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The Effects of Aid and Foreign Direct Investment on Total Factor Productivity: Empirical Evidence from Bangladesh

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Abstract

This paper investigates the effects of official development assistance (ODA) and foreign direct investment (FDI) on total factor productivity (TFP) in Bangladesh. Using data ranging from the period 1985-2019, an autoregressive distributed lag (ARDL) bound testing approach to cointegration is employed. Robust statistical results show that ODA has a long-run as well as a short-run positive effect on the TFP. On the other hand, FDI appears to hurt the TFP in the long-run as well as in the short-run. These findings have two important implications: funds obtained as aid from foreign donors may have been utilized in the proper development avenues, which improve overall productivity, and FDI invested in the relatively less productive sectors in the country by foreign businesses may weaken TFP. Additionally, the Toda-Yamamoto Granger causality test identifies bidirectional causality between TFP and ODA, and a unidirectional causality running from FDI to TFP. Based on the findings, this paper calls for urgent attention to upgrading the skills of the labor force in Bangladesh so that a substantial share of the FDI is drawn to the sectors which may generate strong spillovers and eventually enhance the TFP.

Keyword: FDI, ODA, TFP, ARDL, Toda-Yamamoto causality

1. Introduction

An extensive number of empirical studies establish that *something else* besides factor accumulation explains a sizable extent of cross-country variations in the level and growth of per capita GDP. In the growth literature, this term is known as total factor productivity (TFP) or technological progress. Easterly and Levine (2001) observe that differences in TFP growth may account for 60% of cross-country differences in per capita GDP growth in the period 1960-1992. They also incorporate human capital data from Benhabib and Spiegel (1994) to find that TFP growth differences can explain 90% of cross-country differences in per capita GDP growth. The latter finding of Easterly and Levine (2001)

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echoes an earlier observation of Klenow and Rodriguez-Clare (1997), which finds that TFP growth explains 90% of per capita income variations across a sample of 98 developing countries between the years 1962-95.

The theoretical argument of the neoclassical models such as Solow (1957) limits us to analyze the determinants of TFP growth, but according to endogenous growth theory such as Romer (1990), TFP growth is essentially an endogenous component of the economic growth, thus we can study its determinants and form necessary policies. Amongst others, human capital in the form of education, FDI, and openness are crucial determinants of TFP (Benhabib and Spiegel, 1994; Isaksson, 2007; Nachega and Fontaine, 2006). Most of the studies related to estimating the determinants of TFP growth focus on cross-country regression and incorporate variables that are available for all countries in the panel (see, for example, Senhadji 1999; Gehringer *et al.*, 2015). In this process, except for very few studies such as Alvi and Senbeta (2012), Groß and Danzinger (2022), Nachega and Fontaine (2006), and Kumar *et al.* (2017), most ignore official development assistance (ODA) to be a determinant of TFP growth, especially in the case of developing nations. An extensive number of studies (e.g., Burnside & Dollar, 2000; Durbarry *et al.*, 1998; Easterly *et al.*, 2004; Minoiu & Reddy, 2010; Rajan & Subramanian, 2008) assess the aid-growth nexus, and these studies are often irreconcilable as to a specific direction of the aid-growth relationship; therefore, often studies investigate the channels such as investment and TFP through which aid places its effect on growth.

In addition to ODA, FDI is also a vital source of foreign capital and sophisticated technology for a developing nation. Generally, FDI flows in the developing countries to utilize the abundance of cheap labor. In this process, FDI may act as a key catalyst to enhance the TFP in the recipient country. Despite such expectations, empirical literature suggests a rather indecisive conclusion concerning the FDI-TFP link. For example, Yeaple and Keller (2003) observe that FDI spillovers significantly increase productivity in a host of US plants, and the effect is strong for high-technology firms. Roy and Paul (2022) observe a negative effect of FDI on TFP in Indian low-tech industries such as textiles, food, paper, and beverages. Using aggregate data for 70 developing countries Herzer and Donaubauer (2017) report a strong negative long run effect of FDI on TFP. By utilizing a computational general equilibrium model recently, Hossain and Hosoe (2017) have observed that FDI in the RMG sector of Bangladesh results in an overall higher industry output, but the share of domestic firms in the output market declines relative to that of the foreign firms.' The decline in the market share of the domestic RMG firms may indicate a dampening character of the productivity of the factor inputs employed in these firms. In fact, in the presence of multinational enterprises (MNEs), domestic firms face intense competition from the MNEs, which acquire a larger market share through their cost advantages. More succinctly, MNEs pull away superior factor inputs from the domestic firms by offering higher compensations. The ultimate results for the domestic firms are lower productivity, lower outputs, and thus a lower level of exports relative to the MNEs. Currently, Bangladesh attracts a significant share of FDI in low-tech firms such as RMG; therefore, it is worth investigating whether the country receives any advantages from FDI to TFP at the aggregate level.

Despite the importance of ODA and FDI as key determinants of TFP, there is a dearth of literature assessing the link between TFP, ODA, and FDI from the perspective of Bangladesh. Two notable studies, such as Mujeri (2004) and Ahmed and Chowdhury (2019), examine an array of variables as the determinants of TFP growth in Bangladesh but overlook the paramount role of ODA and FDI in influencing TFP. In the long-run estimation of the TFP determinants by Kumar *et al.* (2017), a negative effect of aid on the TFP in Bangladesh is observed. The estimated results of Kumar *et al.* (2017) might be debatable since their model did not acknowledge the importance of domestic sources of innovation (e.g., human capital), which directly influences TFP (see Benhabib & Spiegel, 1994). Considering the dearth of literature assessing the role of two vital foreign sources of innovations, FDI and ODA, in influencing TFP from the perspective of a developing nation like Bangladesh, there is a need for a study that should be based on a well-defined model that accounts for important foreign sources of innovations while at the same time acknowledging the necessary role of domestic sources of innovations. Against this backdrop, our present study aims to examine the effects of aid and FDI on TFP by taking Bangladesh as a case.

