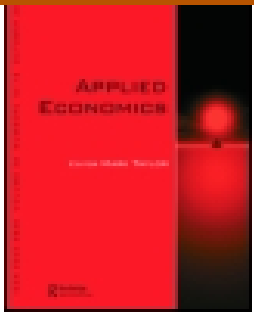

Applied Economics

Taylor & Francis Group

ISSN: 0003-6846 (Print) 1466-4283 (Online) Journal homepage: http://www.tandfonline.com/loi/raec20

Revisiting the threshold effect of remittances on total factor productivity growth in South Asia: a study of Bangladesh and India

Ronald Ravinesh Kumar, Peter Josef Stauvermann, Nikeel N. Kumar & Syed Jawad Hussain Shahzad

To cite this article: Ronald Ravinesh Kumar, Peter Josef Stauvermann, Nikeel N. Kumar & Syed Jawad Hussain Shahzad (2017): Revisiting the threshold effect of remittances on total factor productivity growth in South Asia: a study of Bangladesh and India, Applied Economics, DOI: 10.1080/00036846.2017.1412074

To link to this article: https://doi.org/10.1080/00036846.2017.1412074

Published online: 07 Dec 2017.

APPLIED ECONOMICS, 2017
https://doi.org/10.1080/00036846.2017.1412074

Revisiting the threshold effect of remittances on total factor productivity growth in South Asia: a study of Bangladesh and India

Ronald Ravinesh Kumar [a,b], Peter Josef Stauvermann [c], Nikeel N. Kumar [d,e] and Syed Jawad Hussain Shahzad [f]

[a]Informetrics Research Group, Ton Duc Thang University, Ho Chi Minh City, Vietnam; [b]Faculty of Social Science and Humanities, Ton Duc Thang University, Ho Chi Minh City, Vietnam; [c]Changwon National University, Changwon, Republic of Korea (South Korea); [d]The University of the South Pacific, Suva, Fiji; [e]The University of Fiji, Lautoka, Fiji; [f]Montpellier Business School, Montpellier, France

ABSTRACT
Both Bangladesh and India are among the top recipient of remittances in absolute terms. However, in relative terms – remittances as a per cent of GDP – the two countries stand at 6.1% and 2.8%, respectively, well below the levels of the top 10 recipients. In this article, we explore the effect of remittances on the total factor productivity (TFP) growth considering Bangladesh and India, as reference countries over the periods 1980–2012 and 1977–2012, respectively. We examine the presence of a long-run association between remittances and TFP using a number of tests. The results indicate that remittances have threshold effects on TFP growth in both countries. Despite the two countries receiving substantial amount of remittances, we note that Bangladesh has a U-shaped relationship whereas India has an inverted U-shaped relationship with TFP growth. For Bangladesh, a minimum threshold of remittances (% GDP) is 5.3% and for India, a tipping point of remittances (% GDP) is at 1.8%. The causality tests confirm a bidirectional effect, which implies that remittances and TFP growth are mutually reinforcing. Interestingly, while the two economies have similar remittances impact in regards to causality, the study highlights two different tipping points of remittances.

KEYWORDS
Remittance inflows; total factor productivity; cointegration; causality

JEL CLASSIFICATION
B22; D24; F24; F63; O53

I. Introduction

Remittances, defined as the money transfers of people working abroad to an individual or group of people in his/her home country, are one of the most important financial inflows of developing countries, sometimes more important than development aid. However, unlike development aid which is irregular and unstable, inward remittances (henceforth remittances) are continual and sent in relatively small amounts by individuals from mainly developed countries to developing countries to finance consumption, micro-scale investments, education and health care among other expenditures of relatives. It must be noted that remittance transfer is not a new phenomenon and is closely associated with migrants ties back home.[1]

Moreover, where remittances are invested, the effects are magnified as a result of the positive long-term impacts of physical and human capital investments. Additionally, remittances are an important source of foreign exchange for the home country and a means to reduce poverty. In comparison to development aid, remittances are received directly by individuals and thus, losses and distortions caused by corrupt and inefficient governments are prevented. The long-run consequences of remittances depend on whether remittances are used for consumption or investments, because only the latter have an enduring growth enhancing impact. Earlier studies such as Griffin (1976) and Stark (1991) argue that remittances are mainly used to support investment in production, adoption of new technologies (Rapoport, 2002) and education (Perotti, 1993). All three possible uses are suitable to increase the growth of TFP in developing countries (Rao and Hassan, 2011).

In this article, we explore the impact of remittances on the growth of TFP and examine possible threshold levels necessary to ensure TFP growth. We use the framework developed by Rao and Hassan (2011) and Hassan, Chowdhury and Bhuyan (2016)

CONTACT Syed Jawad Hussain Shahzad j.syed@montpellier-bs.com

[1]The benefits and effects of remittances on economic growth among other aspects are well discussed in the literature (see Hassan, Chowdhury, and Bhuyan 2016 and the reference therein).

and take Bangladesh and India as the sample countries. The choice of using Bangladesh and India as case studies is because they are one of the two largest recipients of remittances (in absolute terms) and these two countries have been examined in different fronts on remittances-growth nexus which enables us to compare with earlier studies. Moreover, we are interested to explore whether both countries receiving large amounts of remittances tend to differ in terms of the relationship between remittances and TFP growth, given that in relative to GDP terms, Bangladesh has a higher ratio (6.1%) than India (2.8%) (World Bank 2017). The analysis is important because, arguably, the differences in terms of the impact on TFP can allude the effective uses of remittances and the consumption–investment mix viz. remittances.

For Bangladesh, Hassan, Chowdhury and Bhuyan (2016) examine the threshold level of remittances in relation to TFP growth, where the latter is computed using the method of Rao and Hassan (2011). Hassan, Chowdhury and Bhuyan (2016) find that remittances (% GDP) in the range from 0% to 14% lower TFP growth.[2] Only if the remittances to GDP threshold of 14% will be exceeded, a positive net effect on TFP can be expected. Unfortunately, this threshold is questionable, because the value lies outside of the sample range (see Wagner 2008).[3]

While we apply the similar method as proposed by Hassan, Chowdhury and Bhuyan (2016), we note that our results differ in the following ways: (1) although we establish a U-shaped relationship between TFP growth and remittances, the computed threshold value of 5.3% is within the remittances (% GDP) sample range; (2) applying the same method to another country, India, we establish an inverted U-shape relationship and hence a maximum threshold; (3) we examine the structural breaks using well-specified econometric methodologies that lead to model parameter and variance-structure stability instead of relying on an ad-hoc process; (4) our results also differ in terms of diagnostic properties of the model; (5) we note that the error-correction term in absolute term is showing non-convergence in Hassan, Chowdhury and Bhuyan (2016) which we correct in our analysis before estimating the short-run and long-run coefficients; and (6) we find the evidence of bidirectional pairwise causality on the stationary remittances and TFP growth unlike Hassan, Chowdhury and Bhuyan (2016), who find no evidence of causality for Bangladesh.[4]

Additionally, we contribute to the literature on remittances–TFP growth by highlighting that remittances will have greater impact on TFP growth and economic activities if it is sufficiently high in relative terms and the consumption–investment mix of remittances is more favoured towards investments. The rest of the article is set out as follows. In Section II, we present a brief review of the literature, in Section III, we present the methodology and data used. In Section IV, we present the results and finally, in Section V, we conclude with some policy implications.

II. Literature review

The studies focusing on the effect of inward remittances on economic growth are increasing. Country-specific and panel empirical studies examining the remittance-led growth hypothesis (RLGH) follow a standard econometric procedure examining cointegration followed by long- and short-run estimates and a causality test to identify the nature and direction of the causal relationships.

Remittance-led growth hypothesis

A plethora of studies have used inward remittances to model its growth effects against real output (or real output growth). A summary of the studies is presented in Table 1. The growth effects of remittances will be only persistent and permanent, if remittances influence productivity growth rather than only influencing the level of per-worker real output. Easterly, Levine and Roodman (2004) point out that in some empirical growth studies, equations are specified without any clear link to the underlying economic theory. By following Hassan, Chowdhury and Bhuyan (2016), we specify an extended Solow (1957) growth accounting framework with insights from Senhadji (2000) who states that permanent productivity growth effects of remittances imply a

[2]Using their results, we note that this comes to on average, 8.6% and not 14% as emphasized in the study.
[3]It is somewhat strange to get a threshold or turning point value which is outside the domain.
[4]Kumar and Stauvermann (2014a) also find bidirectional causality between remittances and economic growth for Bangladesh.

Table 1. Summary of the previous work on remittance-led growth hypothesis.

Studies	Method	Sample	Country	Results: Has cointegration? and effect (+, –, ǁ)	Results: Causality
Pradhan, Upadhyay and Upadhyaya (2008)	FE, RE	1980–2004	39 Developing countries	Yes and REM (+)	–
Barajas et al. (2009)	FE-IV	1970–2004	84 Countries	No	–
Kumar (2010)	ARDL and causality	1979–2007	Fiji	Yes and REM (+)	–
Bhaskara Rao and Takirua (2010)	GETS	1970–2005	Kiribari	REM (–)	NE
Jayaraman, Choong and Kumar (2011a)	ARDL and ECM causality	1979–2008	Fiji	Yes and REM (+)	REM → GDP
Jayaraman, Choong and Kumar (2011b)	ARDL and ECM causality	1981–2008	Tonga and Samoa	Yes and REM (+)	Tonga: REM → GDP Samoa: REM ↔ GDP
Kumar (2011a)	ARDL	1980–2009	Pakistan	Yes and REM (+)	NE
Kumar (2011b)	ARDL and T-Y causality	1975–2010	Nepal	Yes and REM (+)	–
Kumar, Naidu and Kumar (2011)	ARDL	1983–2009	Vanuatu	Yes and REM (+)	NE
Jayaraman, Choong and Kumar (2012)	ARDL and ECM causality	1970–2009	India	Yes and REM (+)	REM → GDP
Rao and Hassan (2012)	SGMM	1960–2007	40 Countries	Yes and REM (+)	–
Siddique, Selvanathan and Selvanathan (2012)	VAR	1976–2006	Bangladesh, India, Sri Lanka	NE	Bangladesh: REM → GDP India – N Sri Lanka: REM ↔ GDP
TehseenJawaid and Raza (2012)	Johansen–Juselius Granger causality	1980–2009	China and South Korea	Yes and REM (+)	REM → GDP
Agbola (2013)	FMOLS	1965–2008	Ghana	Yes and REM (+)	–
Kumar (2013a)	ARDL and T-Y Causality	1970–2010	Sub-Saharan African countries	Yes and REM (ǁ)	NE
Kumar (2013b)	Cointegration and ARDL panel	Years vary between 1965–2010	Mexico cluster, Brazil cluster and combined LAC	Yes and Brazil cluster REM (–); Mexico cluster REM (+); LAC REM (–)	NE
Kumar (2013b)	ARDL Bounds, T-Y causality	1982–2010	Guyana	Yes and REM (+)	–
Ramirez (2013)	Panel FMOLS	1990–2007	LAC	Yes and REM (+)	NE
Datta and Sarkar (2014)	ARDL	1975–2011	Bangladesh	Yes and REM (+)	NE
Kumar (2014)	ARDL and T-Y causality	1978–2010	Kenya	Yes and REM (+)	REM → GDP
Kumar and Vu (2014)	ARDL and T-Y causality	1980–2012	Vietnam	Yes and REM (+)	REM ↔ GDP
Kumar and Stauvermann (2014a)	ARDL and T-Y causality	1979–2012	Bangladesh	Yes and REM (+)	REM ↔ GDP
Kumar and Stauvermann (2014b)	ARDL and T-Y causality	1980–2012	Lithuania	Yes and REM (+)	REM → GDP
Rahman (2014)	VAR	1976–2011	Bangladesh	NE	REM ↔ GDP
Ramirez (2014)	Johansen–Juselius	1970 – 2010	Mexico	Yes and REM (+)	NE
Donou-Adonsou and Lim (2016)	ECM – Westerlund (2009)	1975–2011	Waemu countries	–	–
Chowdhury (2016)	Dynamic Panel OLS	1979–2011	33 Countries	Yes and REM (+)	NE
Hassan, Chowdhury and Bhuyan (2016)	DOLS, FMOLS	1976–2012	Bangladesh	Yes and REM (+)	NE
Hassan and Shakur (2017)	DOLS, FMOLS	1976–2012	Bangladesh	Yes and REM (+)	NE

