How to Increase the Long Run Growth Rate of Bangladesh?

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Abstract

This paper develops a framework to analyse the determinants of the long term growth rate of Bangladesh. It is based on the Solow (1956) growth model and its extension by Mankiw, Romer and Weil (1992) and follows Senhadji's (2000) growth accounting procedure to estimate total factor productivity (*TFP*). Our growth accounting exercise showed that growth rate in Bangladesh, until 1990, was due to factor accumulation. Since then, however, *TFP* made a small positive contribution to growth. An analysis of the determinants of *TFP* showed that remittances by emigrant workers have negative effects which seem to be due to the loss of skilled labour force. Using these results policy options, to double per capita income of Bangladesh in about 15 years, are discussed.

Keywords: Solow Growth Model, Endogenous Growth, Total Factor Productivity, Growth Accounting, Remittances, Bangladesh.

JEL Classifications: O11

1. Introduction

In comparison to several studies on growth and development issues of the developing countries, Bangladesh seems to have received relatively less attention. Bangladesh is a poor Asian country with a per capita income of US$428 in 2007. Its average rate of growth of output (GDP) from 1970 to 2007 was 3.5% with large fluctuations until the early 1990s. Its population has increased at 2.3% per year and therefore its per capita incomes grew only at 1.2% implying that it will take 58 years to double per capita incomes. However, the average growth rate of GDP has increased during 2000 to 2007 to 5.6% and the rate of growth of population decreased to 1.9%, implying that per capita income grew at 3.8% and can be doubled in 18 years if this growth rates can be sustained. To double per capita incomes in about 15 years, the target rate of growth of GDP for the policy makers of Bangladesh should be about 6.5%. The question is whether it is possible to achieve this higher rate of growth in GDP. The 5.6% growth since 2000, as we show later, has been mainly due to factor accumulation and difficult to sustain for decades without a substantial increase in total factor productivity (*TFP*). While *TFP* is generally low in many developing countries, it seems to be even lower in Bangladesh. The objective of this paper is to addresses some issues concerning the low *TFP* growth and how it can be increased by analysing its main determinants. We pay special attention to the effect of remittances by the emigrant workers, which has been relatively high for Bangladesh. Remittances as a proportion of GDP *(REMRAT)*, during 2000 to 2007, were 6.5% and growing at the rate of 12% per year. To address these issues we shall use Solow (1956, 1957) for theoretical guidelines and our empirical methodology is based on the extensions to Solow by Mankiw, Romer and Weil (1992, MRW henceforth), Senhadji (2000) and Rao and Cooray (2008).

The structure of this paper is as follows. Section 2 briefly outlines the use of aforesaid theoretical and empirical works for this paper. Estimates of the production function are given and discussed in Section 3. A growth accounting exercise (*GAE*) is conducted in Section 4 to obtain estimates of *TFP*. Section 5 analyses a few key determinants of *TFP* and attention is given to the role of *REMRAT*. Policy implications of our paper are discussed in Section 6 and Section 7 concludes.

2. Solow Model and Extensions

The literature on the economics and econometrics of growth is vast. It has used two types of theoretical growth models viz., the Solow (1956) exogenous growth model and the canonical endogenous growth models of Uzawa (1968), Romer (1986,1990), Lucas (1988) and Barro (1990) and their variants.[1] However, many empirical works have used specifications based on the endogenous growth models with a variety of cross country techniques. Commenting on the policy relevance of these empirical works for the developing countries, Pritchett (2006) has observed that in spite of the progress in this literature, there is a tension between the academic interests in the determinants of the long term growth and the need for short to medium term growth policies by the policy makers of the developing countries. Rao and Cooray (2008) have argued that this tension is partly due to a failure to distinguish between policies for growth in the short to medium terms from policies for long run growth. They have pointed out that MRW have shown how the Solow (1956) growth model can be used to explain both the long run steady state growth rate and the dynamics of growth between the steady states.[2] Rao and Cooray have also noted that Senhadji (2000) has demonstrated how Solow's (1957) growth accounting framework can be used to analyse the determinants of *TFP*. The implication of these observations is that the usefulness of the Solow (1956) growth model and his 1957 growth accounting framework seem to have been underestimated for analysing the growth and development policies of the developing countries. This is important because the prevalent view is that the Solow (1956) growth model does not have any significant policy implications for growth, even for the developed countries, and somewhat irrelevant for the problems of the developing countries. Hicks (1965), for instance, observed that "Growth Theory (as we shall understand it) has no particular bearing on underdevelopment economics, nor has the underdevelopment interest played any essential part in its development."[3] Therefore, the vast empirical growth literature has neglected the Solow model and used, by and large, some *ad hoc* specifications loosely justified as based on a variety of endogenous growth

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[1] Ignoring refinements and extensions, these canonical endogenous models use different factors to explain the observed persistent growth in per capita incomes in the advanced countries. In Uwaza (1968) and Romer (1986) persistent growth is due to investment with externalities. In Romer (1990) this is due to accumulation of knowledge through research and development. In Lucas (1988) it is human capital and in Barro (1990) government expenditure on infrastructure causes growth. In comparison, in the exogenous model of Solow (1956) persistent growth is due to the exogenous (unexplained) growth of knowledge i.e., growth in total factor productivity (*TFP*).

[2] This transitional dynamics can also be explained with the much neglected closed form solution of Sato (1962) for the Solow model; see Rao (2004?).

[3] Quoted by Pritchett (2006).

models. Commenting on the unsatisfactory nature of specifications in these empirical works Easterly, Levine and Roodman (2004) have noted that "This literature has the usual limitations of choosing a specification without clear guidance from theory, which often means there are more plausible specifications than there are data points in the sample." Consequently, as found by Durlauf, Johnson, and Temple (2005), the number of potential growth improving variables used in various empirical works is as many as 145.

Since Rao and Cooray (2008) have demonstrated how Solow (1956) and its extended version by MRW (1992) can be used to analyse the short to medium term growth rates with country specific time series data, in this paper we shall demonstrate how the growth accounting framework of Senhadji (2000) can be used to analyse the determinants of the long term growth rate of Bangladesh. Prior to this it is necessary to understand, albeit briefly, the main conclusions of the Solow (1956) growth model and its extensions.

The standard Cobb-Douglas production function with constant returns and Harrod neutral technical progress can be used to explain the main implications of the Solow (1956) model. Further, the following assumptions are necessary. The two inputs capital and labour are assumed, respectively, to grow due to positive net investment until the marginal productivity of capital (*MPK*) equals the market rate of interest; and labour supply grows due to population growth. The stock of knowledge also grows due to the exogenous progress of technology. The model, with these assumptions, can be represented as follows.