The rest of the paper is organized as follows: Section 2 provides a survey of literature. Section 3 depicts the scenario concerning ODA and FDI from the perspective of Bangladesh. The next section conceptualizes TFP and outlines the main model. Section 5 discusses the data and the estimation strategy. The subsequent sections provide results analysis and robustness checks for the main regression analysis. Section 8 provides Toda and Yamamato (1995) Granger causality test results, and Section 9 concludes the paper.

2. Literature Review

The literature on aid-growth is quite voluminous. Roughly, it can be classified into two broad categories. In the first category, studies concentrate on the effectiveness of aid on the economic growth or growth of per capita GDP. The second category of studies delves deeper to understand the channels through which aid places its effects on economic growth. This category mainly concentrates on two main channels, such as investment and TFP, through which aid may influence economic growth. Our work focuses on the comparatively less charted channel of TFP.

Burnside and Dollar (2000) (henceforth BD) initiate a debate on the aid-growth relationship. They observe that aid positively influences growth in a good policy environment. Hansen and Tarp (2001) question BD's findings. They empirically prove that aid spurs growth, but it is not conditional on 'good policy', contrary to BD's findings. Easterly *et al.* (2004) expand the dataset originally used by BD but fail to generate similar results observed in BD to the inclusion of the new dataset. In a reply, Burnside and Dollar (2004) renew their claim of a positive aid-growth nexus conditional on good policy in a cross-country analysis with a new dataset focusing on the 1990s. Dalgaard *et al.* (2004) once again reiterate the weak policy-aid interaction in the aid-growth regression in a new paper. Also, theoretically, in a standard over lapping generation (OLG) model they establish that aid in general affect long-run productivity.

Apparently, there exists no common pattern of the association between aid and growth. Debate concentrates on not just policy interaction but also on the positive or negative impact of aid on growth. For example, Rajan and Subramanian (2008) find no robust positive aid-growth nexus. Rajan and Subramanian (2011) also show that aid inflow reduces the competitiveness of a nation's exportable manufacturing sector by causing a real appreciation of the exchange rate.

It is often hypothesized that the effect of aid on the growth of output per capita works by financing investment. Against this backdrop, a particular strand of literature focuses on understanding aid-investment linkage. For example, Gyimah-Brempong and Racine (2008) use a local linear kernel estimator and the data of a large host of least-developed countries over the period 1995-2004 to find a positive aid-investment relationship in various policy environments. Alvi and Senbeta (2012), as a part of investigating both channels of the aid-growth nexus, observe that aid enhances investment as measured by gross capital formation relative to GDP. Nowak-Lehmann and Gross (2021), utilizing a large sample of cross-country data, also observe a long-run positive aid-investment linkage. In contrast, Dollar and Easterly (1999) observe for a host of African nations that aid does not spur total investment, but if conditioned on good policy, aid appears to increase private investment, and a higher volume of aid is subject to diminishing returns.

The other channel through which aid may influence growth is TFP. But there is a dearth of literature exploring this channel. Alvi and Senbeta (2012) find a negative impact of foreign aid on TFP growth in a cross-country analysis with 62 developing nations and argue that this finding may corroborate the earlier negative findings on the aid-growth nexus. Groß and Danzinger (2022) find that net ODA decreases TFP. Also, ODA in the form of bilateral aid and grants reduces TFP. They conduct their central regression models using data of TFP in level but also report similar findings using TFP growth data.

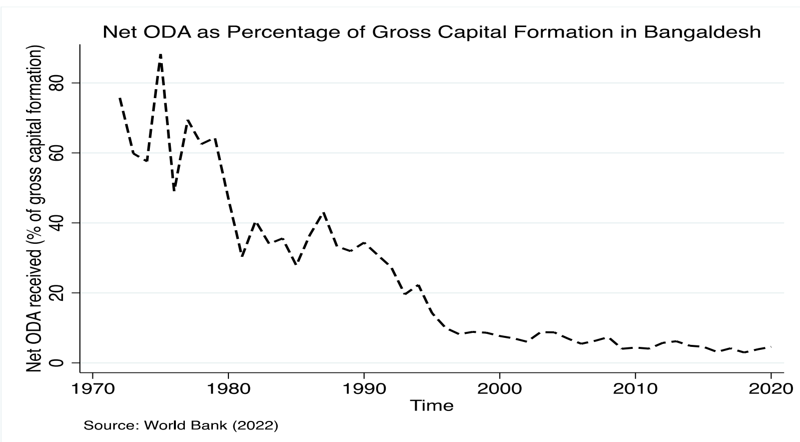
Cross-country regressions concerning aid effectiveness often lead to conflicting results. Therefore, a country-specific case study may shed strong light on this very issue to provide a clear picture. For example, Collodel and Kotzé (2014) assert that each developing nation has a distinct and constantly changing economic and natural environment, which may influence the aid effectiveness differently in each aid recipient country.

In the perspective of Bangladesh Mujeri (2004) is one of the few studies that investigates the determinants of TFP. The study finds that an appreciation of real effective exchange rate (REER) negatively impacts TFP, while increased trade openness yields higher productivity growth. The study also observes that inflation and public consumption have statistically insignificant impacts on TFP growth. Although the study offers valuable insights into the impact of a foreign source of innovation on TFP growth, such as the openness index, it overlooks domestic sources of innovations, such as human capital, which is of paramount significance for a developing nation like Bangladesh. Furthermore, the study does not employ any time series method to estimate its econometric models, which could potentially lead to spurious results. On the other hand, Ahmed and Chowdhury (2019) address the econometric limitations of Mujeri (2004) and introduce a set of new variables as the determinants of TFP, such as voice and accountability, regulatory control, control of corruption, rule of law, credit, broad money, and remittance, among others. Although the study is an improvement over Mujeri (2004), it still doesn't distinguish between the domestic and foreign sources of innovations. The use of remittance as a determinant of TFP in this study cannot be rationalized since it doesn't introduce any new technology in the country. Most importantly, both studies overlook FDI as well as ODA as two major sources of foreign innovations that may have a significant influence on TFP in Bangladesh. Our present study intends to fill this gap in the literature by explicitly outlining the domestic as well as foreign sources of innovations and estimating the impact of two vital sources of foreign technology, FDI and ODA, on TFP.

