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The Economics of Foreign Aid: Time Series Evidence from a Less Developed Country (LDC)

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Abstract

Empirical literature on aid-growth nexus mostly centered within cross-country framework exploiting typical ordinary least squares (OLS) estimation. As a result, scarcity prevails studies empirically examine country-specific causes of aid-growth nexus exercising distinct methods. This study aims to fill this gap, taking the case of Bangladesh- a leading aid recipient country. Empirical findings based on vector error correction modeling and Granger causality test unearth absence of long-run and short-run causality of aid on GDP growth. Therefore, this study argues that although aid remains a major component of LDCs macroeconomic framework; however, it is yet to emerge as a significant player in their economic growth.

Keywords: Aid-growth nexus, Vector error correction modeling, Causality, Bangladesh.

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1. Background

'Foreign aid' popularly known as official development assistance (ODA) is a saga of over seven decades (Dalgaard *et al.*, 2004). Starting its expedition at the end of World War Two (WW2) and intensifying in 1960s and since then aid-growth nexus has been staying a key area of research interests (Boone, 1996; Alesina and Dollar, 2000; Dalgaard *et al.*, 2004; Doucouliagos and Paldam, 2009). For example, last five decades (1960- 2010) have witnessed a revolution in aid-growth paradigms where record number of cross-country growth regressions proved insufficient justifying aid effectiveness (or ineffectiveness) (Sala-i-Martin, 1997a;1997b; Hansen and Tarp, 2000; Clemens *et al.*, 2004; Hendry and Krolzig, 2004). Major reasons of this aid-growth impasse is because of great controversies in model specification, instrumentation and estimation strategies (Easterly, 2003; Bourguignon and Sundberg, 2007; Rajan and Subramanian, 2008; Deaton, 2010; Galiani *et al.*, 2014). More pertinently, studies before 1990s were unable to draw adequate inferences due to shortage of data, and standard instrumentation and estimation strategies (Easterly, 2003). While, considering donors' point of views, growth is absent in the core of their major aid agendas. Instead, development assistance largely extended to respond emergency and humanitarian needs, and these sorts of external resources normally originate negative causal link towards growth (Clemens *et al.*, 2004). In addition, aid packages frequently designed to serve other purposes including promoting political systems, supporting democracies, and addressing health and environmental issues. Although, growth is prompted around those kinds of aid but hardly in the long run (Clemens *et al.*, 2004). However, Alesina and Dollar (2000) find nothing significant regarding humanitarian role of aid and argue that it is simply continuing to serve political motives and this notion strongly supported by Rajan and Subramanian (2008) who branded 'political motives' as noneconomic reasons. Final category of Clemens *et al.* (2004)classified foreign aid is exploited for productive purposes and in particular, supporting budget, balance of payments, and invests in infrastructure and other development projects. Research evidence suggests that this type of development assistance maintain robust short run causal link towards economic growth (Clemens *et al.*, 2004).

Aid effectiveness literature (AEL)[1] has come across a number of phases reaching its extant form (Clemens *et al.*, 2004; Roodman, 2007). Classification of those phases magnificently recorded in a good number of outstanding literature notably in Doucouliagos and Paldam (2009);Roodman (2007);Clemens *et al.* (2004) and Hansen and Tarp (2000). These exceptional works label the phases as; early, first, second and third generation. Early stage includes studies of 1960s predominantly explain impact of aid on savings and investments rather than examining its effectiveness on growth (Clemens *et al.*, 2004; Roodman, 2007; Doucouliagos and Paldam, 2009). This early phases' particular academic interest intensified due to the influences of Harood-Domar model, where significance of savings on growth has been strongly argued (Roodman, 2007). Two pioneering early studies are, Rosenstein-Rodan (1961) and Chenery and Strout (1966). Among the authors, Rosenstein-Rodan and Chenery held World Banks' chief economist position one time each. While, Hansen and Tarp (2000) identify that first generation studies ranging from early 1970s to 1980s also focusing on aid-savings link, and major works include Griffin and Enos (1970); Weisskopf (1972); Papanek (1972); Papanek (1973); Griffin (1978); Gulati (1978) and Mosley (1980). Second generation studies counting from early 1980s to early 1990s explore aid effects on investments and growth, and this generation dominated by a number of works of Mosley (1986;1987) and Mosley *et al.* (1987). Finally, third generation begins with Boone (1996) and continuing tills the date.

Although, AEL has a vibrant legacy; however, this paper centered mainly within third generation works. More importantly, third generation AEL enter in a new order with the emergence of 'conditional growth studies' in early 2000s (Easterly, 2003). Burnside and David (2000) led this uprising and more significantly, majority of third generation AEL organized in such a fashion keeping (Burnside and David, 2000) 'influential' conclusions that 'aid works better in good policy environments', in the middle (Easterly *et al.*, 2003). On the other hand, most of the AEL based on cross-country empirics exploiting typical OLS estimation (Hansen and Tarp, 2001; Doucouliagos and Paldam, 2009). In addition, more difficulties would appear when OLS estimations deliver 'spurious' outcomes (Wassell and Saunders, 2005). For this reason, scholars and practitioners express their reservations capitalizing conventional OLS estimations in policy implications due to 'unclear and ambiguous results' (Bourguignon and Sundberg, 2007). Accordingly, major objectives set for this study consist of estimating development assistances' impact on growth within country-specific framework through applying a logical instrumentation approach. Moreover, we want to employ rational estimation strategies which have the mechanisms of amending typical OLS estimation errors. In doing so, we adopt popular econometric methodologies of augmented Dickey-Fuller (ADF) test, Johansen test of cointegration, vector error correction modeling (VECM), and Granger causality test. Selecting the case, we consider size of the economy, stability in growth, population, and volume of development assistance. We take Bangladesh, an economy of $227 billion[2] identified as one of the new growth-engines of Asia[3] experienced an average GDP growth over 6 per cent (6.22%)[4] for the last ten years (2007-2016), and forecasts show that she will grow at the rate of 7 per cent (7%)[5] in the next six years (2017-2022) also (International Monetary Fund (IMF), 2017). More importantly, Bangladesh is a major aid-recipient country who consistently manages sizable amount of development assistance measuring nearly 2 per cent (1.5%) of GDP[6] during the period of 2005 to 2014 (World Bank, 2017).

Remainder of the article is structured as follows: section 2 reviews major aid effectiveness literature focusing on models, instrumentation and estimation strategies adopted there. Section 3 deals with this works' modeling and instrumentation strategies. Section 4 runs an exclusive analysis on estimation strategies, and present and discuss empirical findings. Finally, section 5 summarizes the findings and makes concluding remarks.