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha} \quad (1)$$
$$\Delta K_t = I_t - dK_{t-1} \quad (2)$$
$$I_t = sY_t \quad (3)$$
$$\Delta \ln L_t = n \quad (4)$$
$$\Delta \ln A_t = g \quad (5)$$

where Y = output, K = capital, A = stock of knowledge and L = labour, d = depreciation rate, s = proportion of output saved and invested, n = growth of labour force and g = growth of the stock of knowledge. The steady state or equilibrium is defined as a state where *MPK* equals the rate of interest and positive net investment stops at this point. The solution for the steady state output per worker (y^*) is:

$$y^* = \left(\frac{s}{d+g+n} \right)^{\frac{\alpha}{1-\alpha}} A \qquad (6)$$

Given that the parameters are constant, the steady state growth rate of output (*SSGR*) per worker is $\Delta \ln A$ i.e., the rate at which *TFP* grows. An important implication of the Solow model is that the equilibrium rate of growth of an economy equals *TFP* and a change in the investment rate would have only transitory growth effects. Since the Solow model assumed that *TFP* is exogenous, it is also known as the exogenous growth model. Another important implication of the Solow model is that although different countries may grow at different growth rates, eventually all countries will converge to an equilibrium growth rate. However, countries with lower initial incomes will grow at a faster rate because *MPK* in these countries will be higher. Therefore, the gap between actual and the steady state levels of income will be higher, which makes the transitory growth rate higher. As these countries attract more capital inflows, this gap will eventually decrease and all countries will reach equilibrium (steady state) and grow at the rate of *TFP*. This prediction of the Solow model, known as convergence hypothesis, was the subject matter of many empirical papers in the 1960s of which the pioneering work is Baumol (1986). The convergence hypothesis has been used as an indirect test for the validity of the Solow (1956) growth model. While this hypothesis was shown to be valid by Baumol for a group of advanced economies, later empirical studies with larger samples of developed and developing countries found that there is no support for the convergence hypothesis. This finding and the assumption that *TFP* is exogenous in the Solow model seem to be the main reasons for the popularity of endogenous growth models in the empirical growth literature; see footnote 1.

MRW (1992) is the first attempt to extend the Solow (1956) model. They have augmented the production function in equation (1) with human capital (*HK*) and showed that the extended Solow model can explain the growth rates of a large sample of developed and developing countries. However, they have modified the convergence hypothesis by arguing that *SSGRs* differ between countries and therefore different countries will converge to different *SSGR*s. This is known as the conditional convergence hypothesis. The main message given by MRW is that the extended Solow (1956) growth model is applicable to a large number of countries with diverse structures.

However, *TFP* still remained exogenous even in the extended model of MRW. Therefore, Senhadji (2000), based on the extended Solow model and the growth accounting framework of Solow (1957), is of considerable interest for policy. Senhadji has used Solow (1957) to conduct a growth accounting exercise for a sample of 88 developed and developing countries. He has estimated *TFP*s as the Solow residuals for all these 88 countries and examined what factors determine *TFP* by regressing on some key determinants. He also found that the conditional convergence hypothesis is valid for his sample and added additional support to MRW's findings. We shall explain later Senhadji's approach in some detail.

3. The Production function

The previous section has noted that an extended Cobb-Douglas production function is useful for using the Solow model to explain growth. Using the estimated factor shares from this production function a growth accounting exercise (*GAE*) can be conducted to decompose growth into contribution due to factor accumulation. *TFP* is estimated as the difference between the actual growth rate and growth due to factor accumulation. Using these estimates of *TFP,* which are also estimates of the long run growth rate for a country, it is possible to examine some key factors that determine *TFP*.

For this purpose we follow Senhadji (2000) to conduct a *GAE* to estimate *TFP* for Bangladesh and to analyse its key determinants. While Senhadji has used only one time series method based on the fully modified ordinary least squares (*FMOLS*) of Phillips and Hansen (1990) because he has estimated production functions for a large number of countries, we shall use four time series methods viz., *FMOLS,* the Johansen maximum likelihood (*JML*), the bounds test of Pesaran and Shin (1990) and the LSE-Hendry general to specific (*GETS*) method. Senhadji has also used a simpler specification for the human capital augmented production function of MRW.[4] His Cobb-Douglas specification, with constant returns, is as follows.

$$Y_t = A_t K_t^{\alpha} (H_t \times L_t)^{(1-\alpha)} \tag{7}$$

where Y = output, A = stock of knowledge, K = stock of capital, H = an index of human capital formation through education and L = employment. The assumption of constant returns to scale gives the following simplified form, known as the intensive form of the production fn ction.

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[4] MRW have used a Cobb-Douglas function with three input factors of the following type:

$$Y_t = A_t K_t^{\alpha} H_t^{\beta} L_t^{(1-\alpha-\beta)}$$

However, they have used secondary school enrolment ratios as a proxy for human capital and this was much criticised. Senhadji's specification reduces the above to one parameter for estimation instead of two.

$$y_t = A_t k_t^{\alpha} \tag{8}$$

where $y = (Y / H \times L)$ and $k = (K / H \times L)$. In equation (8) the variables are measured in per worker terms adjusted for skill improvement. To estimate (7) and (8) it is first necessary to check the time series properties of the variables Y, K, LH, y and k. We have conducted the *ADF*, *KPSS* and *DF-GLS* tests to test if these variables are $I(1)$ in levels and $I(0)$ in their first differences. *ADF* and *KPSS* less power against the null although the null of unit roots in *ADF* is reversed in *KPSS*. In contrast the Elliot, Rothenberg and Stock (2001, hereafter ERS) *DF-GLS* belongs to a class of efficient unit root tests. Others in this class are the ERS (xxxx) point optimal test and the Ng and Perron (2001) tests. These efficient tests have more power against the unit root null and less size distortions in comparison to the *ADF* and Phillips-Perron tests. The test results based on *ADF*, *KPSS* and *DFGLS* are in Table 1.

Table 1
Unit Root Tests

Variable	*ADF*	*KPSS*	*DF-GLS*	Variable	*ADF*	*KPSS*	*DF-GLS*
$\ln Y$	0.206 (-3.553)	0.220* (0.146)	-1.221 (-3.190)	$\Delta \ln Y$	-9.310* (-2.948)	0.614* (0.463)	0.963 (-1.952)
$\ln K$	-2.007 (-3.544)	0.195* (0.146)	-1.399 (-3.190)	$\Delta \ln K$	-1.850 (-2.951)	0.654* (0.463)	-1.511 (-1.951)
$\ln LH$	-5.210* (-3.568)	0.093 (0.146)	-2.183 (-3.190)	$\Delta \ln LH$	-2.886** (-2.968)	0.156 (0.463)	-3.148 (-1.953)
$\ln y$	-5.185 (-3.536)	0.217* 0.146	-2.088 -3.190	$\Delta \ln y$	-4.971* (-2.946)	0.585* (0.463)	-3.117 (-1.951)
$\ln k$	-3.132 (-3.568)	0.193* (0.146)	-1.165 (-3.190)	$\Delta \ln k$	-1.682 (-2.945)	0.635 (0.463)	-0.956 (-1.951)

Notes: 5% CVs are in the parentheses below the computed test statistics.
* significant at 5% and ** significant at the 10% levels.

As can be seen, they did not give unequivocal results. While in the more efficient *DF-GLS* test all the levels of the variables are found to be non-stationary, *ADF* test rejected the null of non-stationarity for $\ln(L \times H)$ and $\ln y$. In the *KPSS* test, where the null is stationarity, the null could not be rejected for $\ln(H \times K)$. *DF-GLS* could not reject the null of non-stationarity for $\Delta \ln Y$, $\Delta \ln K$, and $\Delta \ln k$ although $\Delta \ln Y$ is found to be stationary by the less efficient *ADF* test. All the 3 tests found $\Delta \ln K$ and $\Delta \ln k$ are non-stationary. The ERS point optimal test and *DF-GLS* have the same asymptotic power under some conditions. Therefore, we have applied the point optimal test to determine if $\Delta \ln Y$, $\Delta \ln K$ and $\Delta \ln k$ are stationary. The computed test statics for these 3 variables, respectively, are -13.904, -94.084 and -28.523. These exceed the 5% critical value of -2.970 and the null of unit root can be rejected.[5]

For valid estimates and inferences with *FMOLS* and *JML,* it is necessary that all the variables should be *I(1)* in levels. However, the Bounds test and *GETS* do not need pre-testing of the variables and given the ambiguities in the roots tests comparisons of the estimates of the cointegrating equations with these four techniques are of interest.[6] Estimates of the cointegrating equations for equations (7) and (8), with these four methods are in Tables 2.