3. Trends of ODA and FDI in Bangladesh

During the 1970s, following the independence in 1971, Bangladesh was virtually a closed economy. To supplement the weak domestic savings, the country had to depend heavily on the external funds. But since the 1980s, dependency on external aid has reduced steadily as Bangladesh pursued a policy of gradual reform in the sectors related to industry, finance, and trade. The era of 1982 and onwards is marked as the period of economic liberalization in Bangladesh (Hossain & Alauddin, 2005).

Figure 1. Net ODA (% of gross capital formation) in Bangladesh



Even though the aid-financed investment paradigm has lost its strength and has now been much weaker of an idea in practice than it was in the 1960s (Dollar & Easterly, 1999), it is worth looking at the historical data to track and evaluate the aid dependency of an aid recipient nation for financing its domestic investment. As depicted in Figure 1 during the 1970s, net ODA, on average, would account for roughly two-thirds of the gross capital formation in the country. Over the years, the scenario changed dramatically. Specifically, since the 1990s, the share of net ODA in gross capital formation has been on average a little over 6%.

The share of FDI as a percentage of GDP—another source of foreign capital—is historically low in Bangladesh. Figure 2 depicts the net ODA and net FDI receipts over the years 1985-2019. Clearly, net ODA as percentage of GDP shows a downward trend, and FDI relative to GDP indicates an upward trend.

Figure 2. Net ODA (% of GDP) and net FDI (% of GDP) in Bangladesh

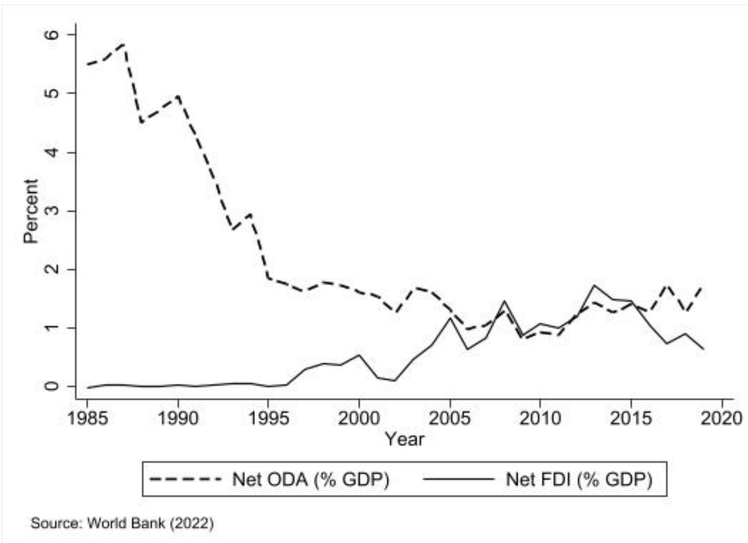


Figure 3 presents the scenario pertaining to the foreign direct investment (FDI) inflow received by the Bangladeshi manufacturing sector, specifically one of its major subsectors: textiles and apparel. At present, this subsector fetches the largest share of income from foreign trade. In 2000-01 fiscal year (FY), the textile and wearing sector received about 62.5% of the total export earnings, and in 2019-20 FY it increased to about 71.9% (Bangladesh Bank, 2020). It is argued that manufacturing FDI plays a positive role in economic growth. For example, Wang (2009) observes for 12 Asian nations over 1987-1997 that manufacturing FDI shows a strong positive effect on growth. According to Figure 3, it is apparent that the textile and wearing sector has been a significant recipient of foreign direct investment (FDI) compared to the total FDI in the manufacturing sector. Between 1996 and 2019, this sector accounted for an average of 48.7% of the total manufacturing foreign direct investment (FDI) inflows. Manufacturing FDI exhibited a consistent upward trend over time, with a pronounced surge between 2010 and 2015. It nearly doubled between 2015 and 2019, indicating robust growth in manufacturing-related foreign investments. FDI in textiles and wearing apparel started with lower values in 1996 but increased significantly through 2010. However, after 2015, there was a noticeable decline in textiles and wearing FDI by 2019, even though it remained higher than earlier years. This could reflect changes in the global demand for RMG or shifts in investment strategies toward other sectors.

Figure 3. Net FDI in textile and wearing sub-sector and manufacturing sector

Source: Author's formulation from Bangladesh Bank (2020)

Even though textiles and wearing is a dominant subsector of the manufacturing sector in Bangladesh, and inflows of FDI in the manufacturing sector, according to empirical evidence, usually have a favorable role on growth; one should, however, be cautious enough to translate the role of FDI on economic growth as well as total factor productivity from the perspective of Bangladesh. This is because the textile and wearing sector usually requires less sophisticated technology and characteristically produces low-technology products.

4. Model Specification

Our empirical investigation begins with estimating a production function. The coefficients obtained in this regression are later used in the levels accounting outlined in Hall and Jones (1999) to derive the level of total factor productivity. The Cobb Douglas (CD) production function that assumes constant returns to scale can be written as:

$$Y = AK^{\alpha}L^{1-\alpha}\ , 0 < \alpha < 1 \qquad (1)$$

Here, A is the total factor productivity; K and L are stock of capital, and labor force respectively. Solow (1957), Denison (1967) find a large TFP growth rate in growth accounting, because their studies do not use quality adjusted inputs data. If labor input is used in growth accounting without adjusting for quality improvements as measured by the mean years of schooling, good health, the unmeasured improvements may show up as an increase in the TFP growth (see, Jorgenson & Griliches, 1967; Barro & Sala-i-Martin, 2003, p. 438). This study, therefore, makes use of labor input data adjusted for quality improvements. Notable studies such as Senhadji (1999, pp. 6), Collins and Bosworth (1996) augment labor in this manner to calculate TFP. Recently, Ahmed and Chowdhury (2019, pp. 35) have also augmented the labor input with human capital to calculate TFP. We have multiplied the series of labor input data by human capital index data found in PWT 10.0 by Feenstra *et al.* (2015) to construct the series of quality labor input or effective labor input. Adjusting for quality labor input we restate the previous equation as follows.