(+), (–), (ǁ) Indicate 'positive', 'negative' and 'not statistically significant' association with GDP, respectively; →, ↔, – indicate 'unidirectional causality', 'bidirectional' and 'neutral' causality, respectively; *NE* implies 'not examined'.
LAC: Latin American and Caribbean.

'U'-shaped relationship. Studies examining the effects of remittances on total factor productivity (TFP) in this way are limited, especially in the remittances related literature.

Although the survey of the studies in Table 1 is restricted in presenting the effects of inward remittances to real output, using either the exogenous models or some ad hoc specifications (Easterly, Levine, and Roodman 2004), it is argued that remittances support broader development goals for less developed countries and is welfare enhancing.

Remittances influence economic activities through multiple and intermediate channels (Rao and Hassan 2012). Remittances can enhance welfare by increasing consumption, investments, education, human development, mitigating credit constraints and alleviating poverty (Frank and Hummer 2002; Cox-Edwards and Ureta 2003; Adams and Page 2005; Ratha 2007; Buch and Kuckulenz 2010; Rao and Hassan 2012; Kumar 2014; Zhunio, Vishwasrao, and Chiang 2012; Musumba, Mjelde, and Adusumilli 2015). Also, remittances support technological diffusion which entails positive externalities necessary for the growth in developing countries (Le and Bodman 2011) and improve the quality of local democratic institutions (Deonanan and Williams 2017).

It must be noted that remittances generate savings and capital thereby remove investment constraints and allow financial market integration and development (Ahamada and Coulibaly 2011; Chiodi, Jaimovich, and Montes-Rojas 2012), in addition to diversification of income sources in rural areas (Lazarte Alcala et al. 2014) and debt servicing (Rahman, 2013). Studies have shown that remittances reduce the level, depth and severity of poverty (Adams and Page 2005; Gupta, Pattillo, and Wagh 2009; Hatemi-J and Uddin 2014). Interestingly, the countercyclical behaviour of remittances enable recipients to smooth out their consumption (Mishra 2005; Sayan 2006; Kurosaki 2006; Chami et al. 2008).[5] However, the volatility of remittances, as highlighted by Nyamongo et al. (2012), has the potential to induce a welfare retarding effect. In any case, Ebeke and Combes (2013) argue that remittances tend to dampen the effects of natural disasters and output growth volatility in developing countries.

Some adverse effects can arise due to remittances, thus leading to overall mixed results and to conflicting impacts on economic development. For instance, Chami et al. (2008) relate the moral hazard problem with altruistic motives of sending remittances and find a negative effect on growth. In addition, it is possible that remittances create a Dutch disease effect causing a downward pressure on the real exchange rate and thus an appreciation of domestic currency (Acosta, Fajnzylber, and Lopez 2007; Chami et al. 2008; Hassan and Holmes 2013). Similarly, remittances strongly respond negatively to exchange rate uncertainty (Higgins, Hysenbegasi, and Pozo 2004), and where the remittance mix in terms of consumption and investment is biased towards former (Stahl and Arnold 1986), there is little positive contribution to growth and reduction in labour force participation (Chami et al. 2008). On the other hand, a worldwide reduction in remittances due to global financial crises (Ruiz and Vargas-Silva 2010), and under-reporting remittances or remittances leading to disincentive to work (Shonkwiler, Grigorian and Melkonyan, 2011), can adversely impact productivity and growth. Hobbs and Jameson (2012) note that positive impacts of remittances on poverty reduction are dependent mainly on where people migrate to and the income level of the home country. A perverse combination of the two can result in increasing income inequality. It has also been shown that remittances have the effect of reducing the fertility rate of women (Anwar and Mughal 2016), although this possible impact is not widely studied.

Remittances in Bangladesh and India

Hasan (2006) shows that remittances have a positive effect on private consumption and thus recommend strengthening microfinance institutions for useful mobilization of remittances. Chowdhury (2011) notes a persistent lack of effective use of remittances as financial resources despite the numerous policy initiatives of the Bangladesh government to increase remittance

[5]This may lend further support for the observed long-run constancy of the average propensity to consume with aggregate time series data.

flows. Similar to Hasan (2006), Barai (2012) highlights that remittances are primarily used for consumption to alleviate poverty.

With respect to empirical studies, scholars tend to disagree on the sign and magnitude of effects of remittances. For example, Ahmed (2010) points out that remittances do not play a significant role in capital accumulation whereas Siddique, Selvanathan and Selvanathan (2012) find a growth supportive effect on output for Bangladesh, and no effect for India. On the other hand, Jayaraman, Choong and Kumar (2012) find evidence of the growth hypothesis for India, Datta and Sarkar (2014) find absence of causality for Bangladesh and Kumar and Stauvermann (2014a) and Rahman (2014) find evidence of bidirectional causality between remittance and income.

Hassan, Chowdhury and Bhuyan (2016) examine the non-linear (quadratic) effects of remittances on the TFP of Bangladesh. He applies a growth accounting framework and estimates in two steps, a neoclassical production function, extracts the growth of TFP and models the TFP as a function of remittances and other variables. The theoretical procedure is well documented in Senhadji (2000). However, we note that the study of Hassan, Chowdhury and Bhuyan (2016) has the following limitations. First, since the study adopts a two-step Engle and Granger (1987) procedure, specification errors in the cointegrating equation get translated to the error-correction model. This is evident in the study where the coefficient of the one period lagged cointegrating residual is showing non-convergence in the error-correction model specifications (Hassan, Chowdhury, and Bhuyan 2016: 12). Second, although the authors apply residual-based cointegration tests such as the Engle–Granger and Phillips–Ouliaris tests, it has to be noted that these tests do not directly test for the stability and specification of the cointegrating equation. These can be tested using test such as the Hansen (1990) instability test, which is not applied in the study. Third, the identification of structural breaks does not use any systematic procedure such as break tests but is done in an ad-hoc manner. Arguably, these limitations can possibly bias the results.

Our study differs from Rao and Hassan (2011) and Hassan, Chowdhury and Bhuyan (2016) in a few respects. Although we examine the non-linear effects of remittances on TFP growth, we apply multiple econometric and diagnostic tests to ensure parameter stability and robustness of results. Also, we include India as another country to examine the relationship between remittances and TFP growth with the possibility of detecting an opposite shape, that is an inverted ‘U’-shaped relationship.

III. Model and method

Modelling strategy

Using insights from the growth model and growth accounting framework (Solow, 1956; Solow 1957; Senhadji 2000), a Cobb–Douglas production function with constant returns to scale is specified as

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{1}$$

where A is the stock of technology, K and L are capital and labour stock, respectively. The parameter α represents the capital income share. Dividing (1) by L, we get

$$y_t = A_t k_t^{\alpha},\ 0 < \alpha < 1 \tag{2}$$

Taking the log of (2) gives

$$\ln y_t = \ln A_t + \alpha \ln k_t \tag{3}$$

Differentiation of (3) with respect to t leads to the equation of growth rate of output as

$$\Delta \ln y_t = \Delta \ln A_t + \alpha \Delta \ln k_t \tag{4}$$

Rearranging (4) we get for the growth rate of TFP as[6]

$$\Delta \ln A_t = \Delta TFP = \Delta \ln y_t - \alpha \Delta \ln k_t \tag{5}$$

To derive the growth rate of TFP, first we estimate the long-run relationship in (4) and derive the growth of TFP using (5). In a second step, we estimate the relationship between remittances and the growth rate of TFP. To estimate the non-linear effects of remittances, the following long-run equation is specified:

[6]Note that Hassan, Chowdhury and Bhuyan (2016) describe this term mainly as TFP and not TFP growth when in fact the latter is the correct meaning and hence use the term interchangeably.

$$TFP_t = \theta + \beta_0 T + \beta_1 rem_t + \beta_2 rem_t^2 + \beta_3 fdi_t + \beta_4 pop_t + \beta_5 gov_t + \beta_6 aid_t + \beta_7 trade_t + u_t \quad (6)$$

where θ is the constant term, β_0 is the coefficient of the time trend, β_1 and β_2 are the respective coefficients of remittances as per cent of GDP (rem) and rem^2; β_3, β_4, β_5 and β_6 are the coefficient of foreign direct investment (fdi), population growth rate (pop), government expenditure on consumption goods (gov), net official development assistance (ODA) (aid) and trade openness ($trade$); and u_t is the error term.

For non-linear in variables association, we consider β_1 and β_2, where we restrict our analysis to three possibilities. First, if $\beta_1 > 0$ and $\beta_2 < 0$, the relationship between remittances and TFP is inverse quadratic. Hence, it would have a maximum amount of remittances, which implies that any excess of remittances from this level will be growth retarding. Second, if $\beta_1 < 0$ and $\beta_2 > 0$, then the relationship is quadratic and has a minimum level of remittances which implies that remittances is growth enhancing for amounts higher than the minimum level. However, if $\beta_2 = 0$ (that is statistically not significant), then we conclude a linear relationship, which can be with growth enhancing or retarding, depending on the sign of β_1.