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[1]We take the term AEL from Doucouliagos and Paldam (2009).
[2]According to IMF World Economic Outlook 2017, volume of Bangladesh's GDP in 2016 stands at $227 billion
[3]In his inaugural speech at the Asian Development Bank (ADB) 50thBoard of Governors annual meeting on 6 May 2017 at Yokohama, Japan, President Takehiko Nakao outlines six member countries as the new growth-engines of Asia. Among the six countries Bangladesh is one of them. Other five countries are: India, Indonesia, Myanmar, the Philippines and Vietnam (source: http://www.thedailystar.net/frontpage/asias-new-growth-engines-1401721)
[4] Authors' calculation based on IMF World Economic Outlook 2017
[5]Authors' calculation based on IMF World Economic Outlook April 2017
[6] Authors' calculation based on World Bank World Development Indicators 2017

2. Aid-Growth Models, Instrumentation, and Estimation Strategies

After surveying vast pile of AEL we find that numerous arguments derived in the formulation of aid-growth strategies. Majority of those debates are well documented in two classic studies of Deaton (2010) and Doucouliagos and Paldam (2009)who systematically scrutinize the methods applied in key aid-growth studies. Ultimately, a consensus emerged from this couple of documents along with other relevant literature that test of aid effectiveness on economic growth has been a regular practice of typical OLS estimation within cross-country framework using standard growth regressions (Hansen and Tarp, 2000; Hendry and Krolzig, 2004; Doucouliagos and Paldam, 2009; Deaton, 2010). As a result, organizing our review initially we focus on highly exploited typical Barro (1991) cross-country growth regression commonly outlined in the form of:

$$\gamma = \alpha + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \ldots\ldots\ldots\ldots + \beta_n \cdot x_n + \varepsilon \qquad (1)$$

In this model γ represents the vector of rates of economic growth, $\alpha$is the constant, and $x_1,\ldots,x_n$ are vectors of explanatory variables usually have different numbers and forms depend on the characteristics of particular research work and author (Doppelhofer *et al.*, 2000). While, in classical aid-growth strategy, growth means real GDP growth, universally expressed in terms of GDP per capita (Doucouliagos and Paldam, 2009). Examining contemporary aid-growth strategies we want to concentrate on legendary work of Deaton (2010). Deaton (2010) aid-growth strategy structured in the form of following expression:

$$\Delta \text{In}Y_{ct+1} = \beta_0 + \beta_1 \text{In}Y_{ct} + \beta_2 \frac{I_{ct}}{Y_{ct}} + \beta_3 H_{ct} + \beta_4 Z_{ct} + \theta A_{ct} + \mu_{ct} \qquad (2)$$

Where Y is the per capita GDP, I represent investments, H is an indicator of measuring human capital, A is the ratio denoting share of aid to GDP, and Z remains for other control variables. In addition, subscripts c stands for country and t for time. Deaton (2010) acknowledges that this approach basically an extension of Solow growth model except the inclusion of A, and Z variables. Deaton (2010) is extremely critical regarding instrumentation strategies but praises (Boone, 1996) who pioneers employment of standard set of instruments in growth regressions. Estimating country-specific effects (Boone, 1996) uses several dummies and incorporates log of population size. Defending the significance of population size, Deaton (2010) argues that aid is extended primarily on the country basis, instead of considering size of the population. Hence, populous countries per capita aid receipt is lower than those of less-populated countries, and it bears great significance since, performance of aid frequently evaluated on the basis of per capita GDP. Therefore, influenced by Boone (1996) next generation influential aid-growth studies[7] widely capitalize both of GDP per capita and population size or one of these variables in their growth regressions (Deaton, 2010). However, Deaton (2010) is not convinced with the quality of instruments overcoming 'exogeneity' and 'heterogeneity' problems, and identifies inadequacy of standard theories validating the competency of instruments. Accordingly, Deaton (2010) conclude that with the current set of instruments it is quite challenging reaching to a robust conclusion on aid-growth nexus. Deaton (2010) raises all important concern that typical aid-growth estimation strategy considers whole volume of aid is duly invested. However, this is quite unrealistic, therefore, for better inferences, at first, it is required to identify the status of tangible investments and then to conclude on effectiveness. Another constraints noted, is the use of instrumental variables as Deaton (2010) shows great reservation in this regard; since, major AEL are in great jeopardy justifying the adoption of instrumental variable methods. Deaton (2010) warns that econometric estimation strategies changed drastically and centered merely within the statistical program evaluation packages rather than to focus on models originated from theories. Therefore, incorporation of instrumental variables in the estimation strategy creates severe disputes and which is leading to quasi-randomization (Deaton, 2010). Similarly, mishandling of instruments explode confusions and challenge the potentials of econometric analysis responding all important empirical enquiries (Deaton, 2010).

Let we concentrate on another exceptional survey of Doucouliagos and Paldam (2009) whose epic analysis on 97 econometric studies covering a period of four decades (mid-1960s to mid-2000s) summarizes overall standard aid-growth estimation strategy in the following form:

$$g_{it} = \alpha + \mu h_{it} + \gamma_j x'_{jit} + u_{it} \qquad (3)$$

Explaining Equation-3, g_{it} is the real growth rate expressed in GDP per capita, h_{it} is the percentage aid to GDP/GNI, x_{jit} is the vector of j control variable, and u_{it} is the residuals, μ and γ are the two commonly estimated coefficients. More importantly, Doucouliagos and Paldam (2009) organize existing aid-growth models into three 'family' groups specified as 'accumulation', 'growth direct', and 'conditional'. Among those paradigms, 'accumulation' strategies frequently hypothesize that rise of domestic savings and balance of payment; particularly, 'accumulation' factors are vital for growth. The next family 'growth direct' is the overall model stated in equation-3, and more explicitly, while estimating 'accumulation' impact; growth of domestic savings (s_{it}) and investments (i_{it}) are measured instead of real GDP growth (g_{it}). Accordingly, this couple of 'accumulation' strategies frequently estimated in the form of following two equations:

$$s_{it} = \alpha + \mu h_{it} + \gamma_j x'_{jit} + \mu_{it} \qquad (4)$$

$$i_{it} = \alpha + \mu h_{it} + \gamma_j x'_{jit} + \mu_{it} \qquad (5)$$

Apart from above aid-growth paradigms, emergence of 'good policy' studies led by Burnside and David (2000) surge most sensational arguments in aid effectiveness literature (Easterly, 2003; Clemens *et al.*, 2004; Roodman, 2007). Undoubtedly, this development drives entire aid-growth debate into a new height, and Doucouliagos and Paldam (2009) place 'good policy' studies into the family of 'conditional growth model', and branded this group of scholars as 'World Bank group' since they are sponsored or somehow affiliated with aid industry[8] World Bank. In 'good policy' paradigm it is strongly argued that aid is effective simply in good policy environments. Burnside and David (2000) 'good policy' strategy structured splendidly in Roodman (2007) in the following way:

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[7]Deaton (2010). list of next generation studies includes Burnside and David (2000). Hansen and Tarp (2000;2001). Guillaumont and Chauvet (2001). Lensink and White (2001). Clemens, Radelet and Bhavnani (2004). Dalgaard, Hansen and Tarp (2004). Easterly, Levine and Roodman (2004). Roodman (2007). and Rajan and Subramanian (2008).