Table 2

Estimates of the Cointegrating Equations

Production Function	$Y_t = A_t K_t^{\alpha} (H_t \times L_t)^{\beta}$			$y_t = A_t k_t^{\alpha}$	
	1	2	3	4	5
Method	*Intercept*	α	β	*Intercept*	α
FMOLS	3.203 (7.80)	.377 (8.68)	.791 (9.41)	4.947 (19.23)	.490 (20.65)
JML	5.130 (3.48)	.467 (.16152)	.533 (.16152)	5.836 (18.17)	.404 (13.33)
ARDL (Bounds Test)	2.242 (2.57)	**.402** (4.50)	.808 (4.66)	5.177 (15.97)	**.468** (15.30)
GETS	3.550 (5.143)	**.443** (12.30)	.665 (7.15)	4.597 (11.50)	.529 (12.80)

Notes: t-ratios are in the parentheses below the coefficients

[5] The SBC criteria, generally used for selecting the lag length, has selected a zero lag for $\Delta \ln k$. This may leave some serial correlation in the residuals of the equation with GLS detrended variables for the *ADF* equation. Therefore, we have used the modified SBC to select the lag length and this option selected 2 lags for this variable. It is also not uncommon to add 2 additional lags to the unmodified lag selection criteria to minimise serial correlation and for MA structures in the residuals; see Harris and Sollis (2003). It is not uncommon to get such conflicting test results in small samples which lead some to say that it is possible to get any result with more than 150 options available to test for unit roots in softwares like the EViews.

[6] This is one reason why the bounds test, also known as the *ARDL* approach to cointegration, is very popular in the applied work. However, it is less well known that *GETS* can also be used without the need for pretesting; see Rao, Singh and Kumar (2009).

In this table estimates of the share of profits α varied from 0.377 with *FOML* (row 2) to 0.529, with *GETS* in the last row. The stylised value of α, used in many growth accounting exercises—especially for the developed countries—is one third. But, it is generally felt that α for the developing countries could be higher than the stylised value.[7] In the estimates of the unconstrained equation in columns (1) to (3) the null that there are constant returns ($\alpha + \beta = 1$) is not ejected. Good estimates of α are necessary because it effects the estimate of *TFP*. Differentiating the specification in (7) and rearranging terms gives:

$$
\begin{aligned}
& d\ln Y = d\ln A + \alpha(d\ln K) + (1-\alpha)(d\ln L + d\ln H) \\
& \therefore d\ln A = TFP = d\ln y - \alpha \ln k \\
& and\ \frac{\partial TFP}{\partial \alpha} = -\ln k < 0
\end{aligned} \tag{9}
$$

where the lower case letters are as defined earlier.[8] The result in (9) implies that using overestimated values of α, in a *GAE,* gives underestimated *TFP* values. However, this is unlikely to significantly affect the regression results when *TFP* is regressed on its potential determinants because α is held constant in the *GAE.* Therefore, the selected value for α, higher or lower, may yield similar coefficients for the determinants of *TFP.*

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4. Growth Accounting

As noted in the introduction, to double per capita incomes in Bangladesh, it is necessary to achieve a GDP growth rate of about 6.5%. However, if growth in GDP is mainly due to factor

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[7] By definition the share of profits is:

$$
\alpha = \frac{\dfrac{\partial \ln(Y)}{\partial \ln(K)} \times K}{Y} \approx \frac{\Delta Y}{\Delta K}\left(\frac{K}{Y}\right)
$$

The numerator is the remuneration for capital which is the marginal product of capital (*MPK*) multiplied by capital stock and (*K/Y*) is the capital-output ratio (*KYRAT*). It is to be expected that *MPK* will be higher in the developing countries because of their lower capital stocks and α should be higher. This effect will be partly offset by lower *KYRAT*s in the developing countries. But in proportionate terms the differences in *MPKs* are likely to be higher than *KYRATs*.

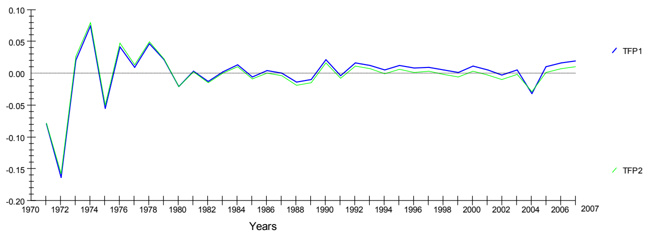
[8] Senhadji's derivation of the result in (4) doe not seem to be correct because he fails to simplify this derivation.

accumulation instead of *TFP*, it will be difficult to sustain this higher growth rate. For this reason a *GAE* is important because it can be used to decompose the rate of growth of output ($\Delta \ln Y$) into how much is due to the rates of growth of capital ($\Delta \ln K$), labour (ΔL) and human capital ($\Delta \ln H$). The total of these 3 contributions is the rate of growth due to factor accumulation. The residual is an estimate of *TFP*. This can be explained as follows with the production function (7). Taking its total differential gives:

$$D\ln Y = D\ln A + \alpha(D\ln K) + (1-\alpha)(D\ln L + D\ln H)$$
$$\therefore D\ln A = D\ln Y - \left[\alpha(D\ln K) + (1-\alpha)(D\ln L + D\ln H)\right] \qquad (10)$$
$$= \mathrm{D}\ln y - \alpha D\ln k \qquad (10a)$$

From the above it can be seen that *TFP* can be estimated as a residual using either of the two equations, but it is more convenient to tabulate results from (11a). We shall use two alternative estimates of α. The lowest estimate of 0.377 is close to the stylised value of one third. The average of all the estimated values in Table 2 is 0.448. Its estimate of 0.468 with the bounds test in column (5) is very close to this average. We shall use both values to estimate *TFP*. These values of *TFP* are plotted, respectively, as *TFP1* and *TFP2* in Figure 1. As can be seen these two estimates are very close but the mean of *TFP*2 will be lower than *TFP*1.

Figure 1



The summary statistics of the two estimates of *TFP* with growth decomposition for the entire sample period and sub-periods are in Table 3. *TFP* has been negative up to 1989 and made a positive contribution to growth only since 1990. Its contribution was about 1% during the decade of the 1990s and then decreased to 0.5% during the 8 years of 2000. Although in Bangladesh *TFP*'s contribution to growth is small and virtually negligible, this is also true in many other developing countries. Senhadji has estimated that *TFP*'s proportionate contribution to growth in the South Asian countries is 12% during 1960-2000. To reach this regional average, Bangladesh should sustain its *TFP* of the 1990s and improve this to achieve a sustainable growth in GDP of

6.5% to double per capita incomes within a decade and half. For this purpose it is necessary to analyse some key determinants of *TFP*.