Method of analysis

Unit root and structural breaks

To examine the order of integration of each series, we apply the conventional unit root test of augmented Dickey and Fuller (1979) (ADF), the Phillips and Perron (1988) (PP) and the Kwiatkowski et al. (1992) (KPSS). Moreover, structural breaks in the series can influence the cointegration, magnitude and the causality effects. Hence, to identify structural breaks in the series, we apply the innovational (IO) and additive outlier (AO) breakpoint tests. If a series is deemed non-stationary in its first difference, then the identified break point is to be included in the cointegration analysis.

Cointegration, long- and short run analysis

Next, four cointegration tests are applied to examine the long-run relationship: (1) the Engle and Granger (1987) (E–G), (2) the Phillips and Ouliaris (1990) (P–O), (3) the Hansen (1992) and (4) the Park (1992) (H–P) test. Both the E–G and P–O are residual-based (R–B) cointegration tests, and H–P is a single test for cointegration with a long-run parameter instability test, and spurious time trends in the cointegrating error terms.

According to the R–B tests, if two series (x_t, y_t) are non-stationary in levels but stationary after first difference $(I(1))$, then cointegration implies that the disequilibrium errors between them should be $I(0)$. Since the parameters of the cointegrating equation are unknown, the disequilibrium errors are also unknown. Therefore, the initial step to test for cointegration involves estimating the hypothesized equilibrium relationship using OLS and then testing the disequilibrium errors for stationarity. Because OLS residuals have a zero mean and do not have deterministic trends, they are excluded from the test equation. Specifically, the errors of Equations (4) and (6) are assumed to follow:

$$\Delta u_t = \vartheta_1 u_{t-1} + e_t \quad (7)$$

where the residuals of (7) are assumed to be normally, identically and independently distributed and the lagged differenced terms are included up to the lag which eliminates auto-correlated residuals so that $cov(e_{t-i}, e_{t-j}) = 0$. The null hypothesis of no cointegration $\{H_0 : \vartheta_1 = 0\}$ is tested against the alternative of the presence of cointegration $\{H_A : \vartheta_1 < 0\}$. Rejection of the null hypothesis implies stationarity of the residuals u_t, which implies cointegration. Unlike the E–G test, in the P–O test, the cointegration tests are asymptotic distribution and depend on the number of deterministic trend terms and the number of variables with which co-integration is being tested. Moreover, the test equation is a non-ADF equation without the lagged differenced residuals in (7) and uses non-parametric techniques to account for serial correlation in the long-run residuals.

Next, the H–P test examines the null hypothesis of cointegration against the alternative of no cointegration. Under the alternative hypothesis of no cointegration, it is plausible to encounter evidence of long-run parameter instability. In contrast to residual-based cointegration tests, the H–P test does not rely on estimates from the cointegrating equation and uses the L_C statistic which is a consequence of the Lagrange multipliers. The P-test (Park-added variable or PAV) has the null hypothesis of the presence of cointegration and is used to test for the significance of spurious time trends in cointegrating equations. Under the null hypothesis, the spurious trend coefficients are insignificant, implying that the residuals are stationary. Under the alternative hypothesis, the spurious trend terms will mimic the remaining stochastic trends present in the residual.

The long-run relationship is estimated using the Saikkonen (1992) and Stock and Watson (1993) Dynamic OLS (DOLS) procedure. To remove long-run serial correlation within the error term, the DOLS method constructs an asymptotically efficient estimator by augmenting the cointegrating equation with leads and lags of the differenced explanatory variables. The resulting error term is orthogonal to the entire history of the stochastic regressor innovations. The general specification is

$$Z_t = X_t'\beta + D_t'\gamma + \sum_{j=-q}^{r} \Delta X_t'\delta + u_t \quad (8)$$

where Z_t is a T-dimensional vector of the dependent variable observations, X is a T times K matrix of independent variables, β is a K-vector of coefficients, D_t is a T times K matrix of a deterministic trend regressor, T is a number of observations and K is the number of the right hand side regressor. The addition of q lags and r leads absorbs the long-run correlation between the disturbances and hence provides robust long-run coefficients.

Subsequently, if the time series are cointegrated, then the short-term disequilibrium relationship between the growth of TFP and remittances (with other independent variables) can be expressed in the error-correction form as

$$\begin{aligned}\Delta TFP_t = {} & \alpha + \beta_0 \Delta T + \sum_{i=1}^{p} \beta_1 \Delta TFB_{t=i} \sum\nolimits_{i=0}^{q1} \beta_{2i} \Delta rem_{t-i} \\ & + \sum\nolimits_{i=0}^{q2} \beta_{3i} \Delta rem^2_{t-i} + \sum\nolimits_{i=0}^{q3} \beta_{4i} \Delta fdi_{t-i} \\ & + \sum\nolimits_{i=0}^{q4} \beta_{5i} \Delta pop_{t-i} + \sum\nolimits_{i=0}^{q5} \beta_{6i} \Delta gov_{t-i} \\ & + \sum\nolimits_{i=0}^{q6} \beta_{7i} \Delta aid_{t-i} + \sum\nolimits_{i=0}^{q7} \beta_{8i} \Delta trade_{t-i} \\ & + \lambda ECT_{t-1} + u_t\end{aligned} \quad (9)$$

where the ECT is the error-correction term specified in Equation (6) ($ECT_t = u_t$) and $-1 < \lambda < 0$ implies convergence to the long-run equilibrium.

Causality tests

The pairwise Granger (1969) causality test assumes that the information relevant for the prediction of the respective variables is contained solely in the time series data of these variables. Importantly, the method requires the underlying variables to be stationary.[7] To examine the causality between growth of TFP and remittances, the following equations are specified:

$$\Delta TFP_t = \sum_{i=1}^{n} \alpha_i \Delta REM_{t-i} + \sum_{j=1}^{n} \beta_j \Delta TFP_{t-j} + u1_t \quad (10)$$

$$\Delta REM_t = \sum_{i=1}^{n} \lambda_i \Delta REM_{t-i} + \sum_{j=1}^{n} \theta_j \Delta TFP_{t-j} + u2_t \quad (11)$$

where it is assumed that the error terms $u1_t$ and $u2_t$ are uncorrelated. A unidirectional causality from remittances to TFP $\{\Delta REM \rightarrow \Delta TFP\}$ is noted if $\alpha_i \forall i \neq 0$ and a reverse causality $\{\Delta TFP \rightarrow \Delta REM\}$ exists if $\theta_j \forall j \neq 0$. Bilateral or feedback causality between remittances and TFP exists if $\alpha_i \forall i \neq 0$ and $\theta_j \forall j \neq 0$. Both variables are said to evolve independently if these coefficients are found insignificant in either Equations (10) or (11).

IV. Results and discussion

We present the basic statistics and correlation matrices for Bangladesh and India (Table 2). In case of Bangladesh, we note that the growth rate of TFP is negatively correlated with lny and lnk (lny, $TFP = -0.3857$; lnk, $TFP = -0.3275$) and positively correlated with the population growth (TFP, $pop = 0.4058$). Similar observations are made for India – the growth in TFP is negatively correlated with lny and lnk (lny, $TFP = -0.0773$; lnk, $TFP = -0.1049$) and positively with population growth (TFP, $pop = 0.0994$).

Unit root results with and without breaks

The results of the unit root tests based on the three tests (ADF, PP and KPSS) in Table 3 indicate in general that all series are stationary in their first

[7]If a variable x_t is said to granger cause y_t, then a change in x_t should precede a change in y_t. It is unclear in Hassan, Chowdhury and Bhuyan (2016) whether this test is conducted in levels or first differences.

Table 2. Descriptive statistics and correlation matrix.

Variables →	$\ln y_t$	$\ln k_t$	TFP_t	REM_t	FDI_t	AID_t	GOV_t	POP_t	$TRADE_t$
Panel 1A: Bangladesh descriptive statistics									
Mean	10.49907	10.81917	0.005147	4.745931	0.369372	0.037899	4.792364	2.017661	27.90141
Median	10.43026	10.66235	0.002495	3.310640	0.071280	0.025115	4.928410	2.126891	26.59187
Maximum	11.07561	11.66086	0.064125	10.58794	1.449748	0.073776	6.141041	2.769204	48.11092
Minimum	10.15670	10.44276	−0.016456	1.867162	−0.029894	0.011583	4.030633	1.109062	16.68780
SD	0.274042	0.393256	0.014649	2.795914	0.460069	0.021684	0.487893	0.576697	9.608270
Skewness	0.644549	0.769849	2.008465	0.970942	0.940966	0.330760	0.224558	−0.308850	0.706340
Kurtosis	2.187493	2.217167	8.809668	2.389081	2.464593	1.437482	2.930267	1.709340	2.353768
Jarque–Bera	3.289414	4.226625	70.67462	5.870854	5.423461	4.078686	0.292638	2.900421	3.418811
Probability	0.193069	0.120837	0.000000	0.053108	0.066422	0.130114	0.863882	0.234521	0.180973
Panel 1B: Bangladesh correlation matrix									
$\ln y_t$	1.000000	–	–	–	–	–	–	–	–
$\ln k_t$	0.989894	1.000000	–	–	–	–	–	–	–
TFP_t	−0.385655	−0.327512	1.000000	–	–	–	–	–	–
REM_t	0.951454	0.960101	−0.282313	1.000000	–	–	–	–	–
FDI_t	0.923717	0.936305	−0.244767	0.925070	1.000000	–	–	–	–
AID_t	−0.855533	−0.825113	0.484666	−0.724255	−0.730784	1.000000	–	–	–
GOV_t	0.573319	0.615023	−0.276826	0.513243	0.573749	−0.621528	1.000000	–	–
POP_t	−0.973946	−0.955966	0.405771	−0.930005	−0.901344	0.884932	−0.624205	1.000000	–
$TRADE_t$	0.961094	0.964353	−0.314943	0.925285	0.902163	−0.831908	0.656202	−0.936940	1.000000
Panel 2A: India descriptive statistics									
Mean	10.94192	11.34394	0.006539	1.986653	0.696948	0.005559	11.23153	1.893067	26.02890
Median	10.84974	11.20641	0.008656	1.728088	0.378380	0.004734	11.21893	1.930881	20.64182
Maximum	11.84831	12.47901	0.062423	4.082787	3.545983	0.016692	12.79541	2.319938	55.54501
Minimum	10.36360	10.66469	−0.087695	0.429028	−0.029171	0.000910	9.678994	1.226730	12.00868
SD	0.459485	0.554641	0.024506	1.102450	0.859518	0.003912	0.820448	0.357815	14.73899
Skewness	0.478261	0.615475	−1.223832	0.307780	1.410379	0.989418	0.049005	−0.368065	0.832999
Kurtosis	1.998104	2.168540	7.200271	1.646991	4.574362	3.816891	2.119866	1.836545	2.179107
Jarque–Bera	3.197880	3.677608	39.38889	3.682581	17.39216	7.447540	1.307071	3.159191	5.749026
Probability	0.202111	0.159008	0.000000	0.158613	0.000167	0.024143	0.520203	0.206058	0.056444
Panel 2B: India correlation matrix									
$\ln y_t$	1.000000	–	–	–	–	–	–	–	–
$\ln k_t$	0.997715	1.000000	–	–	–	–	–	–	–
TFP_t	−0.077225	−0.104933	1.000000	–	–	–	–	–	–
REM_t	0.934704	0.934528	−0.143140	1.000000	–	–	–	–	–
FDI_t	0.851909	0.857124	−0.194236	0.872867	1.000000	–	–	–	–
AID_t	−0.844953	−0.826035	0.102081	−0.808131	−0.682236	1.000000	–	–	–
GOV_t	0.227794	0.203998	−0.091851	0.166443	0.041788	−0.391300	1.000000	–	–
POP_t	−0.995285	−0.991998	0.099355	−0.935620	−0.843959	0.835348	−0.225962	1.000000	–
$TRADE_t$	0.964526	0.974075	−0.134414	0.915561	0.889529	−0.752222	0.014405	−0.957346	1.000000