[8]Doucouliagos and Paldam (2009).Use the term 'aid industry' while branding influential aid organizations the World Bank, and Danish International Development Agency (DANIDA).

$$\Delta Y= \alpha A+ \beta A\times P + \gamma P + x\delta + \varepsilon \quad (6)$$

Where *Y* is the per capita GDP, aid is represented by *A*, policy is denoted by *P*, *x* is a vector of controls, and *ε* is the error term. Similarly, Doucouliagos and Paldam (2009) prescribed 'good policy' models' unique feature is that it employs a right hand side 'good policy' variable *z*, and which is the good policy index of particular country comprising weighted sum of budget surplus, inflation rate, and trade openness. In addition, two more coefficients *δ* and *ω* are also estimated. Consequently, Doucouliagos and Paldam (2009) outline 'good policy' model estimation strategy in the following manner:

$$g_{it} = \alpha + \mu h_{it} + \delta z_{it} + \omega h_{it} z_{it} + \gamma_{jit} x'_{jit} + u_{it} \quad (7)$$

Regarding origins, Burnside and David (2000) approach based on neoclassical growth model, and their ever dominant theory suggests that aid works positively on growth until recipient country's GDP growth stays below the zenith of her transitional growth rate. According to Burnside and David (2000) negative impact of aid caused due to the presence of distortionary economic policies. Therefore, Burnside and David (2000) advocate for policy development achieving enhanced aid effectiveness, but they are not certain that inclusion of policy instruments will act properly because other factors can make whole spectrum complicated. However, Burnside and David (2000) two universal hypotheses are: aid and 'good policy' combination is most effective, and effects of 'good policy' triggered by foreign aid. While, corresponding 'good policy' study of Collier and Dollar (2002) analyze real aid allocation scenarios through developing a poverty-efficient aid allocation framework using World Bank ratings of aid recipient countries national policies on aid utilization plans. For example, a country with severe poverty but has good policies is fit to be in the priority of poverty-efficient aid allocation framework. Their findings suggest that existing aid allocation mechanisms is not poverty-efficient although, aid works magnificently bringing out millions of people from absolute poverty. Dollar and Kraay (2002) add a couple conditions to Burnside and David (2000) original variables precisely, stability in inflation and small government size. Overall, Dollar and Kraay (2002) conclude that governance, good trade policies, robust financial systems have little systematic effects on growth.

Another branch of 'conditional growth' studies pioneered by Dalgaard *et al.* (2004); Dalgaard and Hansen (2001); Hansen and Tarp (2001) and Hansen and Tarp (2000) employ different types of policy instruments in estimation strategies. For example, Dalgaard *et al.* (2004) claim that 'climate-related circumstances' are the vital factors prompting degree of growth. However, Dalgaard *et al.* (2004) remain in suspicion concerning the competence of policies in aid effectiveness. Their concluding remarks indicate that size and structural characteristics of aid inflow and policies 'may' influence aid effectiveness. Similar inferences also outlined in Hansen and Tarp (2001) as they suggest that aid has 'likelihood' influences on growth but not conditional on 'good policies'. More significantly, 'estimated' aid effectiveness highly depends on the set of exploited instruments. For instance, positive impact of aid is absent when 'investment' and 'human capital' is controlled. Overall, Hansen and Tarp (2001) suggest that extensive theoretical works on aid effectiveness require before capitalizing existing literature in policy formulations. Correspondingly, Hansen and Tarp (2000) widespread survey on three decades cross-country literature comprehensively examine aid-growth, aid-savings, and aid-investment relationships. After careful scrutiny, Hansen and Tarp (2000) confirm that Burnside and David (2000) 'good policy' model considerably discarded in existing empirical cross-country literature. Moreover, Hansen and Tarp (2000) explore that aid effectiveness is not conditional on good policies; instead, it also works significantly in such environments where good policies are absent. Dalgaard, Hansen, Tarp and fellow scholars' association with Danish International Development Agency (DANIDA) highlighted remarkably in Doucouliagos and Paldam (2009). Keeping consistency with the 'World Bank group' they are identified as 'DANIDA group', and their model labeled as 'Medicine Model' exploits an 'aid squared' term in the right hand side and more notably, aid is treated as a condition in the estimation strategies. Since, aid itself is a condition; therefore, Doucouliagos and Paldam (2009) empirically define 'Medicine Model' in the following way by reducing Equation 7:

$$g_{it} = \alpha + \mu h_{it} + \omega h^2_{it} + \gamma_{jit} x'_{jit} + u_{it} \quad (8)$$

3. Methodologies

3.1. Model Specification and Instrumentation Strategy

The origin of our aid-growth model is derived from production functions. In addition, setting the instrumentation strategies we are inspired by a number of works of Ackerberg *et al.* (2015); Yeoh and Stansel (2013); Bloom *et al.* (2012); Lee *et al.* (2005) and Aschauer (1989) who capitalize production technology while investigating economic growth and productivity. More importantly, production function's universal recognition as a fundamental theory of economics and its long history of being capitalized for more than two centuries (Ackerberg *et al.*, 2015) propel us to exploit one of its advanced form- the Cobb-Douglas production function. Moreover, Cobb-Douglas functions' intensity in illustrating 'real-world production processes' makes it a better technology and a credible strategy in econometric estimation process (Besanko and Braeutigam, 2011). Besides, wide ranges of literature suggest that Cobb-Douglas production function is a substantial instrument for linear estimation of various productivity activities (Lee *et al.*, 2005). General framework of Cobb-Douglas production function structured in Besanko and Braeutigam (2011) in the following form:

$$Q= AL^{\alpha}K^{\beta} \quad (9)$$

In this framework *Q* stands for quantity of output derived from *L* units of labor and *K* units of capital, and *A*, *α*, and *β* are positive constants. While, Cobb-Douglas production function's convenience as an augmented neoclassical model encouraged many scholars modifying its original framework. For example, while estimating public expenditures (G) productivity on the economy (Aschauer, 1989) exploits Cobb-Douglas method in the form of:

$$Y_t = A_t * f(N_t, K_t, G_t) \quad (10)$$

Aschauer (1989) add an extra right hand side variable, public expenditure (G) with employment of labor (N), and stock of nonresidential capital (K). Similarly, examine the role of IT on firms' productivity (Bloom *et al.*, 2012) extend original model by employing two more right hand side variables, materials (m) and IT capital (c) in addition to labor (l) and capital (k). Therefore, remodeled Cobb-Douglas production function organized in Bloom *et al.* (2012) in the way of:

$$q_{it}= a_{it}+ a_{it}^{M}m_{it}+ a_{it}^{L} l_{it}+ a_{it}^{K}k_{it} + a_{it}^{C}c_{it} \quad (11)$$

Alongside, investigating ICT's impact on the economy (Lee *et al.*, 2005) expand Cobb-Douglas model in the form of:

$$Y= AICT^{\beta_1} K^{\beta_2} L^{\beta_3} \quad (12)$$

In their approach (Lee *et al.*, 2005) incorporated ICT as a new instrument with existing labor (L) and capital (K). Where A is a constant represents other elements of production, β_1, β_2, and β_3 are the elasticities of production resources. We follow both Bloom *et al.* (2012); Lee *et al.* (2005) and Aschauer (1989)approaches studying the role of foreign aid (ODA)[9] in economic growth. Therefore, we rewrite Cobb-Douglas production function in the below form:

$$Y= AODA^{\beta_1} K^{\beta_2}L^{\beta_3} \quad (13)$$

Where ODA is the net disbursement flows of official development assistance measured as the percentage of GNI, K is the gross capital formation in terms of percentage of GDP. Due to the inadequacies of labor statistics we proxy labor (L) with population growth (POPLG)[10]. Because, growth of population stimulates productivity in a couple of ways; through supplying additional labor force and create extra demand in the economy (Oxley and Greasley, 1998). Therefore, we argue that economic growth of Bangladesh is the function of foreign aid (ODA), gross capital formation (CAPITAL), and population growth (POPLG). Accordingly, we organize of our aid-growth strategy in the subsequent way:

$$Y= AODA^{\beta_1} CAPITAL^{\beta_3}POPLG^{\beta_3} \quad (14)$$

Finally, for estimation conveniences we capitalize classical (Barro, 1991) cross-country growth regression and structure the above function in the following form:

$$Y= \alpha + \beta_1ODA+ \beta_2CAPITAL+\beta_3POPLG + \varepsilon \quad (15)$$

3.2. The data

We use annual time series data of World Bank's World Development Indicator (WDI). The data has a span of 42 years ranging from 1973 to 2014, and comprises 4 series including per capita GDP (current prices and in US$), net ODA received as percentage of gross national income (GNI), gross capital formation as percentage of GDP, and population growth. We rely on this single source because no other institutional sources have comprehensive time series data on Bangladesh for longer period than World Bank has. In addition, we consider that other source resources may not act properly with World Bank data because of different methodologies applied in data collection and processing and which eventually lead to inconsistencies in estimation and analysis[11].

