-integration test imply that only the leading regions have long-run equilibrium relation with selected factors affecting per capita income, namely private sector credit as a per cent of GDP, use of agricultural machinery and tractors, electric power consumption, fertiliser consumption, adult literacy rate, gross capital formation as per cent of GDP, and value added by agriculture, industry, and

services sectors as shares of GDP. The absence of co-integration among the lagging regions and the factors affecting per capita income explain why these lagging regions fail to catch up the leading regions overtime because they lack any long-run equilibrium relationship among them.

VI. CONCLUSIONS

The present study employs unit-roots and co-integration procedures including simple OLS technique to test the existence of income convergence across six divisional regions in Bangladesh. The empirical evidence presented in the paper provides very little support in favour of the convergence hypothesis. The outcome of non-convergence among the regions has important policy implications where proper attention in terms of providing infrastructural as well as technological and financial supports to the lagging regions may be intensified. It may be worth mentioning, in this regard, that the current strategy of pro-poor growth seems to be a proper way of expediting per capital income convergence across regions in Bangladesh. The results of non-convergence of this paper are in line with several other time series studies of income convergence (Durlauf 1995, Quah 1992). This study, however, differs from the existing studies on account of its application of the time series approach to various regions of a single economy instead of different economies. The testing of convergence across regions of a single country is more appropriate due to less heterogeneity of different socio-economic factors than those across nations. The outcome of non-convergence of the current study contradicts the findings of Hossain (2006) reporting evidence in support of convergence across regions in Bangladesh. It should, however, be mentioned that his study uses different techniques as well as definition of convergence compared with the ones used in the present study. While Hossain (2006) used the definition of conditional β-convergence based on the OLS method, the present study uses definitions of δ-convergence based on purely time series technique i.e. unit-root test.

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