Source: Authors' estimation in Eviews 9.

differences. Further, from Table 4, it is noted that the identified breaks from the IO and AO approaches appear in sequential clusters and sparsely over the sample range for both panels. The structural break parameters are identified based on the conditions that (1) the break should lead to short- and long-run parameter stability; (2) the inclusion of the break should not result in a negative adjusted –*R*-squared value; (3) the long-run break augmented residual should lead to suitable coefficients of the error-correction term; (4) the break augmented short- and long-run models should satisfy the conditions of homoscedasticity, no autocorrelation, normality of residuals and no functional form bias;[8] and (5) the error-correction model using the break augmented variable should satisfy the conditions of variance stability, the latter is examined using the cumulative sum of residual (CUSUM) and CUSUMQ (cumulative sum of residuals square) plot. Not all identified breaks (Table 4) satisfy these restrictions; thus, the dates are re-examined and manually adjusted to satisfy these conditions. Hence, the finalized break periods are from 2001 to 2012 for Bangladesh and 1989 to 1995 for India.

Cointegration tests

Next, we examine the cointegration relationship. Table 5 presents the results of three cointegration tests: Residual based (I), Hansen Parameter Instability (II) and PAV (III) test, respectively. The general conclusion is that there is a long-run association (cointegration) among the variables for both countries (Bangladesh and India).

TFP and remittances

TFP is estimated using the method explained earlier. The long-run capital share is 0.58 and 0.69 for Bangladesh and India, respectively (Table 6). The value of the capital share exceeds the stylized value of one third. However, this is to be expected for developing countries because their marginal productivity of capital is higher with low capital-to-labour ratios (Hassan, Chowdhury, and Bhuyan 2016) among other reasons (Kumar and Stauvermann 2014a,b and the reference therein). The respective shares are used to compute the growth rate of TFP for the two countries. The adjusted *R*-square for

Table 3. Unit root test.

	Augmented-DF (1979)		PP (1988)		KPSS (1992)	
Variables	Level	1st difference	Level	1st difference	Level	1st difference
Panel 1: Bangladesh						
ln y_t	7.0079[0]	0.1082[6]	8.0360[2]	−3.3339[4]^{B}	0.6740[5]^{B}	0.6636[5]^{A}
ln k_t	−0.6815[6]	−4.8053[0]^{A}	3.6401[4]	−4.5088[3]^{A}	0.6410[5]^{B}	0.6807[5]^{B}
TFP_t	−3.8160[0]^{A}	−12.9384[0]^{A}	−3.8265[4]^{A}	−12.6283[1]^{A}	0.4735[4]^{C}	0.0417[1]^{A}
REM_t	−0.8703[3]	−2.0799[2]	−0.6322[3]	−4.8754[2]^{A}	0.5812[5]	0.5812[5]^{B}
REM_t^2	−1.3121[3]	−1.7461[2]	−0.5836[3]	−5.1388[3]^{A}	0.5381[5]^{B}	0.1399[3]^{A}
FDI_t	0.7478[2]	−8.1454[0]^{A}	0.0777[2]	−9.6233[9]^{A}	0.6189[5]^{C}	0.3579[7]^{B}
POP_t	−1.2103[8]	−1.7150[7]	−0.4218[4]	−2.5253[2]	0.6610[5]	0.0959[4]^{A}
GOV_t	−3.004[0]^{B}	−6.8906[0]^{A}	−3.0808[3]^{A}	−6.8321[1]^{A}	0.4903[4]^{C}	0.3388[1]^{A}
AID_t	−1.2641[1]	−8.9143[0]^{A}	−1.4254[5]	−9.3326[3]^{A}	0.6085[5]^{B}	0.2823[16]^{A}
$TRADE_t$	0.5366[0]	−6.2011[0]^{A}	1.3709[4]	−6.2296[2]^{A}	0.6951[4]^{B}	0.3745[2]^{B}
Panel 2: India						
ln y_t	3.0069[0]	−6.0296[0]^{A}	3.7463[2]	−6.1216[4]^{A}	0.7596[5]^{C}	0.6292[4]^{C}
ln k_t	0.5944[1]	−1.6152[0]	6.7127[3]	−1.6032[2]	0.7514[5]^{C}	0.6717[5]^{C}
TFP_t	−6.2279[3]^{A}	−7.5567[6]^{A}	−10.9260[8]^{A}	−28.6647[10]^{A}	0.1051[4]^{A}	0.0448[3]^{A}
REM_t	−1.0232[0]	−7.4503[0]^{A}	−0.9383[1]	−7.9515[4]^{A}	0.7222[5]^{B}	0.0944[4]^{A}
REM_t^2	−1.0797[0]	−6.4910[1]^{A}	−0.7665[7]	−13.1591[37]^{A}	0.7062[5]^{B}	0.5000[38]^{B}
FDI_t	−1.4636[0]	−7.3094[0]^{A}	−1.4636[0]	−7.3307[3]^{A}	0.6315[5]^{B}	0.0584[3]^{A}
POP_t	1.5013[8]	−2.0039[7]	2.6454[4]	−2.1901[2]	0.7583[5]^{C}	0.4876[5]^{B}
GOV_t	−2.9857[1]^{B}	−4.6043[0]^{A}	−2.6643[0]^{C}	−4.4353[5]^{A}	0.2492[4]^{A}	0.1644[1]^{A}
AID_t	−1.4246[7]	−7.1605[3]^{A}	−1.6730[13]	−14.6723[23]^{A}	0.7553[5]^{C}	0.3632[28]^{B}
$TRADE_t$	2.0778[1]	−6.6508[0]^{A}	1.8177[1]	−6.5778[3]^{A}	0.6039[5]^{B}	0.5147[3]^{B}

Critical values of the ADF and PP tests are based on MacKinnon (1996) while the KPSS is based on Kwiatkowski et al. (1992). The optimal lag and bandwidth used are based on the Schwarz Information Criterion (SC). The null hypothesis for the ADF and the PP unit root test is of the presence of a unit root while for the KPSS it is that a series is stationary. A, B and C denotes stationarity at the 1%, 5% and 10% levels, respectively; and '–' indicates not applicable. Source: Authors' estimation in Eviews 9.

[8]If autocorrelation is identified, the heteroscedasticity and autocorrelation consistent SEs are applied with pre-whitened (1 lag) Bartlett kernel and Newey–West fixed bandwidth.

Table 4. Innovational and additive outlier break point tests results.

	Innovational outlier (IO)				Additive outlier (AO)			
	Level		1st difference		Level		1st difference	
Variables	IO stat	Break	IO stat	Break	AO stat	Break	AO stat	Break
Panel 1: Bangladesh								
TFP_t	−5.0854[0]^A	1994	−13.0903[0]^A	1994	−5.2649[0]^A	1994	−13.2874[0]^A	1994
REM_t	−3.4366[0]	2001	−5.7498[0]^A	2012	−3.0179[0]	2004	−5.2368[0]^A	2002
REM_t^2	−4.0705[3]	2005	−4.5364[4]^B	2004	−5.5820[7]^A	1999	−4.5180[8]^B	2002
FDI_t	−3.8224[0]	2002	−9.6771[0]^A	2008	−2.1699[0]	1996	−8.3178[0]^A	1995
POP_t	−3.1115[8]	2001	−6.5156[1]^A	1982	−1.8211[8]	2002	−6.1008[1]^A	2003
GOV_t	−4.9542[0]^A	1992	−8.0673[2]^A	1985	−8.9131[0]^A	1993	−8.4192[1]^A	1992
AID_t	−4.6492[0]^B	1994	−9.8474[0]^A	1987	−4.9107[0]^B	1994	−9.0218[0]^A	1999
$TRADE_t$	−2.0820[0]	2004	−7.4212[0]^A	2010	−6.5340[8]^A	2000	−6.7627[0]^A	1992
Panel 2: India								
TFP_t	−9.0118[0]^A	1999	−8.0812[3]^A	2008	−6.6903[0]^A	1991	−9.7571[0]^A	2003
REM_t	−3.1032[0]	1995	−8.0626[0]^A	2010	−3.2559[0]	1993	−7.8547[0]^A	1994
REM_t^2	−3.1859[0]	1999	−9.5253[1]^A	2008	−3.4598[9]	1997	−7.4187[0]^A	1990
FDI_t	−3.5749[0]	2005	−7.2418[0]^A	2003	−8.2029[9]^A	1996	−8.7492[9]^A	1995
POP_t	−2.5625[8]	1999	−3.4125[7]	1981	−2.1975[3]	1995	−6.4762[1]^A	1988
GOV_t	−3.8540[1]	1984	−5.2320[1]^A	1987	−2.8021[1]	1986	−5.4528[0]^A	1998
AID_t	−3.3065[4]	1994	−8.6894[0]^A	1993	−4.1914[0]	1996	−10.0923[1]^A	1990
$TRADE_t$	−1.1552[1]	2003	−8.0111[0]^A	2001	−4.2634[6]^C	1997	−7.5077[0]^A	1991

The break selection is based on the Dickey–Fuller *t* statistic and critical values are based on Vogelsang (1993). Lag length used is indicated in parenthesis and is automatically determined by Schwarz Criterion (SC). A, B and C indicate stationarity after controlling for structural breaks at the 1%, 5% and 10% levels, respectively. Trend and break specification assumes intercept only. Source: Authors' estimation using Eviews 9.

Table 5. Cointegration test results.