4. Estimation Strategies and Empirical Findings

Setting the estimation strategies we carefully consider following two factors: at first, inability of typical OLS estimation extending standard inferences for policy implications (Deaton, 2010) and the recent surge of time series application (for example, (Nowak-Lehmann *et al.*, 2012; Juselius *et al.*, 2014; Lof *et al.*, 2015; Juselius *et al.*, 2017)) in growth studies. Both reasons prompted us exploiting time series instruments in our empirical strategies. In addition, time series applications' universal acceptance as a superior technology of handling stationary data, motivated us in a great deal (Phillips and Perron, 1988). Generally, time series data are nonstationary in nature and models with nonstationary variables and their statistical significance vastly a debated issue (Wassell and Saunders, 2005). Since, regressions between two or more nonstationary series often produce spurious outcomes; notably, in the form of high coefficient of determination (R^2), and significant t-statistics even in the absence of sensible correlation (Granger and Newbold, 1974; Phillips and Perron, 1988; Wassell and Saunders, 2005). For this reason, regressions output derived from nonstationary series frequently disqualify for rational policy implications (Wassell and Saunders, 2005).To address this problem, time series techniques initially examine (unit root test) quality (stationarity) of data before using it in empirical investigations.

4.1. Testing Stationery: The Unit Root Test

Unit root testis predominantly exploited to identify the stationarity (whether a variable is stationary or nonstationary) of a series (Gujarati, 2004). Major features of stationarity is that when mean and autocovariances of a series does not depend on time then the series is stationary; and in contrast, a series which mean and autocovariances depend on time labeled as nonstationary (Gujarati, 2004). A typical nonstationary series is the random walk can be expressed in the following form:

$$Y_t= \rho Y_{t-1} + u_t \quad (16)$$

In this model u_t is a white noise error term. The variance of series Y is changing over time since it depends on the condition of t. While random walk is a difference stationary series and the first difference of Y is stationary and can be written in the form of:

$$\Delta Y_t = \delta Y_{t-1} + u_t \quad (17)$$

Estimating above equation we take null hypothesis $\delta= 0$, If $\rho=1$ then $\delta= 0$ meaning that series under consideration has a unit root, and the series is not stationary. The notion is that a difference stationary series is integrated and symbolized as I(d), and d denotes order of integration, the number of unit roots a series contained or the number of difference operations required to make a series stationary. For example, a series has one unit root signified as I(1) series, and a stationary series free of unit root symbolized as I(0) series. In analytical environments several types of unit root test practiced. Among those tests, we utlize a popularly accepted method of an advance option of Dickey-Fuller (DF) test- universally known as augmented Dickey-Fuller (ADF) test (Ng and Perron, 1995).Generally, DF test conducted in three distinct forms considering diverse possibilities, and the options are: random walk process has no drift, random walk process may have drift, and random walk process may have both deterministic and stochastic trends (Gujarati, 2004). While, conducting a DF test, hypothesis is that error term u_t

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[9]We proxy foreign aid as the net disbursement flows of official development assistance (ODA)
[10] Details of the variable descriptions stated in appendix C
[11]According to World Bank (2017). Bangladesh's per capita GDP (current prices) in 2014 is US $1,086.80. On the contrary, IMF World Economic Outlook April 2017 shows that Bangladesh's per capita GDP (curr) in 2014 is US $ 1,162.74.

$$\sum_{i=1}^{m} \alpha_i$$

remains uncorrelated (Gujarati, 2004). However, difficulties surfaced when u_t is correlated. To resolve this, Dickey and Fuller (1979) developed a modified version by 'augmenting' all three types of DF test equations and adding a lagged value of dependable variable ΔY_t. However, in this paper we estimate the regressions based on the following two ADF test equations[12] (Gujarati, 2004):

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \quad \Delta Y_{t-i} + \varepsilon_t \qquad (18)$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \varepsilon_t \qquad (19)$$

Table-1. Augmented Dickey-Fuller (ADF) test output (5% level of significance)

Variable	ADF test statistic (t-statistic)		Test critical values (t-statistic)		Prob.	
	Constant	Constant, trend	Constant	Constant, trend	Constant	Constant, trend
Level						
GDP	-2.935001	-3.523623	3.553140	1.660312	1.0000	1.0000
ODA	-2.936942	-3.540328	-0.479362	-2.056948	0.8848	0.5514
CAPITAL	-2.936942	-3.526609	-1.581257	-3.330771	0.4827	0.0759
POPLG	-2.938987	-3.529758	0.392503	-2.200237	0.9801	0.4762
First difference						
D(GDP)	-2.936942	-3.526609	-4.222689	-5.446197	0.0019	0.0003
D(ODA)	-2.936942	-3.526609	-9.563917	-9.593832	0.0000	0.0000
D(CAPITAL)	-2.936942	-3.526609	-5.269162	-5.291244	0.0001	0.0005
D(POPLG)	-2.938987	-3.529758	-9.291159	-8.351394	0.0000	0.0000

The ADF test statistic displayed in Table 1, indicate that all four variables are integrated in order of 1 meaning that all four variables are I(1)series. Since, the variables are I(1), therefore, we need to identify the number of cointegrating vectors in the subsequent analytical process (Oxley and Greasley, 1998); (Masih and Masih, 1997). However, conducting remaining tests, we need to determine optimal lag length, at first.

4.2. Selection of Optimal Lag Order

Determining optimal lag length we follow Toda and Yamamoto (1995) approach. In doing so, we capitalize usual methods and conduct an unrestricted VAR estimate involving data in levels with automatic 2 lag order. The lag order selection output exhibited in Table 2, and five lag selection criterions (LR, FPE, AIC, SC, HQ) suggest that optimal lag length is 3. For cross checking, we attempt another unrestricted VAR estimation with 4 lag order. Nevertheless, this calculation also recommends same lag length, 3. Since, all the series are integrated in order of I(1), therefore, following T-Y approach we decide optimal lag order is 4 (3+1) by adding an extra lag. Consequently, we use 4 lag orders in all the remaining estimations.