Table 3
Decomposition of Growth

	Mean $\Delta \ln Y$	Mean $\Delta \ln K$	Mean $\Delta \ln(L + HK)$	*GDTFA1	GDTFA2	*GDTTFP1	GDTTFP2
1971-2007	0.0353	0.0467	0.0280	0.0351	0.0364	0.0003	-0.0011
Contribution to Growth (%)				99.29%	103.04%	0.71%	-3.04%
1971-1979	0.0080	0.0004	0.0272	0.0171	0.0152	-0.0091	-0.0072
Contribution to Growth (%)				212.85%	189.15%	-112.85%	-89.15%
1980-1989	0.0316	0.0473	0.0281	0.0353	0.0367	-0.0037	-0.0051
Contribution to Growth (%)				111.83%	116.13%	-11.83%	-16.13%
1990-1999	0.0469	0.0619	0.0229	0.0376	0.0404	0.0093	0.0065
Contribution to Growth (%)				80.19%	86.09%	19.81%	13.91%
2000-2007	0.0562	0.0791	0.0352	0.0517	0.0549	0.0044	0.0013
Contribution to Growth (%)				92.09%	97.63%	7.91%	2.37%

Notes: *GDTFA1 and *GDTTFP1 mean growth due to factor accumulation and growth due to total factor productivity where the estimations were made using α = 0.337. Similar interpretations hold for GDTFA2 and GDTTFP2 using α = 0.448.

5. Determinants of *TFP*

It is difficult to interpret annual estimates of *TFP*, obtained as residuals from *GAE*s, as estimates of true long run or the steady state growth rate (*SSGR*). *SSGR* is an unobservable theoretical concept and similar to the natural rate of unemployment. It can be derived by imposing the steady state conditions on an estimated non-steady state dynamic model that fits the data. In the Solow growth model, as discussed in Section 2, *SSGR* can be derived from equation (6) for the steady state level of per worker income (y^*). Since

$$y \equiv \frac{Y}{L \times H}$$

and using equation (6) gives:

$$Y^* = \left(\frac{s}{(n+d+g)} \right)^{\frac{\alpha}{1-\alpha}} A \times L \times H$$

$$\therefore \Delta \ln Y^* = SSGR = \Delta \ln A + \Delta \ln L + \Delta \ln H \quad (12)$$

The above derivation implies that the parameters s, d, n, g and α remain constant in the steady state. Using the average value of *TFP1* for the entire sample period of 1971-2007 from Table 3 as a proxy for $\Delta \ln A$, which is near zero, and the actual average growth rates of labour of 2.5% and human capital of 0.3%, the *SSGR* of output of Bangladesh is slightly above 2.8%. The rate of growth of population is 2.2% implying that per capita incomes can grow only at about 0.6%. If the average values for these variables from 2000 to 2007 are used and sustained, the implied long growth rates of output and per capita income, respectively, are 3.5% and 1.7%. If the average values are used for 1970-2007 it will take more than 100 years to double per capita incomes. To double per capita incomes in 15 years, per capita incomes should grow at 4.6% implying that the target rate of growth of GDP should be about 6.5%. How can this be achieved? For this purpose first it is necessary to understand some key variables determining *TFP*. It is hard to sustain a high growth rate with factor accumulation alone and policies to increase the low rate of growth of *TFP* are necessary. Although *TFP* is not a true measure of *SSGR* an analysis this proxy variable gives insights into how to improve the long run growth rate.

Many empirical works, based on the endogenous growth models and cross country regressions, have identified, as stated before, too many determinants of *TFP*.[9] Therefore, any list of a few crucial determinants is unlikely to be complete. Durlauf, Kourtellos, and Tan (2008) have summarised the main findings of several cross country studies and grouped them into 6 broad categories. According to them the fundamental determinants of growth are (1) economic institutions (2) legal and political systems (3) climate (4) geographical isolation (5) ethnic fractionalization and (6) culture.[10] These findings are unlikely to satisfy the needs of the policy

[9] Actually these studies regress the average growth rate for the whole sample of 30 or more years in the cross section studies and average growth rates of 5 to 10 years in the panel data studies. The assumption is that these average growth rates are good proxies for the unobservable long run growth rate or the *SSGR*. In the Solow model *SSGR* is given by *TFP*. It is for this reason we interpret endogenous empirical work as explanations of *TFP*.

[10] These are broadly consistent with the view of Frankel (2003) that the three big theories [sic] that seem to have emerged from the cross country studies on growth are based on climate, openness, and institutions.

makers of developing countries because they need policies to quickly increase the growth rate of per capita incomes; see Pritchett (2006) and Rao and Cooray (2008). Some variables identified by Durlauf, Kourtellos and Tan can be changed only in the very long run and others like ethnic fictionalisation and culture etc., are difficult to change even in the long run. It is pragmatic, therefore, to follow Senhadji's approach where he has identified some determinants that can respond to policy measures in the short to medium terms of about 3 years to increase *TFP*. However, he has used cross country methods for estimating the relationship between *TFP* and its determinants and modifications are necessary to suit our country specific time series data. The *TFP* determinants used by Senhadji are: (1) initial level of income, (2) life expectancy, (3) external shocks (proxied with the terms of trade shocks), (4) macro economic conditions (proxied with inflation rate, public consumption, real exchange rate, ratio of reserves to imports and level of external debt), (5) trade regime (current account and capital account convertibility) and (6) political stability (proxied with the ratio of war casualties to the population). His major findings are as follows. Firstly, growth in the developing countries is mostly due to factor accumulation and the contribution of *TFP* is small;[11] secondly, there is support for conditional convergence, thus validating the applicability of the MRW augmented Solow model for a large number of countries with diverse economic structures; and thirdly, the significant explanatory variables of *TFP*, with the expected signs in brackets, are: (1) life expectancy (positive), (2) public consumption (negative), (3) real exchange rate (negative),(4) ratio of reserves to imports (positive), (5) external debt to GDP ratio (negative), (6) capital account convertibility (positive) and (7) the ratio of war casualties to population (negative). The insignificant variables are: (8) terms of trade shocks (positive), (9) inflation (negative) and (10) current account convertibility (positive) but its coefficient turned out to be negative. Some of these findings are useful for our analysis of *TFP* of Bangladesh.

Some neglected variables by Senhadji, which are likely to have significant albeit small long run growth effects, are (1) the ratio of investment to GDP (*IRAT*) if it has some externalities besides increasing the capital stock, (2) ratio of workers' remittances to GDP (*REMRAT*) if some of this is invested in human and physical capital, (3) ratio of overseas development assistance to GDP (*ODARAT*), (4) ratio of foreign direct investment to GDP (*FDIRAT*) and (5) financial development which we proxy with the ratio of M2 to GDP (*M2RAT*). We have also selected some variables of Senhadji, with modifications. These are (6) the ratio of current government expenditure to GDP

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[11] In the East Asian countries, with an average value of $\alpha = 0.48$, factor accumulation contributed 77.5% to growth. In the South Asian countries, where the average α = 0.56, *TFP*'s contribution was half at only 12%. The rate of growth of *TFP* was negative in the Sub-Saharan Africa, Middle East and North Africa and Latin America.