(I) R–B Tests 1 and 2				
	Test 1: Engle–Granger test		Test 2: Phillips–Ouliaris test	
Function	EG-Tau	EG-Z	PO-Tau	PO-Z
Panel I(a): Bangladesh				
$\ln y_t \| \ln k_t$	−4.1334^B [0.0128]	−10.1345 [0.2979]	−4.0418^B [0.0156]	−8.5312 [0.4101]
$TFP_t \| REM_t; REM_t^2; \ldots$	−5.7577 [0.1321]	22.1162 [1.0000]	−8.7378^A [0.0006]	−38.7603^B [0.0176]
Panel I(b): India				
$\ln y_t \| \ln k_t$	−4.9787^A [0.0039]	−33.7883^A [0.0033]	−4.9808^A [0.0038]	−32.5837^A [0.0048]
$TFP_t \| REM_t; REM_t^2; \ldots$	−6.0107^B [0.0415]	−76.1798^A [0.0000]	−7.3767^A [0.0028]	−35.5306^B [0.0499]
(II) H–P test (Test 3)				
Function	LC	Stochastic trend	Deterministic trend	Excluded trend
Panel II(a): Bangladesh				
$\ln y_t \| \ln k_t$	0.017833^A	1	0	0
$TFP_t \| REM_t; REM_t^2; \ldots$	0.294898^A	7	1	0
Panel II(b): India				
$\ln y_t \| \ln k_t$	0.032488^A	1	1	0
$TFP_t \| REM_t; REM_t^2; \ldots$	0.477603^A	7	0	0
(III) PAV test (Test 4)				
Function	Chi-square	Degrees of freedom	p Value	
Panel III(a): Bangladesh				
$\ln y_t \| \ln k_t$	1.975145^A	1	0.1599	
$TFP_t \| REM_t; REM_t^2; \ldots$	4.006447^C	1	0.0453	
Panel III(b): India				
$\ln y_t \| \ln k_t$	2.162655^A	2	0.3391	
$TFP_t \| REM_t; REM_t^2; \ldots$	10.31521	1	0.0013	

A, B and C indicate the presence of cointegration at the 1%, 5% and 10% levels, respectively. *p* Values are in square parenthesis and based on MacKinnon (1996) one-sided *p* values. Null hypothesis is the absence of cointegration for residual-based tests. Probability values for the Hansen cointegration test are based on Hansen (1992). Null hypothesis is that a series is cointegrated for both cointegration tests of panel 2 and 3. Added trends are linear and quadratic for Bangladesh and Linear trend in the case of India for Equation (6). Source: Authors' estimation in Eviews 9.

both models is 0.99 which indicates a relatively good fit of the data.

Using the TFP series, we proceed with the estimation of the long-run relationship using Equation (6). For Bangladesh (Table 7, Panel 1), we note that the long-run equilibrium relationship between remittances and TFP is U-shaped and the threshold level of remittance is 5.3% of GDP. This implies that a positive effect on the growth of TFP will be realized as long as the ratio of remittances to GDP exceeds

Table 6. Long-run estimation: $\ln y_t | \ln k_t$.

Arguments	Panel 1: Bangladesh Coefficient	SD	t-Stat	Panel 2: India Coefficient	SD	t-Stat
$\ln k_t$	0.583042[A]	0.027073	21.53573	0.698584[A]	0.026425	26.43610
Constant	4.148210[A]	0.283788	14.61728	2.811299[A]	0.272449	10.31863
Time Trend	–	–	–	0.005243[A]	0.000840	6.245178
Statistics	$R^2 = 0.995906$; $adj(R^2) = 0.995321$; $SSR = 0.0097$			$R^2 = 0.99786$; $adj(R^2) = 0.997627$; $SSR = 0.024523$		

A, B and C indicate statistical significance at the 1%, 5% and 10% levels, respectively. DOLS: Dynamic OLS (lead = lag = 1); SEs in square brackets, *t*-statistics in rounded parenthesis. Long-run covariance estimate assumes Bartlett Kernel and Newey west fixed bandwidth of 4. Source: Authors' estimation in Eviews 9.

Table 7. Long-run estimation: $TFP_t | REM_t; REM_t^2; \ldots$.

Arguments	Panel 1: Bangladesh Coefficient	SD	t-Stat	Panel 2: India Coefficient	SD	t-Stat
REM_t	−0.159745[B]	0.028500	−5.605150	0.319790[A]	0.044891	7.123755
REM_t^2	0.015022[C]	0.003531	4.254652	−0.087750[A]	0.011538	−7.605349
FDI_t	−0.023750	0.048920	−0.485491	0.163178[A]	0.016623	9.816526
POP_t	−0.245741[C]	0.071095	−3.456529	0.048951	0.114223	0.428558
GOV_t	−0.152757	0.065924	−2.317188	0.015628	0.011299	1.383167
AID_t	−0.108146[C]	0.035116	−3.079664	0.141185[A]	0.031248	4.518231
$TRADE_t$	−0.027658[C]	0.006984	−3.960174	−0.001981	0.002510	−0.789433
Constant	3.186686[C]	0.877313	3.632327	−0.581763	0.428333	−1.358204
Linear Trend	−0.014399[C]	0.004416	−3.260831	–	–	–
Break	0.052902[C]	0.012886	4.105519	0.029822[A]	0.006896	4.324282
Statistics	$R^2 = 0.941395$; $adj(R^2) = 0.0623$; $SSR = 0.0003$			$R^2 = 0.888398$; $adj(R^2) = 0.348990$; $SSR = 0.002188$		

A, B and C indicate statistical significance at the 1%, 5% and 10% levels, respectively. DOLS: Dynamic OLS (lead = lag = 1); Long-run covariance estimate assumes pre-whitened Bartlett Kernel with 1 lag, and Newey west fixed bandwidth of 4. Source: Authors' estimation in Eviews 9.

the threshold value of 5.3%. A possible drawback of our estimate is the low adjusted R-squared of only 0.06 but this is not a serious drawback given that $\bar{R}^2$ is an in-sample statistic and has no implications for out-of-sample forecasting.[9] Moreover, a low $\bar{R}^2$ is to be expected given that the dependent variable is a first differenced variable and hence is more difficult to predict. This may require a panel estimation setting similar to Senhadji (2000) who obtains a higher $\bar{R}^2$.[10]

Population growth has a negative association with productivity growth in the long run (−0.25) and short run (−0.87). The growth of population reduces marginal productivity in both time frames. FDI and government expenditure have insignificant impacts on productivity growth although both are negative in long and positive in short run. Both aid and trade have a negative association with productivity in the long run, at −0.11 and −0.03, respectively. The structural beak has a positive association with factor productivity and the time trend indicates that productivity has been on the decline at a rate of 1.4% per annum over the sample period, which makes remittances a crucial productivity enhancement device. Our results deviate from Hassan, Chowdhury and Bhuyan (2016) in three main ways. First, we have attained a plausible estimate of the error-correction term, estimated at −0.95; second, our results are supported by a number of diagnostic tests, and third, our dynamic results are different.

For India (Table 7, Panel 2), we observe an inverted U-shaped relationship with a maximum threshold level of remittances as a per cent of GDP at 1.8%. This implies that remittances–GDP ratio of 1.8% or lower will support improvement in TFP growth. FDI is positive and significant in the long run (0.16) and not significant in the short run. Moreover, in the short-run, we note that the one-period lagged effect of the growth of TFP is negative in the short run (−0.38), which is also the case for Bangladesh (−0.65). From the long-run results, only aid has a positive and significant association (0.14) with TFP growth. Lastly, the break period for India has a significant positive association with TFP. The error-correction term is also significant at the 10% level and is estimated at −0.63. Accordingly, 63% of disequilibrium errors of the previous period are corrected within the current period and convergence to

[9] We thank an anonymous reviewer for pointing this out.
[10] Although Hassan, Chowdhury and Bhuyan (2016) obtain a higher δ value of 0.59 using the DOLS estimate, this begs the same question of reliability as its second stage ECM produces unreliable and unstable results.

the mean productivity level should occur in around 1.7 years.

Some observations with reference to the long-run results are in order. We note that for Bangladesh, the average remittance (% GDP) is 4.4% which is below the threshold level and hence an indication that remittances are effectively utilized. On the other hand, in the case of India, we note that the average remittances (% GDP) are very close to 2% which is slightly above the 1.8% threshold, but nonetheless, fairly close. We further this analysis by examining the year on year fluctuations against the threshold level of remittances (% GDP). We observe that Bangladesh achieved its threshold level in 2004 and India in 1995. The U-shaped relationship further emphasizes that Bangladesh is a more remittance-dependent economy than India and that remittances have a direct positive effect on the growth processes of Bangladesh (Kumar and Stauvermann 2014a). In the case of India, the role of remittances in the growth process is declining, which is evident from 1995 onwards. On the other hand, India has maintained an average annual real GDP growth of 6.6% which further supports that the reliance on remittances for TFP growth is lesser, possibly because remittances are used more for consumption purposes, and the growth of TFP and output are mainly supported by sectors other than remittances. Subsequently, at best, the results support that remittances in India do not have a direct growth enhancing effect which contradicts some of the earlier findings (Jayaraman, Choong, and Kumar 2012).

Error-correction representation

The error-correction model is presented in Table 8. From the results, we note that the lagged error-correction term ($ECT = \lambda$) is within acceptable levels. Specifically, the lagged ECT provides the speed of adjustment to the long-run equilibrium based on the previous period shocks and therefore is $-1 < \lambda < 0$. For Bangladesh, we note that the lagged ECT is −0.95 $(ECT_{t-1} = -0.9484)$ which implies that roughly 95% of shocks from the previous period are corrected within the current year. For India, the lagged ECT is −0.64 $(\mathrm{ECT}_{t-1} = -0.6383)$.[11]

Model diagnostics and stability

The model diagnostics for both the short- and long-run models are presented in Table 9. In the case of the long run model, the Ljung-box Q statistic is applied to test for serial correlation. The constancy of cointegrating parameters is checked via the Hansen-instability test, and normality of long-run residuals is examined from the Anderson–Darling normality test. In the case of the short-run equation, the diagnostic tests applied include the Breush–Godfrey/Lagrange multiplier test of residual serial correlation, the Breush–Pagan–Godfrey test of residual heteroscedasticity, the

Table 8. Error-correction representation.