$$Y = AK^{\alpha}(LH)^{1-\alpha} \qquad (2)$$

Here, K, L and H represent stock of capital, labor force and the measure of human capital respectively. The above equation is written in natural logarithms as follows.

$$lnY = lnA + \alpha lnK + (1-\alpha)\ln(LH) \qquad (3)$$

Total factor can then be calculated by rearranging the equation (3):

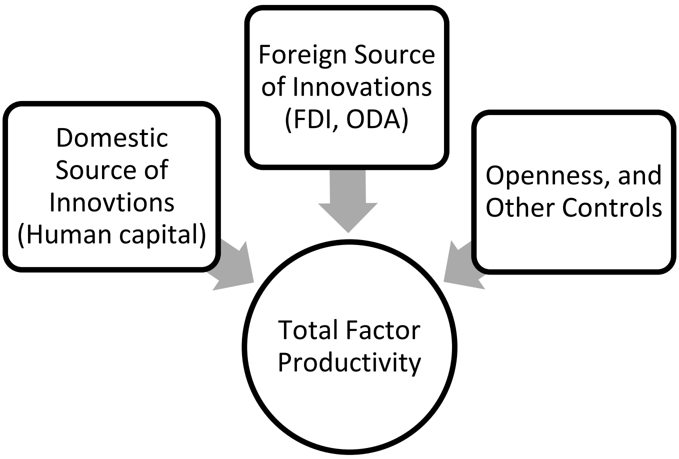
$$lnA = lnY - \alpha lnK - (1-\alpha)\ln(LH) \qquad (4)$$

ODA and FDI can be regarded as the source of foreign technology flowing to a host country from the technologically superior nations. Theoretically, Benhabib and Spiegel (1994) establish that TFP may be influenced by innovations from two sources: Domestic, and foreign sources. They have combined two ideas: Human capital in the form of educational attainment places its effect on growth through TFP (Romer, 1990), and it influences the speed of adoption of foreign technology (Nelson & Phelps, 1966). To put simply, determinants of TFP should account for the innovations arising from both domestic and foreign sources. Against this backdrop, we formulate a model that includes variables representing domestic innovation as well as foreign innovation. A general form of the model is stated below.

$$\ln tfp_t = \beta_0 + \beta_1 h_t + \beta_2 oda_t + \beta_3 fdi_t + \beta_4 open_t + \beta_5 x_t + u_t \quad (5)$$

Here, lntfp is the level of TFP which is calculated using equation (4). The variable h represents measure of human capital or domestic source of innovations, oda, fdi and open represent sources of foreign technology respectively, x is a vector of control variables, and u is the error term. A schematic representation of the model stated in Equation 5 is depicted in the Figure 4.

Figure 4. Schematic representation of the model adopted for TFP regression



Source: Author's formulation based on Benhabib and Spiegel (1994) and Nelson and Phelps (1966)

5. Methodology

This section presents the estimation methodology, and the data utilized in this analysis. All the series employed are annual and cover the period from 1985 to 2019. A common characteristic of macroeconomic time series data is the presence of a unit root. Therefore, we conduct unit root tests employing the Phillips-Perron and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests to determine whether unit roots exist in the variables utilized in this study. The test results are in the Table A1 and Table A2 in the appendix and indicate that all the variables exhibit stationarity at the first difference (I(1)) with the exception of life expectancy, which remains stationary at levels. Table 1 provides an overview of the data. We have used variables that are commonly used in the literature. Still the adoption of a few variables needs explanation. For example, data on the population aged 15-64 is used as a proxy for labor input. This is because in the developing countries people working in the traditional agricultural sector may not be documented in the labor force data (Benhabib and Spiegel, 1994). We have used the export-to-GDP ratio as a measure of openness. Openness of a country to international trade may enable it to adapt foreign technology and augment its catching-up process (Keller, 2004). Miller and Upadhyay (2000) also use the export-GDP ratio as a measure of openness in their TFP regression. Hall and Jones (1999) argue that a favorable social infrastructure allows an economy to obtain higher output per capita and, at the same time, creates an impetus for the economy to become enriched in skill and technology. In the aid-TFP regression, we thus control for variables that represent institutional quality.

Table 1: Variables employed and their sources

Variable	Description	Measurement Unit	Source
lnY	Real gross domestic product	Constant 2015 US$	World Bank (2022)
lnK	Capital Stock at Constant 2017 National Prices	Constant 2017 National Prices	PWT 10.0
L	Population aged 15-64	Number of total populations per year	World Bank (2022)
H	Human capital index	Based on years of schooling and returns to education	PWT 10.0
ln(LH)	Natural log of the product of L and H	The series is in natural log	Author’s calculation using PWT 10.0
lntfp	Total factor productivity	The series is in natural log	Author’s calculation using PWT 10.0
hs	School enrollment, secondary (% gross)	Annual, percentage	World Bank (2022)
ht	School enrollment, tertiary	Annual, percentage	World Bank (2022)

	(% gross)		
eduex	Government expenditure on education, total (% of government expenditure)	Annual, percentage	World Bank (2022)
oda	Net official development assistance (% of GDP)	Annual, percentage	World Bank (2022) and PWT 10.0
fdi	Net foreign direct investment (% of GDP)	Annual, percentage	World Bank (2022)
open	Exports to GDP ratio	Annual, percentage	World Bank (2022)
credit	Domestic credit to private sector (% of GDP)	Annual, percentage	World Bank (2022)
inst	Institutional Quality (Freedom status)	Annual, 1 to 3 scale (Higher is better)	Freedom House (2022)
pts	Political terror scale	Annual, 1 to 5 scale (Higher is worse)	Gibney *et al.* (2021)
lnlife	Life expectancy	Annual, Natural log of life expectancy	World Bank (2022)