(*GRAT*), (7) inflation rate (*PRAT*) and (8) trade liberalization, proxied with the ratio of imports plus exports to GDP (*TRAT*) or ratios of export to GDP (*EXRAT*) and imports to GDP (*IMRAT*) and the ratio of credit to private sector to GDP (*CRAT*). Needless to say this cannot be an exhaustive list of the potential determinants of *TFP*.

Given that there are only 37 observations on *TFP,* we have to be selective in our choice of these determinants. Some of these variables are trended and correlated. Furthermore, they may also have lagged effects on *TFP*. In order to understand their significance, one could regress *TFP* on the current and three periods lagged values of these 8 determinants. However, this would give inefficient estimates because there would be 34 parameters, including the intercept and trend, to estimate with 37 observations. Therefore, an alternative is to remove the insignificant variables to increase the degrees of freedom to get more efficient estimates. But this procedure suffers from the path dependency problem because the results would be sensitive to the order in which the insignificant variables are removed; see Hendry and Krolzig (2000?). Nevertheless, at first, it would be useful to proceed on these lines and ignore the path dependency problem to start with. With these caveats we have estimated the following specification with OLS.

$$TFP_t = \alpha_0 + gT + \sum_{i=0}^{3} \alpha_{1i} TRAT_{t-i} + \sum_{i=0}^{3} \alpha_{2i} IRAT_{t-i} + \ldots\ldots + \sum_{i=0}^{3} \alpha_{8i} \Delta \ln P_{t-i} \qquad (8)$$

where the 9 explanatory variables are time $T(\pm)$, *TRAT(+), IRAT(+), M2RAT(+), GRAT(-), REMRAT(±), ODARAT(±), FDIRAT(+),* and inflation rate $\Delta \ln P(-)$. The prior expectation of the signs of the coefficients is in the brackets with the variables. However, these signs may change. For example if investments are made in the inefficient protected sector or in small scale inefficient industries the sign of *IRAT* may become negative due to negative externalities. Details of the definitions of the variables and sources of data are in the appendix.

We first estimated equation (8), with the levels of the ratios, with OLS after deleting the insignificant variables. The insignificant variables are deleted one at a time by deleting at first the variable with the smallest t-ratio and an insignificant coefficient. In the next round another variable with the smallest t-ratio and insignificant coefficient is deleted and so on. While the summary χ^2 test statistics for this equation were insignificant at the 5% level for functional for misspecification, non-normality of the residuals and heteroscedasticity, the test statistics for the serial correlation in the residuals was highly significant. The adjusted R^2 was high at 0.95. Since these results are not reliable due serial correlation in the residuals, to conserve space, we shall not report these estimates. Therefore, this equation is reestimated with the exact maximum likelihood method (ML) allowing for first and second order serial correlation in the residuals. The second order serial correlation coefficient was insignificant, but the first order serial correlation is near one ($\rho_1 = -0.966$) and highly significant. ML estimates, with first order serial correlation transformation, are in column (1) of Table 4. Its summary statistics are good and all the coefficients of the retained variables are significant at the 5% level. ML estimates for *TFP*2, using the same procedure, are in column (3). In columns (2) and (4) the implied long run coefficients of these estimates are given. All the long run estimates of the coefficients with ML have the expected signs with the exception of *IRAT* which is negative, implying that perhaps there are negative externalities in investments. *REMRAT* and *ODARAT* have negative signs implying that *TFP* decreases when these ratios increase and this is not entirely unexpected. Most recipients of remittances are likely to be relatively poor and spend their receipts on consumption instead of investing for future consumption. However, this may change over time if the government gives incentives to the recipients and the remitters to invest. Furthermore, remittances are also likely to be correlated with the number emigrants from Bangladesh. These workers are relatively more productive and therefore their departure may have decreased skilled labour and adversely affected *TFP*. This may be called the brain-drain effect. *ODARAT* may have a negative effect due to corruption and lack of coordination between the needs of the recipient country and the perceptions of their needs by the donors. It is disappointing that *IRAT* did not have the expected positive sign but a negative for this variables is also plausible as noted earlier. *FDIRAT*, *M2RAT* and *TRAT* have the expected positive effects and *GRAT* and *PRAT* the expected negative effects. Since the mean *FDIRAT* is very small at $0.419E^{-4}$, it has a large coefficient. *FDIRAT* generally brings into the country more productive machinery and management practices. *TRAT,* a proxy for openness, seems to have a relatively larger positive effect in comparison to other ratio variables with positive effects.

Table 4 ML Estimates of *TFP* with Levels				
	1	2	3	4
	ML Coefficients of *TFP1* with AR1	ML Long Run coefficients of *TFP1* AR1	ML Coefficients of *TFP2* with AR1	ML Long Run coefficients of *TFP2*
C	0.321 9.57[0.00]		0.334 11.55 [.000]	
IRAT	-2.434 10.42[0.00]		-2.526 -12.47 [.000]	
IRAT(-1)	1.309 6.70 [0.00]	-1.125	1.258 7.40 [.000]	-1.268
REMRAT	-84.136 6.11 [0.00]		-89.553 7.55 [.000]	
REMRAT(-1)	147.4174 6.00 [0.00]		150.041 7.09 [.000]	
REMRAT(-2)	-162.346 6.43 [0.00]		-158.660 7.29 [.000]	
REMRAT(-3)	93.399 8.58 [0.00]	-5.666	79.076 8.42 [.000]	-19.106
ODARAT	25.944 3.78 [.003]		28.175 4.75 [.001]	
ODARAT(-1)	-54.113 6.03 [0.00]		-55.052 -7.11[.000]	
ODARAT(-2)	23.773 3.30 [0.00]		18.117 2.92 [.014]	
ODARAT(-3)	-17.461 3.19 [0.01]	-21.857	-14.324 -3.03 [.011]	-23.084
FDIRAT	234.035 6.30 [0.00]		237.926 7.41 [.000]	
FDIRAT(-1)	79.861 2.73 [0.02]		68.459 2.71 [.020]	
FDIRAT(-2)	--	--		
FDIRAT(-3)	-266.689 4.07 [0.00]	47.21	-288.019 -5.10 [.000]	18.366
M2RAT(-1)	0.591 6.14 [0.00]		0.634 7.64 [.000]	
M2RAT(-2)	-0.559 6.96 [0.00]	0.032	-0.561 -8.11 [.000]	0.073

	1	2	3	4
	ML Coefficients of *TFP1* with AR1	ML Long Run coefficie nts of *TFP1* AR1	ML Coefficients of *TFP2* with AR1	ML Long Run coefficients of *TFP2*
GRAT	-2.749 3.22 [0.01]		-3.363 -4.57 [.001]	
GRAT(-1)	3.541 5.95 [0.00]		4.025 7.85 [.000]	
GRAT(-2)	-5.101 8.72 [0.00]		-4.935 9.75 [.000]	
GRAT(-3)	1.806 7.02 [0.00]	-2.504	1.821 8.21 [.000]	-2.451
PRAT	-0.223 6.12 [0.00]		-0.250 -7.93 [.000]	
PRAT(-2)	-0.206 10.44[0.00]	-0.429	-0.193 -11.33[.000]	-0.443
TRAT	0.325 5.34 [0.00]		0.304 5.78 [.000]	
TRAT(-3)	-0.123 2.24 [0.05]	0.202	-0.0694 -1.46 [.172]	0.235
ρ_1	-0.973 -22.17 [0.00]		-0.975 -26.05[0.00]	
$\bar{R}^2$	0.975		0.983	
SE	0.003		0.003	
DW	3.042		3.132	
Notes: t-ratios are in the parentheses and p-vales are in the square brackets.				