	Panel 1: Bangladesh			Panel 2: India		
Arguments	Coefficient	SD	t-Stat	Coefficient	SD	t-Stat
ΔTFP_{t-1}	−0.645259[A]	0.088554	−7.286645	−0.383300[A]	0.074333	−5.156532
ΔREM_t	−0.022957[A]	0.005297	−4.333956	−0.004255	0.042019	−0.101261
ΔREM_t^2	0.001065[B]	0.000475	2.242871	−0.001107	0.007267	−0.152374
ΔFDI_t	0.005803	0.003518	1.649494	−0.006797	0.021999	−0.308974
$\Delta POPG_t$	−0.086301[C]	0.041581	−2.075482	−0.134469	0.154788	−0.868729
ΔGOV_t	0.015381	0.014936	1.029772	−0.028641	0.021224	−1.349454
ΔAID_t	0.003804	0.002208	1.722851	−0.017304	0.026353	−0.656633
$\Delta TRADE_t$	0.001415[A]	0.000294	4.807573	−0.004061	0.003546	−1.144964
$\Delta TREND_t$	−0.004905[B]	0.001813	−2.704929	–	–	–
Break Dummy	0.009773[C]	0.005162	1.893401	−0.005809	0.009090	−0.639079
ECT_{t-1}	−0.948366[A]	0.277224	−3.420938	−0.638343[C]	0.335293	−1.903835
Statistics	R^2= 0.758439; $adj(R^2)$= 0.637659; σ_R=0.0086; SSR = 0.0014; $\bar{x}_y$ = −0.0020; $\hat{\sigma}_y$= 0.0142; LL = 110.2140; AIC = −6.4009; SBC = −5.892069; HQC = −6.235035, DW = 1.939086			R^2= 0.433347; $adj(R^2)$= 0.229351; σ_R=0.0319; SSR = 0.0255; $\bar{x}_y$ = −0.0012; $\hat{\sigma}_y$= 0.0364; LL = 76.74023; AIC = −3.81372; SBC = −3.3692; HQC = −3.6603, DW = 2.24167		

A, B and C indicate statistical significance at the 1%, 5% and 10% levels, respectively. Long-run covariance estimate assumes pre-whitened Bartlett Kernel with 1 lag, and Newey west fixed bandwidth of 4. Source: Authors' estimation in Eviews 9.

[11]The case that $|\lambda| > 1$ can imply a specification bias and can be corrected by using appropriate lagged differenced dependent and independent terms. Specification biases can also provide pathological results and may also imply instability of the ECM.

Table 9. Cointegrating model diagnostics.

Primary statistics		Complementary statistics	
Panel 1A: Bangladesh $\ln y_t \vert \ln k_t$			
$Q_{sc}: Q(5) = 38.753$	0.0000	$Q^2_{sc}: Q^2(5) = 33.671$	0.0000
$LC_{ps}: LC = 0.0178^A$	$p > 0.2$	NA	NA
$A^2_{RN}: A^2 = 0.1405^A$	0.9700	$adj(A^2_{RN}): A^2 = 0.1441^A$	0.9700
Panel 1B: Bangladesh $TFP_t \vert REM_t; REM^2_t; \ldots$			
$Q_{sc}: Q(5) = 20.270$	0.0000	$Q^2_{sc}: Q^2(5) = 15.519$	0.0080
$LC_{ps}: LC = 0.2949^A$	$p > 0.2$	NA	NA
$A^2_{RN}: A^2 = 1.3247$	0.0016	$adj(A^2_{RN}): A^2 = 1.3576$	0.0016
Panel 2A: India $\ln y_t \vert \ln k_t$			
$Q_{sc}: Q(5) = 9.9140^A$	0.1020	$Q^2_{sc}: Q^2(5) = 5.6754^A$	0.3390
$LC_{ps}: LC = 0.0325^A$	$p > 0.2$	NA	NA
$A^2_{RN}: A^2 = 0.4390^A$	0.2763	$adj(A^2_{RN}): A^2 = 0.4498^A$	0.2763
Panel 2B: India $TFP_t \vert REM_t; REM^2_t; \ldots$			
$Q_{sc}: Q(5) = 34.789$	0.0000	$Q^2_{sc}: Q^2(5) = 15.806$	0.0070
$LC_{ps}: LC = 0.0178^A$	$p > 0.2$	NA	NA
$A^2_{RN}: A^2 = 0.5630^A$	0.1339	$adj(A^2_{RN}): A^2 = 0.5770^A$	0.1339

A, B and C denote statistical significance at the 1%, 5% and 10% levels, Q_{sc} : Ljung-box *Q* statistic for serial correlation; LC_{ps} : Hansen cointegrating parameter stability LC stat; A^2_{RN} : Anderson–Darling test of residual normality. Source: Authors' estimation in Eviews 9 .

Ramsey (1969) RESET test of functional form bias and the Anderson–Darling test of residual normality.

The CUSUM and CUSUMQ (Brown, Durbin, and Evans 1975) plots show that the parameters of the model are dynamically stable (Hansen 1992) (Figure 1). We corrected the autocorrelation problem in the cointegrating residuals by applying the heteroscedastic and autocorrelation robust estimators (HAC), and the long-run covariance estimator with pre-whitened (lag 1) Bartlett kernel and Newey–West fixed bandwidth, respectively. Hence, all long-run parameters are stable as evidenced by the LC statistics of the Hansen parameter instability test. However, we note that the long-run residuals are not normally

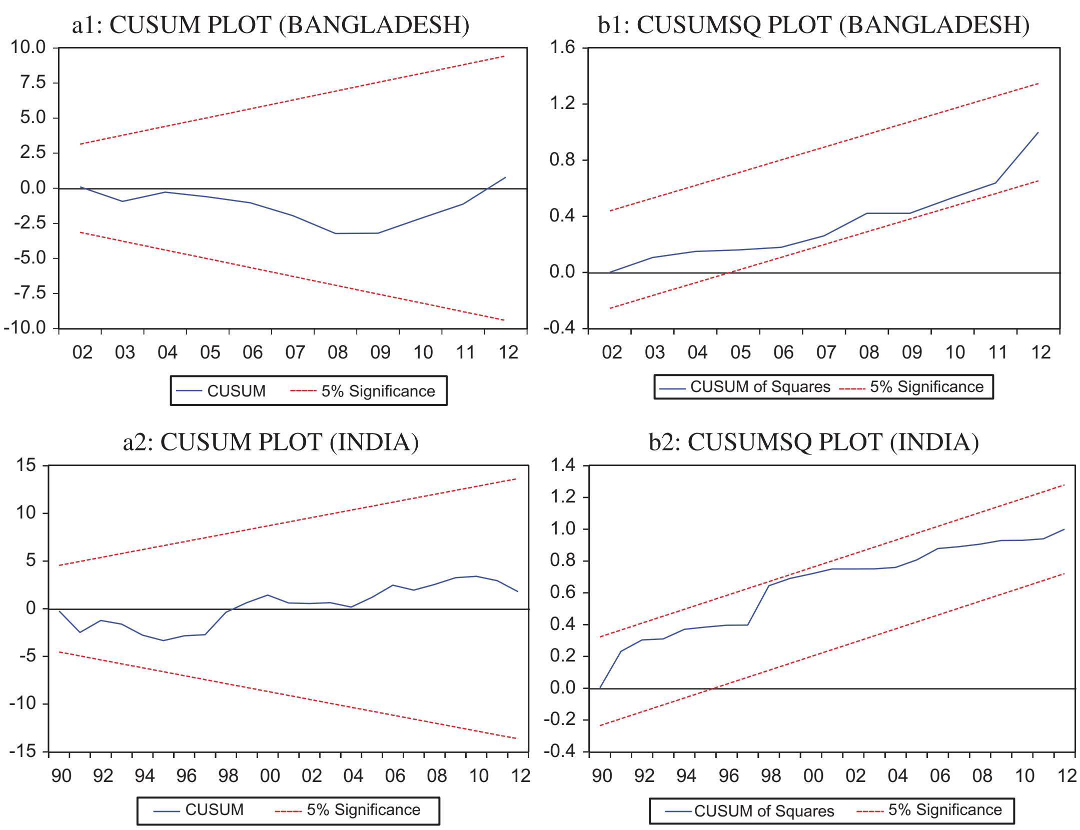

Figure 1. CUSUM & CUSUMSQ Plot.

distributed in the case of Bangladesh. All long-run residuals are stationary as evidenced by the existence of cointegration. We now present the short run diagnostic test results (Table 10).

Granger causality test

Next, the pairwise Granger causality test is carried out on the stationary variables. From the results (Table 11), it is evident that for Bangladesh, remittances Granger cause TFP growth at 1% level ($\Delta REM_t \rightarrow \Delta TFP_t$), and TFP growth Granger causes remittances ($\Delta TFP_t \rightarrow \Delta REM_t$) at 10% level. Similar conclusions are made for India where we note bidirectional causality between remittances and TFP growth ($\Delta TFP_t \leftrightarrow \Delta REM_t$) at 1% level of statistical significance.

V. Conclusions and policy implications

In this article, we examined the presence of an (inverted) U-shaped relationship between TFP growth and remittances (% of GDP) among other variables in two of the largest receipt countries in South Asia – Bangladesh and India. The results confirm a long-run association based on a battery of tests for cointegration (Engle and Granger (1987), Phillips and Ouliaris (1990), and Hansen (1992) and Park (1992)). The long-run equation is estimated via the Stock and Watson (1993) DOLS procedure and the causality is measured using the pairwise Granger causality test. The results show that for Bangladesh, the mini

mum threshold of remittances (% GDP) is 5.3% which is within the sample range examined. We arrive at a similar conclusion as Hassan, Chowdhury and Bhuyan (2016) but tend to differ in terms of the size of the threshold point. For India, we note an inverted U-shaped relationship with the maximum threshold of remittances (% GDP) of 1.8%. The causality nexus shows evidence of bidirectional causality implying that remittances and TFP growth are interdependent and hence mutually reinforcing each other.

In terms of the differences between the relationship between remittances and TFP growth estimated for the two countries, we note that Bangladesh and India are operating differently in terms of remittances impact on TFP growth. However, we plead for caution in interpreting the results. Importantly, the findings do not imply that remittances (% GDP) have reached its peak or that lower levels of remittances are to be maintained for India. Similarly, neither do we propose that remittances (% GDP) lower than the threshold value of 5.2% for Bangladesh is less important. In fact, quite the

Table 10. Short-run diagnostics.

Primary statistics		Complementary statistics	
Panel 1: Bangladesh			
$F_{sc}: F(2,18) = 1.7396^A$	0.2038	$\chi^2_{sc}: \chi^2(2) = 5.0213^B$	0.0812
$F_{ff}: F(1,19) = 2.9456^A$	0.1024	$LR_{ff}: LR_1 = 4.4680^C$	0.0345
$F_{hc}: F(10,20) = 0.3052^A$	0.9711	$\chi^2_{sc}: \chi^2(10) = 4.1045^A$	0.9425
$A^2_{RN}: A^2 = 0.2735^A$	0.6420	$adj(A^2_{RN}): A^2 = 0.2808^A$	0.6420
Panel 2: India			
$F_{sc}: F(2,23) = 2.1101^A$	0.1441	$\chi^2_{sc}: \chi^2(2) = 5.3113^B$	0.0703
$F_{ff}: F(1,24) = 2.6717^A$	0.1152	$LR_{ff}: LR_1 = 3.6940^B$	0.0546
$F_{hc}: F(10,24) = 3.0764^C$	0.0117	$\chi^2_{sc}: \chi^2(10) = 19.6613^B$	0.0326
$A^2_{RN}: A^2 = 0.2051^A$	0.8607	$adj(A^2_{RN}): A^2 = 0.2107^A$	0.8607

A, B and C denote statistical significance at the 1%, 5% and 10% levels. SC: Serial correlation; ff: functional form; hc" heteroscedasticity test. Source: Authors' estimation in Eviews 9.