To estimate the model in equation (5), we employ the ARDL bound testing approach to cointegration developed by Pesaran *et al.* (2001). We have adopted this framework because the characteristics of our data requires cointegration approach. Moreover, the approach is highly suitable for a small sample size. The ARDL bound testing approach also does not require pretesting the order of integration of the variables. This framework can detect the existence of a single level relationship between the dependent variable and the regressors regardless of the regressors being purely I(0), purely I(1), or mutually cointegrated. The first step of the ARDL bound testing approach is to estimate an unrestricted error correction model stated in equation (6) using the ordinary least squares (OLS) method. In the second step, joint hypotheses that all the long-run multipliers in the equation (6) are zero are tested against the alternative that at least one of them is not zero. Formally, we can write these two hypotheses as:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$$

$$H_a: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$$

The F-statistic obtained from testing the above null hypothesis has a non-standard distribution, which is compared against a set of critical values supplied by Pesaran *et al.* (2001). Each set of critical values contains a lower bound and an upper bound. If the F-statistic falls below the lower bound, then we fail to reject the null hypothesis of no cointegration, and if it crosses the upper bound, we reject the null and conclude that the variables are cointegrated. In case the F-statistic falls within the bounds, then the test is inconclusive. The next steps involve specifying optimal lag-structure for the model. In this paper we use Schwartz Bayesian criterion (SBC) for this purpose. Pesaran and Shin (1999) show that in the ARDL framework, SBC performs better than the Akaike information criterion. As the data involved in this paper are annual, we assign a maximum two lags for each variable according to the suggestion of Pesaran and Shin (1999). Finally, the lag structure that minimizes the SBC is chosen to be the optimal one for our regression.

$$\begin{aligned}\Delta lntfp_t = a_0 &+ \sum_{i=1}^{p} \psi_i \Delta lntfp_{t-i} + \sum_{i=0}^{p} \phi_{i1} \Delta h_{t-i} \\ &+ \sum_{i=0}^{p} \phi_{i2} \Delta oda_{t-i} + \sum_{i=0}^{p} \phi_{i3} \Delta fdi_{t-i} \\ &+ \sum_{i=0}^{p} \phi_{i4} \Delta open_{t-i} + \sum_{i=0}^{p} \phi_{i5} \Delta x_{t-i} \\ &+ \delta_1 lntfp_{t-1} + \delta_2 H_{t-1} + \delta_3 oda_{t-1} \\ &+ \delta_4 fdi_{t-1} + \delta_5 open_{t-1} + \delta_6 x_{t-1} + e_{1,t}\end{aligned} \tag{6}$$

If there is cointegration among the variables, the long-run and the short-run estimates can be found using the equations (7) and (8).

$$\begin{aligned}lntfp_t = c_0 &+ \sum_{i=1}^{p} c_{1i}\, lntfp_{t-i} + \sum_{i=0}^{q} c_{2i}\, h_{t-i} + \sum_{i=0}^{r} c_{3i}\, oda_{t-i} \\ &+ \sum_{i=0}^{s} c_{6i}\, fdi_{t-i} + \sum_{i=0}^{t} c_{5i}\, open_{t-i} + \sum_{i=0}^{u} c_{6i}\, x_{t-i} \\ &+ w_t\end{aligned} \tag{7}$$

$$\Delta lntfp_t = b_0 + \sum_{i=1}^{p} b_{1i}\Delta lntfp_{t-i} + \sum_{i=0}^{q} b_{2i}\,\Delta h_{t-i} + \sum_{i=0}^{r} b_{3i}\,\Delta oda_{t-i} + \sum_{i=0}^{s} b_{4i}\,\Delta fdi_{t-i} + \sum_{i=0}^{t} b_{5i}\,\Delta open_{t-i} + \sum_{i=0}^{u} b_{6i}\,\Delta x_{t-1} + b_7 ECT_{t-i} + e_{2,t} \quad (8)$$

Here ECT is the error correction term. The coefficient on the error correction term denotes the speed at which deviations from equilibrium are corrected.

6. Results Analysis

At first, we present the estimation results concerning the CD production function outlined in equation (3). Our CD equation includes real GDP, capital stock, and effective labor input. Since these series contain unit roots, we have performed ARDL cointegration technique to obtain the long-run estimations. Table 2 reports the ARDL F-bounds test findings that ensures the presence of cointegration among the variables of CD production function and Table 3 long-run findings.

Table 2: ARDL F-bounds test

	Number of parameters (k)	F-statistic Value	Comment			
Cobb-Douglas production function	2	14.5	Cointegrated			
Model 1	8	16.64	Cointegrated			
Model 2	7	17.93	Cointegrated			
Model 3	7	16.41	Cointegrated			
Significance	Asymptotic: n=1000[a]		Finite Sample: n=35[b]		Finite Sample: n=35[c]	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
10%	1.95	3.06	2.58	3.71	2.30	3.61
5%	2.22	3.39	3.06	4.32	2.75	4.21
1%	2.79	4.10	4.49	5.06	3.84	5.69

Note. [a] Critical value bounds are from Pesaran *et al.* (2001), [b, c] Critical value bounds are from Narayan (2005), [b] Critical values when the model includes unrestricted constant and restricted trend, [c] Critical values when the model includes unrestricted constant and no trend. I(0) and I(1) denote lower and upper bound respectively.