Table-2. VAR lag order selection output

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-375.7156	NA	5617.1111	19.98503	20.15741	20.04636
1	-177.8088	343.7328	0.392830	10.41099	11.27288	10.71764
2	-139.9454	57.79162	0.128150	9.260282	10.81168	9.812257
3	-98.49156	54.54447*	0.036300*	7.920608*	10.16152*	8.717906*
4	-82.76160	17.38575	0.043093	7.934821	10.86524	8.977441

Source: Authors' calculation
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

4.3. Testing Cointegration Using Johansen's Methodology

Analysis of this chapter involves testing cointegration. To move forward, we conduct Johansen (1991;1995) multivariate system of cointegration test to ascertain cointegration relations among the variables. Engle and Granger (1987) are the pioneer of cointegration methodology (Ahmed and Kenji, 2017). However, emergence of Johansen (1991;1995) and Johansen and Juselius (1990) methodologies and their procedural supremacy due to system-based evaluation technologies of cointegration vectors has gained sensible edge over Engle and Granger (1987) theory (Ahmed and Kenji, 2017).While, in a multivariate time series approach with maximum likelihood procedures; Johansen's methodolgy considered as an advanced option (Masih and Masih, 1997). Typically, Johansen methodology is suitable in such an environment where all the variables integrated in order of I(1) (Österholm and Hjalmarsson, 2007). Since, all variables of our model qualify to this criteria therefore, it would be an appropriate practice to apply Johansen's method. Moreover, within a vector error correction (VEC), framework Johansen's methodology extensively utilized to develop substantial strategies identifying cointegrating relations between the variables (Oxley and Greasley, 1998; Ghosh, 2002). Accordingly, determining cointegration vectors we estimate following equation with order of p:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + B_{xt} + \epsilon_t \qquad (20)$$

[12] Equation 16 estimates regression with intercept, while in Equation 17 regressions' estimated with trend and intercept

In this framework y_t is a vector of nonstationary I(1) variables, x_t is a vector of deterministic variables and ϵ_t is a vector of innovations. We can rewrite the equation in the following form also:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p=1} \Gamma_1 \Delta y_{t-i} + B_{xt} + \epsilon_t \qquad (21)$$

Table-3. Johansen cointegration test output (lags interval in first differences: 1 to 4)

Hypothesized No. of CE(s)	Test statistic		0.05 critical value		Prob.**	
	Trace	Max-Eigen	Trace	Max-Eigen	Trace	Max-Eigen
Trend assumption: Linear deterministic trend						
None	119.5347*	61.00638*	47.85613	27.58434	0.0000	0.0000
At most 1	58.52829*	38.02562*	29.79707	21.13162	0.0000	0.0001
At most 2	20.50268*	16.66634*	15.49471	14.26460	0.0081	0.0205
At most 3	3.836339	3.836339	3.841466	3.841466	0.0501	0.0501
Trend assumption: Linear deterministic trend (restricted)						
None	160.7710*	62.71900*	63.87610	32.11832	0.0000	0.0000
At most 1	98.05200*	48.77429*	42.91525	25.82321	0.0000	0.0000
At most 2	49.27772*	32.61259*	25.87211	19.38704	0.0000	0.0004
At most 3	16.66513*	16.66513*	12.51798	12.51798	0.0096	0.0096

Source: Authors' calculation

a. Trace and max-eigen value test indicates 3 cointegrating equations at 0.05 levels under the linear deterministic trend
b. Trace and max-eigen value test indicates 4 cointegrating equations at 0.05 levels under the linear deterministic trend (restricted)
*Denotes rejection of hypothesis at 0.05 level
**MacKinnon *et al.* (1999) p-values

To identify cointegration relationships firstly, we capitalize estimation within linear deterministic trend with 4 lag order to conclude on null hypotheses of 0, 1 and 2cointegration vectors. The output sited in Table 3 indicates that both Trace (119.5347; 58.52829; 20.50268), and Max-Eigen value (61.00638; 38.02562; 16.66634) statistic are significant at 0.05 critical level, and which confirms existence of 3 cointegrating vectors. Similarly, testing null hypotheses of 0, 1, 2 and 3 cointegrating vectors, output of another estimation with 4 lag order and within linear deterministic trend (restricted) find that Trace (160.7710; 98.05200; 49.27772; 16.66513), and Max-Eigen value (62.71900; 48.77429; 32.61259; 16.66513) statistic also remain significant at 0.05 critical level confirming 4 cointegratiing vectors. Thus, existence of multiple cointegrating vectors has been proved through this test.

4.4. Vector Error Correction Estimate

In the preceding two tests we examine quality of data. The initial one, ADF test determines that order of integration of all series stand at I(1) confirming the existence of unit roots and more specifically, data will be stationary at first differences. However, major concern is that data in levels suffer significant damage of information linked to their co-movement while making it stationary through first differencing operations (Wahab and Applanaidu, 2015). Subsequent investigation, Johansen maximum likelihood (ML) test of cointegration locates multiple cointegrating vectors and which indicates presence of long-run equilibrium relationship among the variables. Considering such an environment, Engle and Granger (1987) suggest that a vector error correction modeling (VECM) is the appropriate approach instead of a typical VAR estimation to explain the relationships. Therefore, we capitalize (Engle and Granger, 1987) vector error correction framework in the following form to identify causal relationships:

$$\Delta GDP_t = \alpha + \Sigma\beta_1\Delta GDP_{t-n} + \Sigma\beta_2\Delta ODA_{t-n} + \Sigma\beta_3\Delta CAPITAL_{t-n} + \Sigma\beta_4\Delta POPLG_{t-n} + \lambda ECT_{t-n} + \varepsilon_t \qquad (22)$$

Where α is the constant, λ stands for coefficient of error correction term, ECT_{t-n} is the error correction term and ε_t is the white noise error term. In addition, n is the optimal lag length and β_1, β_2, β_3 and β_4 are the coefficients which explain short-run Granger causality of explanatory variables on dependent variable. While coefficient of ECT exploited to determine the long-run equilibrium relationships, and for Granger causality it must be negative and significant (Ahmed and Kenji, 2017).

Table-4. Vector error correction estimates output

Variable	Coefficient	t-statistic	Prob.
Model A: Dependent variable ΔGDP			
ECT	-0.018332	-1.654018	0.1146
C	32.67681	1.834772	0.0822
Δ GDPt-1	0.192055	0.743635	0.4662
Δ GDPt-2	-0.132601	-0.603823	0.5531
Δ GDPt-3	0.326056	1.735313	0.0989
Δ GDPt-4	-0.021262	-0.103901	0.9183
Δ ODAt-1	0.944205	0.114328	0.9102
Δ ODAt-2	2.950476	0.259035	0.7984
Δ ODAt-3	4.675114	0.469008	0.6444
Δ ODAt-4	0.230430	0.032125	0.9747
Δ CAPITALt-1	-8.834268	-0.827020	0.4185
Δ CAPITALt-2	-7.986122	-0.876074	0.3019
Δ CAPITALt-3	2.340438	0.306893	0.7623
Δ CAPITALt-4	0.218031	0.032159	0.9747
Δ POPLGt-1	574.9397	1.388137	0.1812
Δ POPLGt-2	-917.3912	-1.020177	0.3205
Δ POPLGt-3	682.4348	0.777814	0.4463
Δ POPLGt-4	-136.3971	-0.337605	0.7394

There are 4 models emerged from the vector error correction estimates (details in appendix, E-2). Out of 4 models we are basically focus on a solo model which is taking GDP as the dependent variable. For analytical convenience, we define this model as model-A. Similarly, we define rest of the three models as model-B (dependent variable Δ ODA) model-C (dependent variable ΔCAPITAL), and model-D (dependent variable Δ POPLG). All coefficients of vector error correction estimates (displayed in Table 4) of model-A found insignificant at 5% and 10% significance level stating the nonexistence of short-run or long-run causality among the explanatory variables and GDP growth (ΔGDP). Since, major purpose of this study is to explain aid-growth nexus therefore; we check four aid coefficients through conducting Wald Test (taking null hypothesis $\Delta ODA_{t-1} = \Delta ODA_{t-2} = \Delta ODA_{t-3} = \Delta ODA_{t-4} = 0$). Results displayed in Table 5, and it indicates the absence of short-run causality of aid on GDP growth.