Table 11. Pairwise granger causality test.

Causality direction	Lag 1	Lag 2	Lag 3
Panel 1: Bangladesh			
$\Delta REM_t \rightarrow \Delta TFP_t$	$F_{32} = 0.02675^A$ [0.8712]	$F_{31} = 0.21734^A$ [0.8061]	$F_{30} = 0.76481^A$ [0.5254]
$\Delta TFP_t \rightarrow \Delta REM_t$	$F_{32} = 0.06439^A$[0.8015]	$F_{31} = 3.94498^C$[0.0319]	$F_{30} = 3.11776^C$[0.0458]
Panel 2: India			
$\Delta REM_t \rightarrow \Delta TFP_t$	$F_{38} = 0.75893^A$ [0.3896]	$F_{37} = 0.2457^A$ [0.7836]	$F_{36} = 0.51238^A$ [0.6769]
$\Delta TFP_t \rightarrow \Delta REM_t$	$F_{38} = 2.68125^A$[0.1105]	$F_{37} = 1.00479^A$[0.3774]	$F_{36} = 0.65371^A$[0.5871]

A and C denote statistical significance at the 1% and 10% levels. Lag = 3 was used.
Source: Authors' estimation in Eviews 9.

opposite is intentioned. The results here at best highlights that in case of Bangladesh, remittances (% GDP) are still fairly low and an increase in the ratio will continue to provide a stimulus to the growth rate of TFP. Of course, productive use of remittances is necessary and the results confirm that remittances play a more direct role in the growth enhancing process in Bangladesh. However, in case of India, a 1.8% threshold marks a tipping point and therefore implies that remittance incomes are not a major source of TFP growth rate. Thus, in this regard, remittances have a more intermediary and indirect role in the growth process. While in the study, we underscore the importance of and favour remittances use in the economic growth process, we present the different ways in which remittances impact growth in the two economies. In case of India, we highlight that a high flow of remittances when effectively used will support GDP growth, so long as the ratio is in balance even when the absolute levels of remittances are increasing. Thus, to maintain a robust growth in income, other key sectors in addition to remittances need to be identified and exploited. Our policy proposal in terms of boosting remittances in Bangladesh resonates with earlier studies (Hassan, Chowdhury, and Bhuyan 2016; Kumar and Stauvermann 2014a; and others).

Additionally, we acknowledge that the type of analysis is basic. However, an important outcome of the study is that although Bangladesh and India are large recipients of remittances, the impact of remittances on the TFP growth is different. A number of reasons can be provided for this. Among other things, the most important that we see is the mix between remittances used for consumption smoothing or investment and other income generating activities. Of course, the latter two are necessary to have higher impact on TFP growth. Also, the thresholds computed in the study largely depend on the approach used and being cognizant that that thresholds are within the sample range to ensure validity and relevance. Our study strives to do just that. Moreover, other methods can be used, among them are the ARDL bounds approach to cointegration, and the Toda and Yamamoto (1995) causality procedure. More countries can be examined in a similar fashion to identify any uniformness or polarity in terms of threshold effects. We leave these for further research.

Disclosure statement

No potential conflict of interest was reported by the authors.

Acknowledgements

Peter J. Stauvermann acknowledges the financial support of the Changwon National University in 2017-2018 for his research contributions. All the authors thank the editor and the anonymous reviewers for their comments. The usual disclaimer applies.

ORCID

Ronald Ravinesh Kumar http://orcid.org/0000-0001-9658-4896

Syed Jawad Hussain Shahzad http://orcid.org/0000-0003-3511-6057

References

Acosta, P., P. Fajnzylber, and J. H. Lopez. 2007. *The Impact of Remittances on Poverty and Human Capital: Evidence from Latin American Household Surveys*. Policy Research Working Paper No. 4247. Washington, DC: World Bank Publications. https://openknowledge.worldbank.org/handle/10986/7392

Adams, R. H., and J. Page. 2005. "Do International Migration and Remittances Reduce Poverty in Developing Countries?" *World Development* 33 (10): 1645–1669.

Agbola, F. W. 2013. "Does Human Capital Constrain the Impact of Foreign Direct Investment and Remittances on Economic Growth in Ghana?" *Applied Economics* 45 (19): 2853–2862.

Ahamada, I., and D. Coulibaly. 2011. "How Does Financial Development Influence the Impact of Remittances on Growth Volatility?" *Economic Modelling* 28 (6): 2748–2760.

Ahmed, M. S. 2010. "Migrant Workers Remittance and Economic Growth: Evidence from Bangladesh." *ASA University Review* 4 (1): 1–13.

Anwar, A. I., and M. Y. Mughal. 2016. "Migrant Remittances and Fertility." *Applied Economics* 48 (36): 3399–3415.

Barai, M. K. 2012. "Development Dynamics of Remittances in Bangladesh." *Sage Open* 2 (1): 2158244012439073.

Barajas, A., R. Chami, C. Fullenkamp, M. Gapen, and P. J. Montiel. 2009. "Do Workers' Remittances Promote Economic Growth?" IMF Working Papers, 1–22. SSRN. https://ssrn.com/abstract=1442255.

Bhaskara Rao, B., and T. B. Takirua. 2010. "The Effects of Exports, Aid and Remittances on Output: The Case of Kiribati." *Applied Economics* 42 (11): 1387–1396.

Brown, R. L., J. Durbin, and J. M. Evans. 1975. "Techniques for Testing the Constancy of Regression Relationships

over Time." *Journal of the Royal Statistical Society. Series B (Methodological)* 37 (2): 149–192.
Buch, C. M., and A. Kuckulenz. 2010. "Worker Remittances and Capital Flows to Developing Countries." *International Migration* 48 (5): 89–117.
Chami, R., A. Barajas, T. Cosimano, C. Fullenkamp, M. Gapen, and P. Montiel. 2008. *Macroeconomic Consequences of Remittances*. Washington, DC: International Monetary Fund.
Chiodi, V., E. Jaimovich, and G. Montes-Rojas. 2012. "Migration, Remittances and Capital Accumulation: Evidence from Rural Mexico." *Journal of Development Studies* 48 (8): 1139–1155.
Chowdhury, M. 2011. "Remittances Flow and Financial Development in Bangladesh." *Economic Modelling* 28 (6): 2600–2608.
Chowdhury, M. 2016. "Financial Development, Remittances and Economic Growth: Evidence Using a Dynamic Panel Estimation. Margin." *The Journal of Applied Economic Research* 10 (1): 35–54.
Datta, K., and B. Sarkar. 2014. "Relationship between Remittances and Economic Growth in Bangladesh: An Econometric Study." Working Paper Series 19. Bangladesh Development Research Center. http://www.bangladeshstudies.org/files/WPS_no19.pdf
Deonanan, R., and K. Williams. 2017. "The Effect of Remittances on Democratic Institutions." *Applied Economics* 49 (5): 403–416.
Dickey, D. A., and W. A. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association* 74 (366a): 427–431.
Donou-Adonsou, F., and S. Lim. 2016. "An Empirical Analysis of Remittance Flows into West African Economic and Monetary Union: A Panel Time-Series Approach." *Applied Economics* 48 (11): 1018–1029.
Easterly, W., R. Levine, and D. Roodman. 2004. "Aid, Policies, and Growth: Comment." *American Economic Review* 94: 774–780.
Ebeke, C., and J. L. Combes. 2013. "Do Remittances Dampen the Effect of Natural Disasters on Output Growth Volatility in Developing Countries?" *Applied Economics* 45 (16): 2241–2254.
Edwards, A. C., and M. Ureta. 2003. "International Migration, Remittances, and Schooling: Evidence from El Salvador." *Journal of Development Economics* 72 (2): 429–461.
Engle, R. F., and C. W. Granger. 1987. "Co-Integration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55 (2): 251–276.
Frank, R., and R. A. Hummer. 2002. "The Other Side of the Paradox: The Risk of Low Birth Weight among Infants of Migrant and Nonmigrant Households within Mexico." *International Migration Review* 36 (3): 746–765.
Granger, C. W. 1969. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." *Econometrica* 37 (3): 424–438.
Griffin, K. 1976. "On the Emigration of the Peasantry." *World Development* 4 (5): 353–361.
Gupta, S., C. A. Pattillo, and S. Wagh. 2009. "Effect of Remittances on Poverty and Financial Development in Sub-Saharan Africa." *World Development* 37 (1): 104–115.
Hansen, B. E. (1990). *Lagrange Multiplier Tests for Parameter Instability in Non-linear Models*. University of Rochester. https://www.ssc.wisc.edu/~bhansen/papers/LMTests.pdf
Hansen, B. E. 1992. "Efficient Estimation and Testing of Cointegrating Vectors in the Presence of Deterministic Trends." *Journal of Econometrics* 53 (1–3): 87–121.
Hasan, R. A. (2006). *Harnessing Remittances for Economic Development of Bangladesh*. Bangladesh Working Paper 1. Philippines: INAFI. http://www.inafiasia.net/download/new/Microfinance%20&%20Remittance/1.pdf
Hassan, G. M., M. Chowdhury, and M. S. Bhuyan. 2016. "Growth Effects of Remittances in Bangladesh: Is There a U-Shaped Relationship?" *International Migration*. doi:10.1111/imig.12242.
Hassan, G. M., and M. J. Holmes. 2013. "Remittances and the Real Effective Exchange Rate." *Applied Economics* 45 (35): 4959–4970.
Hassan, G. M., and S. Shakur. 2017. "Nonlinear Effects of Remittances on per Capita GDP Growth in Bangladesh." *Economies* 5 (3): 25.
Hatemi-J, A., and G. S. Uddin. 2014. "On the Causal Nexus of Remittances and Poverty Reduction in Bangladesh." *Applied Economics* 46 (4): 374–382.
Higgins, M. L., A. Hysenbegasi, and S. Pozo. 2004. "Exchange-Rate Uncertainty and Workers' Remittances." *Applied Financial Economics* 14 (6): 403–411.
Hobbs, A. W., and K. P. Jameson. 2012. "Measuring the Effect of Bi-Directional Migration Remittances on Poverty and Inequality in Nicaragua." *Applied Economics* 44 (19): 2451–2460.
Jayaraman, T. K., C. K. Choong, and R. Kumar. 2011a. "Role of Remittances in Small Pacific Island Economies: An Empirical Study of Fiji." *International Journal of Economics and Business Research* 3 (5): 526–542.
Jayaraman, T. K., C. K. Choong, and R. R. Kumar. 2011b. "Financial Sector Development and Remittances in Pacific Island Economies: How Do They Help the World's Two Most Recipient-Dependent Countries?" *Perspectives on Global Development and Technology* 10 (3–4): 386–405.
Jayaraman, T. K., C. K. Choong, and R. R. Kumar. 2012. "Role of Remittances in India's Economic Growth." *Global Business and Economics Review* 14 (3): 159–177.
Kumar, R. R. 2010. *Growth and Remittance Nexus in the Fiji Islands: An Investigation Using Bounds Test Analysis*. SSRN 1566626. doi:10.2139/ssrn.1566626. https://ssrn.com/abstract=1566626
Kumar, R. R. 2011a. "Do Remittances, Exports and Financial Development Matter for Economic Growth? A Case Study of Pakistan Using Bounds Approach." *Journal of International Academic Research* 11 (1): 18–26.
Kumar, R. R. 2011b. "Nexus between Financial and Technology Inclusion, Remittances and Trade Openness

Vis-À-Vis Growth: A Study of Nepal." *The Economic Journal of Nepal* 34 (1): 13–30.