The coefficient denoting share of capital is estimated to be 0.79. The higher estimate of the share of capital, $\alpha = \frac{\delta y}{\delta k}\frac{K}{Y}$, obtained in the regression of CD production function is not surprising. This is because, theoretically, in a capital-deficient country, marginal productivity of capital tends to be higher. Generally, the common value for the share of capital in literature is 1/3. For example, Hall and Jones (1999) uses the standard 1/3 value for the share of capital in levels accounting. Akinlo and Adejumo (2016) use a value of 0.4 for the share of capital in their growth accounting exercise for Nigeria since this developing nation uses labor-intensive technology. Abekah-Koomson *et al.* (2021) observe a value of 0.71 for the share of capital for a host of West African economies. Recently, Ahmed and Chowdhury (2019) have also observed the value of the share of capital to be more than 2/3 for Bangladesh. The authors posit that the high value of capital share may be attributed to inadequate capital data recording management, an inflated share of capital in the production process, and a higher marginal productivity of capital due to its scarcity within this nation.

Table 3: Cobb-Douglas production function long-run estimation results based on the ARDL framework

Dependent Variable: lnY		
Independent Variables	Coefficient	p-value
lnK	0.79 (0.08)	0.0000
ln(LH)	0.21 (0.09)	0.0214
constant	10.94 (1.03)	0.0000
R-squared	0.99	

Note. Standard error is reported in the parentheses

In addition, in Bangladesh, the capital share of GDP could be higher than the labor share due to factors such as surplus labor, limited collective bargaining power of the workers, and a shift towards capital-intensive production processes. Bangladesh earns most of its foreign currencies by mainly exporting RMG goods, among others. The RMG sector takes advantage of an abundant supply of cheap labor. If the prediction of Heckscher-Ohlin (H-O) theory is right, then opening to international trade should increase the income of labor input, or the share of labor should generally be higher. However, a high value of capital share in the estimated production function seems to contradict the H-O theory. This could be due to simplified assumptions of the theory concerning labor homogeneity and the influence of technological advancements (automation) that raise the income shares of capital and skilled workers and depress the income share of unskilled workers, cross border capital mobility via FDI, and weak labor unions. In fact, the declining trend of labor share is now a worldwide phenomenon. Historically, the labor share has been failing in developed as well as in developing labor-abundant nations such as China, India, and Mexico (Karabarbounis & Neiman, 2014).

After estimating the production function to obtain our TFP measure, we estimate the model stated in equation (5). As there is evidence of both I(0) and I(1) variables in the unit root tests, we employ the ARDL bound testing approach to cointegration here as well for finding long-run equilibrium among the variables of interest.

Three different specifications are evaluated based on the equation (5). Table 2 reports the results on cointegration tests. The calculated F-statistic values for all the models are significant at the 5% level. That is, we can safely conclude that all the models contain cointegration among the variables as specified by them respectively. The optimal lag lengths that minimize SBC for the evaluated Model 1, Model 2, and Model 3 are (2, 2, 1, 1, 2, 2, 1, 2, 1), (2, 0, 1, 2, 2, 0, 2, 1), and (2, 0, 1, 2, 2, 0, 2, 1) respectively.

The confirmation on the long-run relationship in all the models allows us to estimate the long-run coefficients for each specification. Table 4 reports the results. Columns labeled [1] through [3] report regression results for the specifications of Model 1 through Model 3. The long run findings in [1] indicate that ODA positively influences TFP in Bangladesh, while FDI shows a negative effect. Both coefficients are statistically significant. While the variables that measure technology diffusion from abroad exhibit some effects, the variables that represent domestic innovation, such as the secondary enrollment ratio and the tertiary enrollment ratio, play a questionable role in this specification.

Table 4: ***Long-run regression on ODA-TFP link***

Dependent Variable: lntfp

Independent Variable	[1] Model 1	[2] Model 2	[3] Model 3
hs	0.000696**	-0.00014	
	(0.000297)	(0.000276)	
ht	-0.0000469		0.001374**
	(0.000987)		(0.000524)
oda	0.03209***	0.029421***	0.027404***
	(0.006957)	(0.008138)	(0.008884)
fdi	-0.02595***	-0.03312***	-0.0244***
	(0.005823)	(0.004481)	(0.004696)
credit	-0.00638***	-0.00853***	-0.00724***
	(0.000615)	(0.000777)	(0.000713)
open	0.008256***	0.006935***	0.005678***
	(0.001241)	(0.00087)	(0.000852)
inst	-0.02244***	-0.03085***	-0.0219***
	(0.00285)	(0.004719)	(0.004998)
lnlife	0.854403***	0.574378*	0.93201***
	(0.185984)	(0.320829)	(0.269292)
trend		0.005972***	
		(0.001593)	
Serial correlation LM test	10.57981 [0.0050]	5.536425 [0.0628]	0.40812 [0.8154]
Heteroskedasticity Test- BPG	17.10236 [0.7577]	23.94921 [0.1567]	17.68806 [0.4088]
Jarque-Bera	3.40 [0.1822]	1.88 [0.39]	0.644 [0.72]
Ramsey RESET Test		7.008976 [0.0201]	0.308293 [0.5875]

Note. Robust standard errors are in the parentheses. Individual coefficients are significant at the ***1%, **5% or *10% level. P-values are reported within the square brackets for the LM, BPG, Jarque-Bera, and Ramsey RESET test statics.

Diagnostic test concerning serial correlation indicates that this specification has autocorrelation problem. Moreover, both *hs* and *ht* are highly correlated to each other. In the later specifications [2] and [3], we keep only one of these variables while retaining all the other variables from specification [1]. In doing so, the estimated models [2] and [3] are now not only free of autocorrelation problem but also correctly specified as indicated by Ramsey RESET test.