Table-5. Output of Wald Test

Null Hypothesis: $\Delta ODA_{t-1} = \Delta ODA_{t-2} = \Delta ODA_{t-3} = \Delta ODA_{t-4} = 0$

Test Statistic	Value	df	Probability
F-statistic	0.113678	(4,19)	0.9761
Chi-square	0.454714	4	0.9778

On the contrary, error correction term (ECT), which is used to examine long-run causality estimated at: coefficient, -0.018332 and probability (prob.) 0.1146 respectively. The ECT also confirms the nonexistence of long-run equilibrium relationships among the dependent and explanatory variables.

4.5. Vector Error Correction Granger Causality/Block Exogeneity Wald Tests

Identifying causal relationship we conduct another test- Granger causality/block exogeneity Wald tests using vector error correction framework. The output (details in appendix, F) in Table 6 demonstrates the absence of Granger causality while taking ΔGDP as the dependent variable. In contrast, when ΔODA, ΔCAPITAL, and ΔPOPLG are considered dependent variable we can reject null hypothesis of no causality at 5% significance level and that confirms the presence of Granger causality. Therefore, this estimation endorses our analytical approach since, it is consistent with one of the important features of the significance of VEC models that cointegrated variables must have causality 'at least one direction either unidirectional or bidirectional' (Granger, 1986; Granger, 1988; Masih and Masih, 1997).

Table-6. Vector error correction Granger Causality/Block Exogeneity Wald Tests output

Model	Dependent variable	Independent variable	Chi-sq	df	Prob.
A	ΔGDP	ΔODA ΔCAPITAL ΔPOPLG	10.42330	12	0.5789
B	ΔODA	ΔGDP ΔCAPITAL ΔPOPLG	22.25028	12	0.0348
C	ΔCAPITAL	ΔGDP ΔODA ΔPOPLG	31.27932	12	0.0018
D	ΔPOPLG	ΔGDP ΔODA ΔCAPITAL	27.84601	12	0.0058

4.6. Residual Diagnostic Tests of VECM

We examine model-A's significance through conducting several residual diagnostic tests (details in appendix, G) and output exhibited in Table 7. At first, we conduct Breusch-Godfrey serial correlation LM test to check serial correlation. Estimated F-statistic and corresponding probability (prob.) reveals that model-A is free of autocorrelation problem. While, three types of heteroskedasticity tests including Breusch-Pagan-Godfrey, Harvey, and ARCH carried out to identify the heteroskedasticity of time series regression of model-A. All three estimated F-statistic and corresponding probabilities suggest that null hypothesis of no heteroskedasticity is not in a position for rejection. Finally, we conduct histogram normality test of Jarque-Bera to check data distribution status. The Jarque-Bera statistic and corresponding probability (prob.) suggests that data are normally distributed. Therefore, all the residual diagnostic tests confirm the significance of model-A. In addition, model-A's statistical significance also established in other ways particularly, with a good R^2 of 0.692773 and a significant prob. (F-statistic) of 0.027249 (appendix, E-2).

Table-7. Summary of residual diagnostic tests

<table>
<tr><th colspan="2" rowspan="2">Breusch-Godfrey Serial Correlation LM Test*</th><th colspan="6">Heteroskedasticity Test</th><th colspan="2" rowspan="2">Histogram- Normality Test</th></tr>
<tr><th colspan="2">Breusch-Pagan-Godfrey</th><th colspan="2">Harvey</th><th colspan="2">ARCH**</th></tr>
<tr><td>F-statistic</td><td>Prob. (4, 15)</td><td>F-statistc</td><td>Prob. F (20, 16)</td><td>F-statistc</td><td>Prob. F (20, 16)</td><td>F-statistc</td><td>Prob. F (20, 16)</td><td>Jarque-Bera</td><td>Probability</td></tr>
<tr><td colspan="10">Model: Dependent variable ΔGDP</td></tr>
<tr><td>0.926414</td><td>0.4746</td><td>1.047583</td><td>0.4686</td><td>1.661351</td><td>0.1532</td><td>0.843695</td><td>0.5094</td><td>0.846931</td><td>0.654774</td></tr>
</table>

Source: Authors' calculation
* Lag to include 4
**Number of lag 4

5. Conclusions

We endeavor to answer few crucial issues raised at the prevailing aid-growth literature including model specification, instrumentation, and estimation strategies. Firstly, we address the issue of model specification proposing an aid-growth approach exploiting both neoclassical cross-country growth model (Barro, 1991) and Cobb-Douglas production technology. In relation to instrumentation strategies, we intensely survey 'conditional growth studies' where it is argued that aid effectiveness depends on good macroeconomic, trade, political, and environmental policies. However, we simply rely on conventional macroeconomic statistic instead of incorporating policy variables; since, highly rated (Rajan and Subramanian, 2008) remain unsuccessful finding any significance of development assistances while incorporating policy variables with conventional macroeconomic variables following four major 'conditional aid-growth studies'[13]. We consider this will act to get back the aid-growth debate on the right track. In the next, we address the concerns of Deaton (2010) and Rajan and Subramanian (2008) regarding the inability of typical cross-country OLS estimations to get rid of the 'spurious regressions' problem due to the existence of noise in the data. We adopt country-specific approach by taking the case of a leading aid-recipient country. Our estimation strategies equipped with error correction techniques which are able keeping the outcomes free of 'spurious regressions' problem. Capitalizing vector error correction modeling and Granger causality test within the vector error correction framework, we do not find any short-run or long-run causality of development assistance on real GDP growth. Therefore, our findings strongly support (Rajan and Subramanian, 2008) and reject the conclusions of so-called 'conditional growth studies'. We consider this study has great policy implications since; core development planning of LDCs still depends on the size of ODA. Given this context, country's like Bangladesh who aspires rapid economic development need to redefine major growth strategies and to revisit existing approaches regarding ODA financed development programs.