Since the serial correlation coefficient is near unity and the adjusted R^2 is high, it is likely that some variables may be non-stationary. Therefore, we followed 2 other procedures. We have tested for unit roots in all the variables and found that *TFP1, TFP*2 and the inflation rate (*PRAT*) are stationary. All other variables are found to be non-stationary in levels and stationary in their first differences, implying that they are *I(1)* in levels.[12] It is not possible to apply cointegration methods to estimate (8) because the order of the variables in the equation is not I(1). However, since the serial correlation coefficient is near unity, the non-stationary explanatory variables can be

[12] Results of these unit root tests can be obtained from the authors.

Table 5
Estimates with the First Differences

1	2	3	4	5	6
TFP1	Coefficient	LONG RUN	TFP2	COEF	LONG RUN
C	0.060 4.25 [.001]		C	0.065 4.53 [.000]	
DREMRAT(-1)	-30.746 -1.44 [.169]		DREMRAT(-2)	-62.131 -4.603 [.000]	-62.131
DREMRAT(-2)	-62.775 -5.53 [.000]	-93.520	DODARAT	20.575 2.33 [.033]	
DODARAT	17.332 2.01 [.061]		DODARAT(-1)	-38.353 -8.86 [.000]	
DODARAT(-1)	-37.495 -8.69 [.000]		DODARAT(-3)	-21.091 -1.89 [.077]	-38.869
DODARAT(-3)	-23.067 -1.80 [.091]	-43.231	DM2RAT	-0.099 -2.06 [.056]	-0.099
DM2RAT	-0.079 -2.60 [.021]	-0.079	GRAT(-2)	0.831 1.72 [.105]	
DGRAT	0.782 2.50 [.024]		GRAT(-3)	-2.116 -4.67 [.000]	-1.285
DGRAT(-3)	-2.004 -5.34 [.000]	-1.223	PRAT	0.056 2.56 [.021]	
DPRAT	0.106 2.56 [.021]		PRAT(-2)	-0.024 -1.86 [.081]	0.031
DPRAT(-2)	-0.051 -5.01 [.000]	0.055	DIRAT	-1.444 -6.01 [.000]	
DIRAT	-1.842 -8.36 [.000]		DIRAT(-1)	0.508 2.85 [.012]	
DIRAT(-1)	0.639 2.67 [.017]		DIRAT(-2)	-1.294 -10.08 [.000]	
DIRAT(-2)	-1.273 -9.54 [.000]		DIRAT(-3)	1.692 7.60 [.000]	1.692
DIRAT(-3)	1.899 7.01 [.000]	-0.577	DTRAT	0.360 9.02 [.000]	
DTRAT	0.440 8.73 [.000]		DTRAT(-2)	0.188 4.63 [.000]	0.548
DTRAT(-1)	0.110 1.729 [.103]		DFDIRAT(-1)	20.393 1.46 [.163]	
DTRAT(-2)	0.237 3.10 [.007]	0.785	DFDIRAT(-2)	83.008 6.90 [.000]	103.401
$\bar{R}^2$	0.888			0.878	
SE	$0.8714E^{-3}$			$0.101E^{-2}$	
χ^2_{sc}	$0.871E^{-3}$ [0.417]			0.788 [0.375]	
χ^2_{ff}	0.381 [0.537]			0.125 [0.723]	
χ^2_{nn}	0.797 [0.671]			2.931 [0.231]	
χ^2_{hs}	2.511 [0.113]			1.611 [0.204]	

Notes: t-ratios (White adjusted) are in the parentheses and p-vales are in the square brackets.

first differenced to make them *I(0)*.[13] That way all the variables would be stationary and the equation can be estimated with the standard classical methods. The specification used in this alternative method is as follows.

$$TFP_t = \alpha_0 + gT + \sum_{i=0}^{3} \alpha_{1i} \Delta TRAT_{t-i} + \sum_{i=0}^{3} \alpha_{2i} \Delta IRAT_{t-i} + \ldots\ldots + \sum_{i=0}^{3} \alpha_{8i} \Delta \ln P_{t-i} \qquad (9)$$

OLS estimates of this equation, after deleting the insignificant variables, are in Table 5.
In the second alternative method, since the results in Table 4 and Table 5 suffer from the path dependency problem, we have used *PcGETS* to reestimate equation (9). *PcGETS* automatically selects the lag structure by minimising the path dependency problem; see Hendry and Krolzig (200?). Although we have also estimated equations with the levels of the ratios as in equation (8), these are not reported because there is no option in *PcGETS* to estimate with serially correlated. The results with levels are unreliable and not reported. Estimates with *PcGETS* of equation (9) are in Table 6.

First, we discuss the results in Table 5, which are comparable to the ML estimates in Table 4. In Table 5 all the estimated coefficients of the retained variables are significant at the 5% level. summary χ^2 for serial correlation in the residuals (χ^2_{sc}), functional form misspecification (χ^2_{ff}), non-normality of the residuals (χ^2_{nn}) and heteroscedasticity (χ^2_{hs}) are insignificant at the 5% level. The long run coefficients for *TFP*1 and *TFP*2 are in column (3) and column (6) respectively. It can be seen that only 2 long run coefficients for *TFP*1 viz., $\Delta GRAT(-)$ and $\Delta TRAT(+)$ have the expected signs. In contrast, in the equation for *TFP*2 in column (6), two additional variables viz., $\Delta IRAT(+)$ and $\Delta FDIRAT(+)$ have also the expected signs. The signs of $\Delta ODARAT$ and $\Delta REMRAT$ are negative in both estimates. Negative signs for $\Delta M2RAT$ a positive sign for $\Delta \ln P$ are unexpected. Furthermore, there are some noticeable differences in the estimated long run coefficients for *TFP*1 and *TFP*2. For example the long run coefficient of $\Delta DIRAT$ is negative for *TFP*1 and positive for *TFP*2. These differences seem to be due to the differences in the retained variables in the two equations.

[13] Although there would be some loss of information on the levels relationship, this is a pragmatic option subject to these caveats.

The somewhat disappointing results in Table 5, also Table 4, may also be due to the path dependence problem. Therefore, it would be interesting to examine estimates with *PcGETS* and these are in Table 6. *PcGETS* has deleted $\Delta TRAT$ and its lagged values during the search for optimal lags. We have included in its place changes in the ratios of exports to GDP ($\Delta EXRAT$) and imports to GDP ($\Delta IMRAT$) as two separate variables and *PcGETS* has retained both. Estimates with *PcGETS* are impressive and have some merits over the estimates in Tables 4 and 5. The summary statistics for $TFP1$ and $TFP2$ are impressive. The adjusted R^2s are high and the test statistics for the null hypotheses of no serial correlation and *ARCH* effects are accepted since they are significant only at more than the 10% level.[14] Estimates for $TFP1$ and $TFP2$ are also closer than in Tables 4 and 5 and the retained variables and their lags are the same for $TFP1$ and $TFP2$. The number of long run coefficients, with the expected signs, is more than in Tables 4 and 5. Finally, since the path dependency problem is minimised by *PcGETS* we prefer these estimates and use for policy analysis in the following section.