In the regression [2] in Table 4, the coefficient on the ODA is positive and highly significant at the 1% level. It implies that in the long run ODA raises TFP in Bangladesh. The coefficient on the FDI is significant and enters with a negative sign. This negative effect of FDI on TFP may be attributable to the fact that the sectors that receive FDI fail to generate strong spillovers. The nature of FDI inflows can be at play here too. Wacker *et al.* (2016) argue that the nations in the South Asian region usually receive vertical FDI associated with low-technology products more than they receive horizontal FDI, which usually seeks to serve the domestic markets in the host countries. Because this region is historically endowed with low-skill labor input, it can be a factor attracting such FDI here. Blonigen *et al.* (2003) observe that skill difference between the host and the parent economies shrinks vertical FDI, and Davies (2008) later finds that skill difference also increases horizontal FDI. Historically, Bangladesh receives an extensive amount of FDI in the low-technology textile and wearing sector relative to other subsectors within the manufacturing sector (Bangladesh Bank, 2020). The negative impact of foreign direct investment (FDI) on total factor productivity (TFP) is also not unusual in the literature, particularly in the case of developing nations. For example, Herzer and Donaubauer (2017) using aggregate data for 70 developing countries observes a strong negative long-run effect of FDI on TFP. Such pernicious effect of FDI on TFP is perhaps due to the roles multinational enterprises (MNEs) play in the host nation. Relative to the domestic firms MNEs have cost advantages, which makes the former produce less. Moreover, since MNEs employ fewer domestic inputs, an overall dampening effect engulfs the host nation's productivity growth, leading to a negative impact on TFP. Roy and Paul (2022) observe a similar negative role of FDI in TFP in Indian low-tech industries such as textiles, food, paper, and beverages using firm level data.

Specification [3] controls tertiary education instead of secondary education. Unlike the previous results, domestic sources of innovation now show a significant positive effect on the TFP. The estimated coefficients on ODA and FDI in this specification preserve the same signs and the level of significance observed in the previous model [2]. The size of the estimated coefficient on ODA becomes slightly smaller when we control for tertiary education. At the same time, the negative effect shown by FDI decreases to some extent. Among the other controls, the openness index enters with positive and highly significant coefficients in all the specifications.

Table 5: Short-run regression on ODA-TFP link

Dependent Variable: lntfp			
Independent Variables	[1] Model 1	[2] Model 2	[3] Model 3
D(ltfp(-1))	-0.40383***	-0.391565***	-0.27487***
	(0.061789)	0.069129	(0.072853)
D(hs)	-0.001329***		
	(0.00021)		
D(hs(-1))	-0.000955***		
	(0.000212)		
D(ht)	0.002446***		
	(0.000442)		
D(oda)	0.011976***	0.011647***	0.011647***
	(0.001209)	0.001299	(0.001476)
D(fdi)	-0.012517***	-0.012677***	-0.00985***
	(0.001487)	0.001605	(0.001761)
D(fdi(-1))	-0.008398***	-0.003821**	-0.00484**
	(0.001461)	0.001555	(0.001761)
D(credit)	-0.002274***	-0.002257***	-0.0021***
	(0.000292)	0.000329	(0.000371)
D(credit(-1))	0.000956***	0.001851***	0.001657***
	(0.000299)	0.000337	(0.000376)
D(open)	0.005343***		
	(0.000371)		
D(inst)	-0.0000648	-0.002742	-0.0005
	(0.001653)	0.002042	(0.00225)
D(inst(-1))	0.018588***	0.020053***	0.015563***
	(0.002124)	0.002421	(0.002547)
Dlnlife	17.91202***	14.96792***	14.29246***
	(1.065926)	0.922243	(1.010099)
Constant	5.773708***	6.46382***	5.59345***
	(0.351969)	0.406159	(0.403439)
CointEq(-1)*	-0.83653***	-0.798153***	-0.83573***
	(0.050955)	0.05012	(0.060234)

Note. Robust standard errors are in the parentheses. Individual coefficients are significant at the ***1% or **5% or *10% level. D is the first difference operator. CointEq(-1) denotes error correction term.

Table 5 reports the results on the short-run estimations. Columns labeled [1] through [3] in this table correspond to the long-run regression [1] through [3] in Table 4. In the specification [2], the estimated coefficient on the ODA registers the same sign as its long-run coefficient. The coefficient is highly significant at the 1% level. The same trait of ODA is observable in specification [3]. In the both short-run regression [2] and [3], FDI enters significantly with a negative sign. The negative effect is almost closer to zero in specification [3], which controls for tertiary level of education.

The terms representing error correction or speed of adjustment in both models are highly significant and negative. It implies that both models converge to long-run equilibrium. The estimated coefficient on the error correction term in specification [2] is -0.798 and -0.836 in [3]. This indicates that in each period, about 79.8% and 83.6% of the disequilibrium from the previous period in models [2] and [3], respectively, gets corrected to restore the models to long-run equilibrium.

7. Robustness Check

Although we have found a consistent positive ODA-TFP connection and a negative FDI-TFP nexus in different specifications controlling for alternative human capital variables, we reevaluate our findings by changing the original specification. This time we include government expenditure on education relative to the total government expenditure as a proxy for human capital. According to the World Bank (2022), government expenditure on education may represent the importance a nation assigns to education and human capital development relative to other public investments. We also replace our institutional quality variable with the political terror scale (PTS) by Gibney *et al.* (2021).

Table 6: Robustness check (Dependent variable: lntfp, *Long-run regression)*

Variable	Coefficient	Standard Error	t-Statistic	P-value
eduex	0.002181	0.000553	3.945609	0.0008
oda	0.023015	0.00805	2.858853	0.0097
fdi	-0.02538	0.006665	-3.807512	0.0011
credit	-0.00458	0.000393	-11.67127	0.0000
open	0.00299	0.001251	2.390479	0.0268
pts	-0.00095	0.002735	-0.346264	0.7328
lnlife	0.646804	0.225239	2.871629	0.0094
Short-run Regression				
Variable	Coefficient	Standard Error	t-Statistic	P-value
Constant	4.310452	0.254257	16.95314	0.0000
D(oda)	0.004641	0.001588	2.923344	0.0084

D(fdi)	-0.00862	0.002078	-4.147514	0.0005
D(open)	0.003282	0.000482	6.803758	0.0000
D(pts)	0.003982	0.00129	3.087941	0.0058
D(lnlife)	8.212957	0.507854	16.17188	0.0000
CointEq(-1)*	-0.55174	0.032475	-16.98967	0.0000
Serial correlation LM test		3.153095 [0.2067]		
Heteroskedasticity Test- BPG		9.535930 [0.7314]		
Jarque-Bera		0.806 [0.68]		
Ramsey RESET Test		1.226250 [0.2820]		

Note. p-values are reported within square brackets for the LM, BPG, Jarque-Bera, and Ramsey RESET test statics. CointEq(-1) denotes error correction term.