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Appendix A: Abbreviations

ADF test: Augmented Dickey-Fuller test
AEL: Aid effectiveness literature
AIC: Akaike information criterion
ECT: Error correction term
FPE: Final prediction error
GDP: Gross domestic product
GNI: Gross national income
HQ: Hannan-Quinn information criterion
IMF: International Monetary Fund
LDC: Less developed country
LDCs: Less developed countries
ODA: Official development assistance
OLS: Ordinary least squares
SC: Schwarz information criterion
T-Y: Toda and Yamamoto
WDI: World development indicators
WEO: World economic outlook
WW2: World War Two
VAR: Vector auto regression
VECM: Vector error correction modeling

Appendix B: The Data

Year	GDP per capita in US $ (GDP)	ODA(percent of GNI)	Gross capital formation (percent of GDP) (CAPITAL)	Population growth (POPLG)
1973	117.7819065	5.198165	8.712006898	1.585485524
1974	179.1641755	4.243359853	7.374857223	1.703316829
1975	272.9701785	5.512471456	6.147905815	1.997715897
1976	138.7232244	4.927019983	9.911362042	2.334804116
1977	128.942513	8.162886773	11.5232178	2.596271472
1978	172.6062003	7.5161892	11.54679855	2.766916511
1979	196.6780059	7.48378619	11.20387213	2.810825619
1980	222.9242646	7.08665606	14.4393913	2.769204023
1981	242.2224312	5.337540043	17.15576644	2.710344222
1982	215.7421858	7.096030945	17.36327909	2.677536855
1983	199.6916194	5.751979043	16.56273677	2.658002448
1984	208.9325984	6.100986381	16.48425757	2.661362183
1985	239.5138363	4.972468716	15.8309437	2.675519221
1986	227.8791364	6.432029907	16.17645483	2.689529516
1987	247.5620475	7.208769256	15.47344203	2.683137929
1988	263.7341157	5.938576105	15.73598307	2.64460664
1989	278.3516037	6.116851021	16.12091443	2.567501631
1990	298.144992	6.492388153	16.45867552	2.466950281
1991	285.296976	5.946636189	16.89594746	2.355938926
1992	285.6978098	5.598726634	17.30502928	2.257783657
1993	292.3645263	4.060145962	17.94683201	2.187760068
1994	291.3258679	5.004785042	18.40255619	2.155122135
1995	320.3619277	3.27837883	19.11979582	2.1457187
1996	383.8299551	2.577291706	20.7299506	2.138090473
1997	390.4079054	2.04049926	21.81621451	2.115690607
1998	396.1696495	2.26168444	22.12141282	2.078586608
1999	398.2295463	2.307716612	22.7213703	2.021669268
2000	406.5317405	2.128498674	23.80856257	1.94944844
2001	403.5945462	1.876225243	24.17430673	1.882916186
2002	401.7081533	1.592481356	24.34141614	1.816606212
2003	434.0465632	2.228824518	24.67918886	1.726004223
2004	462.2748798	2.08147327	24.99183394	1.605803333
2005	485.8528881	1.818585047	25.83043551	1.47034775
2006	495.8537802	1.609564116	26.14414575	1.326957091
2007	543.0822631	1.788530336	26.17849707	1.203348026
2008	618.0758836	2.098240471	26.2022714	1.125881485
2009	683.6144223	1.108309467	26.20605702	1.109061795
2010	760.3319352	1.126595014	26.24665618	1.134879634
2011	838.5478017	1.074870504	27.42097337	1.172933905
2012	858.9333626	1.485229114	28.26233501	1.199882864
2013	954.3963997	1.622223223	28.38962075	1.216351172
2014	1086.800087	1.31122154	28.57787571	1.214377385

Source: World Bank World Development Indicators 2017

Appendix C: Data Description

Variable	Description
GDP	GDP per capita is gross domestic product (current prices in US $) divided by midyear population.
ODA	Net official development assistance (ODA) consists of disbursements of loans made on concessional terms and grants by official agencies of the members of the Development Assistance Committee (DAC), multilateral institutions, and non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients, expressed at percentage of gross national income (GNI).
Capital (CAPITAL)	Capital is the gross capital formation expressed in percentage of GDP consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.
Population (POPLG)	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.

Source: World Bank World Development Indicators 2017

Appendix D: Johansen Cointegration Test

Date: 06/04/17 Time: 9:49
Sample (adjusted): 1978 2014
Included obervations: 37 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: GDP ODP CAPTIAL POPLG
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Elgenvalue	Trace statistic	0.05 Critical Value	Prob.**
None *	0.807724	119.5347	47.85613	0.0000
At most 1*	0.642178	58.52829	29.79707	0.0000
At most 2*	0.362653	20.50268	15.49471	0.0081
At most 3*	0.098491	3.836339	3.841466	0.0501

Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-value

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Elgenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.807724	61.00638	27.58434	0.0000
At most 1*	0.642178	38.02562	21.13162	0.0001
At most 2*	0.362653	16.66634	14.26460	0.0205
At most 3*	0.098491	3.836339	3.841466	0.0501

Max-eigenvalue test indicates 3 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-value

Date: 06/04/17 Time: 10:03
Sample (adjusted): 1978 2014
Included observations: 37 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: GDP ODP CAPTIAL POPLG
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Elgenvalue	Trace statistic	0.05 Critical Value	Prob.**
None *	0.816421	160.87610	63.87610	0.0000
At most 1*	0.732390	42.91525	42.91525	0.0000
At most 2*	0.585806	25.87211	25.87211	0.0000
At most 3*	0.362633	12.51798	12.51798	0.0096

Trace test indicates 4 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-value

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Elgenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.816421	62.71900	32.11832	0.0000
At most 1*	0.732390	48.77429	25.82321	0.0000
At most 2*	0.585806	32.61259	19.38704	0.0000
At most 3*	0.362633	16.66513	12.51798	0.0096

Max-eigenvalue test indicates 4 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-value

Appendix E

1 Vector Error Correction Estimates

Date: 04/06/17 Time: 14:15
Sample (adjusted): 1978-2014
Included observations: 37 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1			
GDP (-1)	1.000000			
ODA (-1)	124.4875 (154.249) [0.80705)			
CAPITAL (-1)	92.06700 (78.0954) [1.17890]			
POPULATION (-1)	2489.280 (408.444) [6.09454]			
C	-7928.584			
Error Correction	D (GDP)	D (ODA)	D (CAPITAL)	D (POPLG)
CointEq1	-0.018332 (0.01108) [-1.65402]	-0.000722 (0.00029) [-2.50244]	-0.000296 (0.00023) [-1.31052]	-5.76E-07 (5.1E-06) [-0.11193]