[14] Estimates in Tables 4 and 5 are made with Microfit and *PcGETS* does not compute the same summary statistics. We have reported in Table 6 the summary statistics computed by *PcGETS*. *PcGETS* also computes the standard errors for the long run coefficients and all the long run coefficients in Table 6 are significant. We did not report the standard errors for the long run coefficients in Tables 4 and 5 because Microfit does not compute them. Computation of these standard errors from the variance and covariance matrices is a demanding process because the number of variables is large.

TABLE 6 BASED ON *PcGETS* First Differences				
	1	2	3	4
TFP1		LONG RUN	TFP2	LONG RUN
Constant	0.052 7.78 [0.00]	0.0517	0.059 9.69 [0.00]	0.0061
Trend	-0.003 -7.75 [0.00]	-0.003	-0.004 -9.99 [0.00]	-0.004
DFDIRAT	237.333 4.67 [0.00]		276.500 5.90 [0.00]	
DFDIRAT_1	218.946 3.69 [0.00]	456.2782	233.343 4.34 [0.00]	509.839
DIRAT	-0.817 -3.32 [0.00]		-0.866 -3.89 [0.00]	
DIRAT_1	1.545 7.96 [0.00]	0.7278	1.590 8.89 [0.00]	0.7246
DM2RAT	0.208 2.37 [0.03]		0.249 3.08 [0.01]	
DM2RAT_1	0.758 6.40 [0.00]	0.9667	0.851 7.80 [0.00]	1.0995
DREMRAT	-125.732 -6.45 [0.00]		-144.845 -7.70 [0.00]	
DREMRAT_2	-52.468 -2.59 [0.01]	-178.1996	-43.131 -2.345	-187.9756
DODARAT	-37.826 -4.91 [0.00]		-30.05866 -4.077	
DODARAT_1	-38.752 -4.16 [0.00]	-76.578	-28.915 -3.26	-58.9737
DGRAT_2	-1.251 -3.26 [0.00]	-1.2514	-1.261 -3.52 [0.00]	-1.2609
DCRAT2	-0.496 -3.01 [0.01]	-0.4965	-0.573 -3.81 [0.00]	-0.5727
DEXRAT	0.013 6.17 [0.00]		0.004 2.79 [0.01]	
DEXRAT_1	0.013 6.34 [0.00]		0.015 7.32 [0.00]	
DEXRAT_2	0.006 7.16 [0.00]	0.0269	0.013 6.83 [0.00]	0.0317
DIMRAT	-0.002 -2.86 [0.01]		0.005 6.41 [0.00]	
DIMRAT_2	0.05168	0.0042	-0.002 -2.33 [0.03]	0.0037
$\bar{R}^2$ SE Normality Test	0.900 0.007 0.938 [0.63]		0.922 0.006 1.7821 [0.41]	

6. Policy Implications

For convenience estimates of the long run coefficients from Tables 4 to 6, are given in Table 7. Using the sample means of the determinants of *TFP,* their effects on *TFP* are given in the last column (8).

Table 7

Summary of Long Run Coefficients

		ML Estimates with Levels		OLS Estimates With First Differences		Estimates with *PcGETS* First Differences		
		1	2	3	4	5	6	7
	Variables	*TFP1*	*TFP2*	*TFP*1	*TFP2*	*TFP*1	*TFP*2	Mean Effect on *TFP*
1	*Constant*	0.321	0.334	0.060	0.065	0.052	0.059	
2	*Trend*					-0.003	-0.004	
3	*REMRAT*	-5.666	-19.106	-93.530	-62.131	-178.100	-187.976	-1.00%
4	*IRAT*	-1.125	-1.268	-0.577	1.692	0.728	0.725	0.33%
5	*TRAT*	0.202	0.235	0.785	0.548	--	--	
6	*EXRAT*	--	--	--	--	0.027	0.032	0.01%
7	*IMRAT*		--	--	--	0.004	0.004	0.00%
8	*FDIRAT*	47.210	18.366	--	103.401	456.278	509.839	0.30%
9	*M2RAT*	0.032	0.073	-0.079	-0.099	0.967	1.100	2.40%
10	*ODARAT*	-21.857	-23.084	-43.231	-38.869	-76.578	-58.973	-0.06%
11	*GRAT*	-2.504	-2.451	-1.223	-1.285	-1.251	-1.261	-0.14%
12	*CRAT2*	--	--			-0.497	-0.573	-0.48%
13	*PRAT*	-0.429	-2.451	0.055	0.031	--	--	

We shall discuss in some detail the effect of *REMRAT* and then briefly the effects of other ratios. All estimates show that the long run effect of *REMRAT* on *TFP* is negative. Estimates of the long run coefficients of $\Delta REMRAT$, especially with *PcGETS* are closer for both *TFPs.* These negative effects, with first differences in Tables 4 to 6 (see Table 7) vary from -5.666 to -178.10 for *TFP*1 and from -62.13 to -187.97 for *TFP*2.

Using the mean of $\Delta REMRAT$ for the sample period of $0.555E^{-4}$ these estimates imply that remittances have a negative effect on *TFP1* ranging from -0.5% to -1.0% and on *TFP*2 from -0.3%

to -1.0% which are not far apart. However, if the preferred estimates with *PcGETS* are used these negative effects for both *TFP*s are the same at -1.0% and these are not small. The mean effects of remittances and the other variables on *TFP*1, with the *PcGETS* coefficients from Table 6, are in the last column (8) of Table 7. The general explanation for this negative effect of remittances is that households spend mostly on current consumption instead of investing a part of it for future consumption. The negative effect may also be due to two other factors which many commentators ignore. Firstly, since remittances will be correlated with the number of emigrant skilled workers, *TFP* may be declining due to shortages of skills and this may be called the brain-drain effect. Secondly, remittances also increase foreign exchange reserves and may lead to an appreciation of the currency. This would have a negative effect on exports and growth. However, the long term effects of exports and imports on *TFP* are not large for Bangladesh. Therefore, the brain-drain effect seems to be the more dominant factor that made the effect of remittances on *TFP* negative.[15] If this is correct, then it is necessary to implement labour market policies to increase the supply of skilled labour through education and training. Details of these policies fall outside the scope of the present paper.

The mean effects of the other determinants of *TFP* are computed with only the estimates with *PcGETS* on *TFP*1 because the long run coefficients are close for both measures of *TFP*. The largest positive effect on *TFP* of 2.40% is due to $\Delta M2RAT$, which is a proxy for financial development. Next come $\Delta IRAT$ and $\Delta FDIRAT$, with smaller and similar effects of about 0.3%. The largest negative effect of -0.48% is due to credit to the private sector ($\Delta CRAT$), which is contrary to expectation and hard to justify. Other positive effects of exports ($\Delta EXRAT$) and imports ($\Delta IMRAT$) are negligible. So is the negative effect of government consumption ($\Delta GRAT$).