The model with new variables also meets the criteria for the ARDL cointegration analysis, as indicated by a F-statistic of 26.72, which is higher than the upper bound test statistic at the 5% level of significance. The appropriate lag structure that minimizes the SIC is found to be (1, 0, 1, 1, 0, 1, 1, 1).

Table 6 reports the long-run and the short-run findings. All the coefficients enter the long-run regression significantly except the coefficient on the political terror scale. The coefficient on the ODA is still significant and positive. The size of the coefficient is almost identical to the previous findings in Table IV. FDI reconfirms its negative effect on the TFP. The coefficient on the openness variable is still positive and smaller in magnitude.

In the short-run, ODA and FDI replicate the same trait observed in the long-run. The error correction term is highly significant and has the necessary negative sign to confirm that the model converges to long-run equilibrium. The results on diagnostic tests indicate that our estimated alternative model does not suffer from problems arising from autocorrelation, heteroscedasticity, and non-normality of the error term.

8. Toda-Yamamoto Granger Causality Test

The ARDL bound testing approach employed in this study confirms the existence of the long-run equilibrium among ODA, FDI, and TFP in the presence of a host of controls. In this section, we conduct a closer examination of the causal relationship among the pivotal variables ODA, FDI, and the level of TFP. We employ the Toda and Yamamoto (1995) (henceforth, T-Y) approach of the Granger causality test to achieve this.

We have only considered the series ODA, FDI, and TFP for this test, as the sample size is small and involving all the variables may consume additional degrees of freedom. Using the T-Y approach over the conventional Granger causality test is indispensable in this case because ODA, FDI, and TFP are non-stationary, as indicated by the ADF unit root test. Table 7 reports the results.

Table 7: Toda-Yamamoto granger causality test

Dependent Variable	Independent Variables			
	lntfp	oda	fdi	Comment
lntfp		11.75**	22.44***	oda→lntfp, fdi→lntfp
oda	11.12**		1.22	lntfp→oda
fdi	2.93	4.78		

Notes: Chi-square value to test the null hypothesis "no causality" is reported. ***, **, and * denote the level of significance at the 1%, 5%, and 10% level. The right-most column translates the test results, for example, ODA Granger causes TFP and so on.

The T-Y Granger causality test reveals that there is a bi-directional causality between ODA and TFP, whereas in the case of FDI, causality runs from FDI to total factor productivity, and it is very much in line with the theories and the empirical records. Overall, the findings obtained from the T-Y approach corroborate the ARDL bound testing results regarding long-run relationships and provide a valuable direction for policy alternatives.

9. Conclusion and Policy Recommendation

In this paper, we have investigated the role of aid and FDI in TFP for the data of Bangladesh. Rather than regressing the growth of TFP on aid, FDI, and other controls, we follow Miller and Upadhyay (2000), and Groß and Nowak-Lehmann Danzinger (2022) to employ the level of TFP as a dependent variable in our study. Our empirical model clearly spells out the domestic and foreign sources of TFP, thereby enabling us to carry out a close inspection of how two important foreign sources, such as aid and FDI, influence TFP in Bangladesh. Our long-run estimation results indicate that aid and TFP are positively related, while for FDI, the opposite is true. Our judgment related to the findings on FDI and TFP is that Bangladesh receives an extensive portion of FDI in the textile and wearing sector, which, due to the presence of MNEs, fails to generate strong spillovers. Thus, FDI plays a frustrating role in improving the TFP in Bangladesh. Additionally, low educational attainment of the workforce is perhaps responsible for FDI to flow into the comparatively low-skill sectors. Based on the findings of our study, several policy recommendations can be forwarded for consideration. Increased investment in human capital development may facilitate foreign direct investment in high-technology sectors in Bangladesh. Given the increasing prevalence of multinational enterprises (MNEs) within this nation, the government may consider setting an appropriate level of local content requirements for foreign firms operating within its borders. Since foreign aid is generally beneficial for the economy of Bangladesh, policy makers must devise effective strategies to maximize the beneficial utilization of aid money. A substantial portion of aid funds should be allocated towards research and development in areas where the country shows relative insufficiency compared to its global counterparts.

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Appendix

Table A1: Phillips-Perron Unit Root Test

	Intercept		Intercept and Trend	
	Level	First Difference	Level	First Difference
ltfp	-1.01	-3.53**	-2.06	-3.55**
hs	-0.11	-4.30***	-1.99	-4.28***
ht	4.33	-3.73***	1.01	-5.27***
eduex	-2.04	-8.39***	-1.23	-13.03***
oda	-3.49**	-7.52***	-1.19	-10.01***
fdi	-1.52	-7.34***	-2.58	-7.33***
open	-1.74	-5.93***	-1.17	-6.27***
credit	0.16	-5.66***	-2.11	-5.62***
inst	-3.21**	-5.57***	-3.11	-11.51***
pts	-3.79	-8.35***	-5.73	-9.71***
lnlife	-5.44***	-0.33	0.29	-2.35

Note: *, **, *** denote level of significance at the 10%, 5% and the 1% level

Table A2: Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Unit-root Tests for the variables in the Cobb-Douglas Production Function

	Intercept		Intercept and trend		
	Level	First Difference	Level	First Difference	Comment
lnK	3.87	0.31	24.14	0.09	I(1)
lnY	3.98	0.39	17.79	0.05	I(1)
lnLH	3.27	0.17	9.94	0.10	I(1)
Asymptotic critical values:	1% level	0.74		0.22	
	5% level	0.46		0.15	
	10% level	0.35		0.12	