Kumar, R. R. 2013a. "Linking Remittances with Financial Development and ICT: A Study of the Philippines." *International Journal of Economics and Business Research* 5 (4): 379–399.

Kumar, R. R. 2013b. "Remittances and Economic Growth: A Study of Guyana." *Economic Systems* 37 (3): 462–472.

Kumar, R. R. 2014. "Exploring the Nexus between Tourism, Remittances and Growth in Kenya." *Quality & Quantity* 48 (3): 1573–1588.

Kumar, R. R., and H. T. T. Vu. 2014. "Exploring the Nexus between ICT, Remittances and Economic Growth: A Study of Vietnam." *Journal of Southeast Asian Economies* 31 (1): 104–120.

Kumar, R. R., and P. J. Stauvermann. 2014a. "Exploring the Nexus between Remittances and Economic Growth: A Study of Bangladesh." *International Review of Economics* 61 (4): 399–415.

Kumar, R. R., and P. J. Stauvermann. 2014b. "Exploring the Effects of Remittances on Lithuanian Economic Growth." *Engineering Economics* 25 (3): 250–260.

Kumar, R. R., V. Naidu, and R. Kumar. 2011. "Exploring the Nexus between Trade, Visitor Arrivals, Remittances and Income in the Pacific: A Study of Vanuatu." *Acta Universitatis Danubius. Œconomica* 7: 4.

Kurosaki, T. 2006. "Consumption Vulnerability to Risk in Rural Pakistan." *The Journal of Development Studies* 42 (1): 70–89.

Kwiatkowski, D., P. C. Phillips, P. Schmidt, and Y. Shin. 1992. "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure are we that Economic Time Series have a Unit Root?" *Journal of Econometrics*. 54 (1–3): 159–178. .

Lazarte Alcala, N. R., L. C. Adkins, B. Lahiri, and A. Savvides. 2014. "Remittances and Income Diversification in Bolivia's Rural Sector." *Applied Economics* 46 (8): 848–858.

Le, T., and P. M. Bodman. 2011. "Remittances or Technological Diffusion: Which Drives Domestic Gains from Brain Drain?" *Applied Economics* 43 (18): 2277–2285.

MacKinnon, J. G. 1996. "Numerical Distribution Functions for Unit Root and Cointegration Tests." *Journal of Applied Econometrics* 11 (6): 601–618.

Mishra, P. 2005. "Macroeconomic Impact of Remittances in the Caribbean." *Unpublished paper*. Washington, DC: International Monetary Fund.

Musumba, M., J. W. Mjelde, and N. C. Adusumilli. 2015. "Remittance Receipts and Allocation: A Study of Three African Countries." *Applied Economics* 47 (59): 6375–6389.

Nyamongo, E. M., R. N. Misati, L. Kipyegon, and L. Ndirangu. 2012. "Remittances, Financial Development and Economic Growth in Africa." *Journal of Economics and Business* 64 (3): 240–260.

Park, J. Y. 1992. "Canonical Cointegrating Regressions." *Econometrica* 60 (1): 119–143.

Perotti, R. 1993. "Political Equilibrium, Income Distribution, and Growth." *The Review of Economic Studies* 60 (4): 755–776.

Phillips, P. C., and P. Perron. 1988. "Testing for a Unit Root in Time Series Regression." *Biometrika* 75 (2): 335–346.

Phillips, P. C., and S. Ouliaris. 1990. "Asymptotic Properties of Residual Based Tests for Cointegration." *Econometrica* 58 (1): 165–193.

Pradhan, G., M. Upadhyay, and K. Upadhyaya. 2008. "Remittances and Economic Growth in Developing Countries." *The European Journal of Development Research* 20 (3): 497–506.

Rahman, M. M. 2013. "Gendering Migrant Remittances: Evidence from Bangladesh and the United Arab Emirates." *International Migration* 51 (1): 159–178.

Rahman, Z. 2014. "The Link between Remittances and Economic Growth: Empirical Evidence from Bangladesh." *International Journal of Social and Economic Research* 4 (2): 140–159.

Ramirez, M. D. 2013. "Do Financial and Institutional Variables Enhance the Impact of Remittances on Economic Growth in Latin America and the Caribbean? A Panel Cointegration Analysis." *International Advances in Economic Research* 19 (3): 273–288.

Ramirez, M. D. 2014. "Remittances and Economic Growth in Mexico: An Empirical Study with Structural Breaks, 1970-2010." *Business and Economic Research* 4 (1): 351.

Ramsey, J. B. 1969. "Tests for Specification Errors in Classical Linear Least-squares Regression Analysis." *Journal of the Royal Statistical Society. Series B (Methodological)* 31 (2): 350–371.

Rao, B. B., and G. M. Hassan. 2011. "A Panel Data Analysis of the Growth Effects of Remittances." *Economic Modelling* 28 (1): 701–709.

Rao, B. B., and G. M. Hassan. 2012. "An Analysis of the Determinants of the Long-Run Growth Rate of Bangladesh." *Applied Economics* 44 (5): 565–580.

Rapoport, H. 2002. "Migration, Credit Constraints and Self-employment: A Simple Model of Occupational Choice, Inequality and Growth." *Economics Bulletin* 15 (7): 1–5.

Ratha, D. 2007. "Leveraging Remittances for Development." *Policy Brief* 3: 324–341.

Ruiz, I., and C. Vargas-Silva. 2010. "Another Consequence of the Economic Crisis: A Decrease in Migrants' Remittances." *Applied Financial Economics* 20 (1–2): 171–182.

Saikkonen, P. 1992. "Estimation and Testing of Cointegrated Systems by an Autoregressive Approximation." *Econometric Theory* 8 (1): 1–27.

Sayan, S. 2006. *Business Cycles and Workers' Remittances: How Do Migrant Workers Respond to Cyclical Movements of GDP at Home?* Working Paper No. 06/52. International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Business-Cycles-and-Workers-Remittances-How-Do-Migrant-Workers-Respond-to-Cyclical-Movements-18708

Senhadji, A. 2000. "Sources of Economic Growth: An Extensive Growth Accounting Exercise." *IMF Staff Papers* 47 (1): 129–157.

Shonkwiler, J. S., D. A. Grigorian, and T. A. Melkonyan. 2011. "Controlling for the Underreporting of Remittances." *Applied Economics* 43 (30): 4817–4826.
Siddique, A., E. A. Selvanathan, and S. Selvanathan. 2012. "Remittances and Economic Growth: Empirical Evidence from Bangladesh, India and Sri Lanka." *Journal of Development Studies* 48 (8): 1045–1062.
Solow, R. M. 1956. "A Contribution to the Theory of Economic Growth." *The Quarterly Journal of Economics* 70 (1): 65–94.
Solow, R. M. 1957. "Technical Change and the Aggregate Production Function." *The Review of Economics and Statistics* 39 (3): 312–320.
Stahl, C. W., and F. Arnold. 1986. "Overseas Workers' Remittances in Asian Development." *International Migration Review* 20: 899–925.
Stark, O. 1991. "Migration in LDCs: Risk, Remittances, and the Family." *Finance and Development* 28 (4): 39.
Stock, J. H., and M. W. Watson. 1993. "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems." *Econometrica* 61 (4): 783–820.
TehseenJawaid, S., and S. A. Raza. 2012. "Workers' Remittances and Economic Growth in China and Korea: An Empirical Analysis." *Journal of Chinese Economic and Foreign Trade Studies* 5 (3): 185–193.
Toda, H. Y., and T. Yamamoto. 1995. "Statistical Inference in Vector Autoregressions with Possibly Integrated Processes." *Journal of Econometrics* 66 (1): 225–250.
Vogelsang, T. J. (1993). "Essays on Testing for Nonstationarities and Structural Change in Time Series Models." Unpublished Ph.d Dissertation, Princeton University, Princeton.
Wagner, M. 2008. "The Carbon Kuznets Curve: A Cloudy Picture Emitted by Bad Econometrics?" *Resource and Energy Economics* 30 (3): 388–408.
World Bank. 2017. *World Development Indicators and Global Development Finance*. Washington D.C: World Bank.
Zhunio, M. C., S. Vishwasrao, and E. P. Chiang. 2012. "The Influence of Remittances on Education and Health Outcomes: A Cross Country Study." *Applied Economics* 44 (35): 4605–4616.

Appendix

App 1: Data sources

The data are sourced from the *World Development Indicators and Global Development Finance* (World Bank 2017) which reports data on GDP and investment measured by gross fixed capital formation (in constant Bangladeshi taka and Indian rupees, respectively), labour force participation rate (based on International Labour Organization estimates of the population), personal remittances received (% of GDP), net inflows of foreign direct investments (% of GDP), net ODA (% of GDP), trade (% of GDP), general government expenditure (% of GDP) and population growth rate. The annual capital stock data, K_t, at year t are constructed using the perpetual inventory method $K_t = (1-\delta)K_{t-1} + I_t$, where $K_0 = \gamma Y_0$, $\delta = 0.10$ is the depreciation rate, $\gamma = 1.50$ is the parameter multiplied with initial constant GDP (Y_0), to compute the initial capital stock K_0.[12] The sample size for Bangladesh and India is 1980–2012 and 1977–2012, respectively.[13]

[12]While the values of δ and γ are set arbitrarily, we ensured that the plot of capital per worker is concave and hence converges over time.
[13]To be consistent in terms of same source of data, we extract all key data from World Bank (2017).