These results imply that there are limited options to increase *TFP* in Bangladesh and it is necessary to reduce the large negative effects of remittances, which seem to be due to the brain-drain effects on the skill content of the labour force. To offset the -1.0% effect of remittances, it is necessary to

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15 In one run with *PcGETS* we have added the change in the ratio of emigrants to labour force ($\Delta EMRAT$), lagged up to 3 periods, as an additional variable. To accommodate this it was necessary to reduce the lag lengths for other variables to 2 instead of 3 as in Table 6. This gave a positive long run coefficient for $\Delta REMRAT$ of 66.074 and a negative long run coefficient for $\Delta EMRAT$ of -438.335. The sample mean for $\Delta REMRAT$ is $0.555E^{-4}$ implying that remittances have a positive *TFP* effect of 0.36%. However, in this regression only $\Delta FDIRAT$ retained its expected positive long run effect on *TFP* and the long run coefficients other retained variables $\Delta IRAT$, $\Delta GRAT$, $\Delta EXRAT$ and $\Delta IMRAT$ all had wrong signs. These somewhat mixed results call for a more careful investigation of the brain-drain effect, but we may say that the negative effect of remittances on *TFP* is mostly due to the negative effects of lost skills.

increase *M2RAT*, *IRAT* and *FDIRAT* by 45%, and this is an hard option. However, due to the financial reforms from the late 1990s, the mean $\Delta M2RAT$ at 0.068, from 1999 to 2007, is 6 times more than its average of 0.011 in the pre-reforms period. If the financial sector develops at this rate it would take about 6 years to achieve the target of 45% improvement in the financial sector progress. Compared to this, the means of $\Delta IRAT$ and $\Delta FDIRAT$, respectively, are 0.006 and $0.154E^{-4}$ for the period 1999 to 2007. To increase these ratios by 45% in 5 years, that is to increase *IRAT* to 0.38% and *FDIRAT* to 0.02%, it is necessary to raise them every year by 0.07%, implying that *IRAT* should be increased from its average of 0.26% to 0.28% in the first year and so on. However, if the negative effects of remittances can significantly be decreased, these targets will become more pragmatic to achieve and the net effect of the positives and negatives on *TFP* may become mildly positive.

In summary policies to increase the long run growth rate of Bangladesh are as follows. Firstly, it is necessary to minimize the adverse effects of remittances by reducing the skill shortages left by the emigrant workers. This can be achieved by encouraging the recipient households to invest some of the remittances in both in human and physical capital and through other policies to improve the skill content of the labour force. Secondly, the progress of the financial sector seems to be satisfactory and some of this may be due to the large amounts deposits created by remittances. It is necessary to maintain this rate of progress of the financial sector. Thirdly, it is necessary to provide large incentives to increase the investment rate rapidly, perhaps from the present 26% to more than 35% within a 5 year period. Fourthly, Bangladesh should make a serious attempt to attract foreign direct investment by at least 10 times more than the present negligible ratio of 0.02% of GDP.

The aforesaid measures are just adequate to neutralize the negative effects of *REMRAT*. Perhaps the reason for an insignificant *TFP* in Bangladesh over the sample period may be due to the large negative effects of remittances and its brain-drain effect. Consequently, much of the growth rate in GDP was due to factor accumulation and this is hard to sustain in the long run. As can be seen from Table 3, *TFP's* contribution to growth has become positive from 1990 and declined but remained positive from 2000. This may be due to a significant increase in the growth rate of human capital formation since 1990, which may have increased the supply of skilled workers. The mean value of the rate of growth of human capital formation before 1990 was 0.24% and this has increased by 30% to a mean growth rate of 0.32% since then. A similar increase in the rate of growth of human capital formation in Bangladesh in the coming years may make *TFP*'s contribution to growth positive and slightly larger than 1%. If Bangladesh can sustain its factor accumulation at the average rate since 1999 for another decade and half, with a significant increase in *FDI*, and assuming that *TFP* will be at the least 1% due to increased rate of human capital formation, growth rate of GDP will be at 6.2%. This is close to our target rate of 6.5% in GDP to double per capita incomes in about a decade and half. Therefore, our answer to the main question about policies needed to double per capita incomes in Bangladesh depends on the government's willingness to increase the rate of growth of human capital formation to fill the skill shortages in the labour force and attracting significant amounts of *FDI*. It is also necessary to maintain the progress of the financial sector and ensure that investment ratio increases from the current 26% to 35% or more.

7. Conclusions and Limitations

In this paper we have used the extended versions of the Solow (1956) growth model by MRW (1992) and the growth accounting framework of Solow (1957) used by Senhadji (2000) to derive policies to increase the long run growth rate of Bangladesh. Perhaps this paper is first such attempt to use these extensions to derive policies for long run growth with country specific time series data. Our growth accounting exercise showed that much of the growth in GDP of Bangladesh was due to factor accumulation. *TFP*'s contribution was zero or negative before 1990 and became positive only after 1990.

Our results imply that to double per capita income in Bangladesh within a decade and half, it is necessary to decrease the negative *TFP* effects of remittances by the emigrant workers. These negative effects seem to be due to the brain-drain effect caused by the shortages of skilled workers. Therefore, it is necessary to implement policies to fill the gaps of skills in the labour force through education and training. In addition, Bangladesh should give incentives to invest a part of the remittances in education and health to improve the skill content of the labour force and attract foreign direct investment substantially to improve the investment ratio. The progress made by the financial sectors is impressive after financial reforms and it is necessary that this rate of progress is sustained. However, contrary to expectation, credit to private sector seems to have a negative effect on *TFP*. This needs further investigation because it is hard to justify this to other than a statistical quirk.

There are some limitations in our paper. The range of our estimate of the share of profits with the production function is a bit high although this did not yield conflicting conclusions on the contribution of factor accumulation to growth and the significance of the long run coefficients of the determinants of *TFP* in our preferred estimates with *PcGETS*. We are also not able to justify the large negative effect of remittances on *TFP* and made a plausible conjecture, based on some indirect evidence, that this was mostly due to the brain-drain effect; see footnote 13. However, it is necessary to test the validity of this conjecture with comprehensive studies of the labour market flows. We hope that these weaknesses will be improved by other investigators working on the growth and development issues of not only Bangladesh but also on other developing countries. We are also optimistic that our framework will be used, in improved forms, to analyse the determinants of long run growth of other countries.

Data Appendix:

Variables	Definition	Source
Y	Real Gross Domestic Product	World Development Indicators (WDI) 2008, World Bank
K	Capital Stock; Derived using perpetual inventory method $K_t = .95 * K_{t-1} + I_t$. I_t is real gross domestic fixed investment	International Financial Statistics, IMF
L	Labour Force	WDI 2008
H	Human capital; An average of the Barro-Lee and Cohen-Soto data set and it incorporates a 7 percent rate of Return to each year of education.	Barro-Lee and Cohen-Soto data set.
IRAT	Gross domestic fixed investment to GDP ratio.	World Development Indicators (WDI) 2008
REMRAT	Workers' remittances and compensation of employees to GDP ratio.	World Development Indicators (WDI) 2008
ODARAT	Overseas development aid to GDP ratio.	World Development Indicators (WDI) 2008
FDIRAT	Foreign direct investment to GDP ratio.	World Development Indicators (WDI) 2008
M2RAT	Money and quasi money (M2) to GDP ratio.	World Development Indicators (WDI) 2008
GRAT	General government final consumption expenditure to GDP ratio.	World Development Indicators (WDI) 2008
PRAT	Inflation, (GDP deflator) annual percentage	World Development Indicators (WDI) 2008
TRAT	Sum of export plus import of goods and services to GDP ratio.	World Development Indicators (WDI) 2008

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