D (GDP(-1))	0.192055 (0.25827) [0.74363]	-0.010328 (0.00673) [-1.53548]	0.005085 (0.00527) [0.96510]	-4.77E-05 (0.00012) [-0.39738]
D (GDP(-2))	-0.132601 (0.21960) [-0.60382]	-0.003558 (0.00572) [-0.62202]	-0.005496 (0.00448) [-1.22676]	-2.01E-06 (0.00010) [-0.19708]
D (GDP(-3))	0.326056 (0.18789) [1.73531]	-0.006538 (0.00489) [-1.33610]	0.003398 (0.00383) [0.88644]	0.000121 (8.7E-05) [1.38744]
D (GDP(-4))	-0.021262 (0.20464) [-0.10390]	0.011214 (0.00533) [2.10410]	-0.008723 (0.00417) [-2.08938]	-3.52E-05 (9.5E-05) [-0.36988]
D (ODA(-1))	0.944206 (8.25877) [0.11433]	-0.819793 (0.21510) [-3.81128]	-0.237344 (0.16848) [-1.40873]	0.001366 (0.00384) [0.35597]
D (ODA(-2))	2.950476 (11.3903) [0.25904]	-0.818083 (0.29666) [-275769]	-0.163204 (0.23236) [0.70237]	0.005637 (0.00529) [1.065081]
D (ODA(-3))	4.675114 (9.96808) [0.46901]	-0.606285 (0.25962) [-2.33532]	-0.204697 (0.20335) [-1.00662]	0.003029 (0.00463) [0.65406]
D (ODA(-4))	0.230430 (7.17290) [0.03213]	-0.351906 (0.18682) [-1.88371]	-0.038276 (0.14633)[- [0.026157]	0.002578 (0.00333) [0.77349]
D (CAPITAL(-1))	-8.834268 (10.6821) [-0.82702	-0.717825 (0.27821) [-2.58015]	0.350906 (0.21792) [1.61028]	0.004207 (0.00496) [0.84761]
D (CAPITAL(-2))	-7.986122 (9.11581) [-0.87607]	-0.214859 (0.23742) [-0.90498]	-0.358030 (0.18596) [-1.92526]	0.004375 (0.00424) [1.03290]
D (CAPITAL(-3))	2.340438 (7.62624) [0.30689]	-0.557906 (0.19862) [-2.80887]	0.076628 (0.15558) [0.49254]	-0.005680 (0.00354) [-1.60306]
D (CAPITAL(-4))	0.218031 (6.77971) [0.03216]	-0.333128 (0.17658) [-1.88661]	-0.006779 (0.13831) [-0.04901]	0.008697 (0.00315) [2.76098]
D (POPULATION(-1))	574.9397 (414.181) [1.38814]	-16.34547 (10.7872) [-1.51527]	-14.58656 (8.44938) [1.72635]	1.993824 (0.19245) [10.3604]
D (POPULATION(-2))	-917.3912 (899.247) [-1.02018]	41.35613 (23.4206) [1.76580]	30.92362 (18.3448) [1.68568]	-1.439530 (0.41783) [-3.44527]
D (POPULATION(-3))	682.4348 (877.375) [0.77781]	-37.31820 (22.8509) [2.33422]	11.24026 (8.24197) [1.36378]	0.349115 (0.40767) [0.85638]
D (POPULATION(-4))	-136.3971 (404.014) [-0.33761]	24.56161 (10.5224) [2.33422]	0.496043 (0.36332) [1.36378]	-0.001850 (0.18772) [-0.00986]
C	32.67681 (17.8097) [1.83477]	0.876607 (0.46385) [1.88986]	0.496043 (0.36332) [1.365301]	-0.007797 (0.00828) [-0.94217]
R-squared	0.692773	0.624266	0.765374	0.980194
Adj. R-squared	0.417886	0.288082	0.555446	0.962473
Sum sq. resids	12619.18	8.559883	5.251719	0.002724
S.E. equation	25.77144	0.671208	0.525744	0.011975
F-statistic	2.520211	1.856919	3.645887	55.31306
Log Likelihood	-160.3937	-25.41984	-16.38202	123.5532
Akaike A/C	9.642906	2.347019	1.858488	-5.705580
Schwarz SC	10.42659	3.130708	2.642177	-4.921890
Mean Dependent	25.88804	-0.185180	0.460937	-0.037348
S. D. Dependent	33.77807	0.795504	0.788518	0.061814

Determinant resid covariance (dof adj.)	0.002483
Determinant resid covariance	0.000173
Log Likelihood	-49.71323
Akaike information criterion	6.795310
Schwarz criterion	10.10422

2. Vector Error Correction Estimates

Dependent Variable: D(GDP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 05/30/17 Time: 13:21
Sample (adjusted): 1978 2014
Included observations: 37 after adjustments
D(GDP) = C(1)*(GDP(-1) + 124.487483696*ODA(-1) + 92.0669986939
*CAPITAL(-1) + 2489.28043071*POPLG(-1) - 7928.5843028) + C(2)
*D(GDP(-1)) + C(3)*D(GDP(-2)) + C(4)*D(GDP(-3)) + C(5)*D(GDP(-4))
+ C(6)*D(ODA(-1)) + C(7)*D(ODA(-2)) + C(8)*D(ODA(-3)) + C(9)
*D(ODA(-4)) + C(10)*D(CAPITAL(-1)) + C(11)*D(CAPITAL(-2)) + C(12)
*D(CAPITAL(-3)) + C(13)*D(CAPITAL(-4)) + C(14)*D(POPLG(-1)) +
C(15)*D(POPLG(-2)) + C(16)*D(POPLG(-3)) + C(17)*D(POPLG(-4)) +
C(18)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.018332	0.011084	-1.654018	0.1146
C(2)	0.192055	0.258265	0.743635	0.4662
C(3)	-0.132601	0.219603	-0.603823	0.5531
C(4)	0.326056	0.187894	1.735313	0.0989
C(5)	-0.021262	0.204640	-0.103901	0.9183
C(6)	0.944205	8.258765	0.114328	0.9102
C(7)	2.950476	11.39025	0.259035	0.7984
C(8)	4.675114	9.968084	0.469008	0.6444
C(9)	0.230430	7.172901	0.032125	0.9747
C(10)	-8.834268	10.68205	-0.827020	0.4185
C(11)	-7.986122	9.115808	-0.876074	0.3919
C(12)	2.340438	7.626244	0.306893	0.7623
C(13)	0.218031	6.779708	0.032159	0.9747
C(14)	574.9397	414.1807	1.388137	0.1812
C(15)	-917.3912	899.2467	-1.020177	0.3205
C(16)	682.4348	877.3752	0.777814	0.4463
C(17)	-136.3971	404.0136	-0.337605	0.7394
C(18)	32.67681	17.80975	1.834772	0.0822

R-squared	0.692773	Mean dependent var	25.88804
Adjusted R-squared	0.417886	S.D. dependent var	33.77807
S.E. of regression	25.77144	Akaike info criterion	9.642905
Sum squared resid	12619.18	Schwarz criterion	10.42659
Log likelihood	-160.3937	Hannan-Quinn criter.	9.919192
F-statistic	2.520211	Durbin-Watson stat	1.891938
Prob(F-statistic)	0.027249		

Appendix F: VEC Granger Causality/ Block Exogeneity Wald Tests

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 05/30/17 Time: 14:10
Sample: 1973 2014
Included observations: 37

Dependent variable: D(GDP)

Excluded	Chi-sq	df	Prob.
D(ODA)	0.454714	4	0.9778
D(CAPITAL)	2.913232	4	0.5724
D(POPLG)	3.250685	4	0.5168
All	10.42330	12	0.5789

Dependent variable: D(ODA)

Excluded	Chi-sq	df	Prob.
D(GDP)	6.991891	4	0.1363
D(CAPITAL)	15.11521	4	0.0045
D(POPLG)	13.57706	4	0.0088
All	22.25028	12	0.0348

Dependent variable: D(CAPITAL)

Excluded	Chi-sq	df	Prob.
D(GDP)	6.078254	4	0.1934
D(ODA)	3.926476	4	0.4160
D(POPLG)	7.677406	4	0.1041
All	31.27932	12	0.0018

Dependent variable: D(POPLG)

Excluded	Chi-sq	df	Prob.
D(GDP)	2.178736	4	0.7029
D(ODA)	1.822800	4	0.7683
D(CAPITAL)	11.49740	4	0.0215
All	27.84601	12	0.0058

Appendix G: Residual Diagnostics

1 Breusch-Godfrey Serial Correlation L M Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.926414	Prob. F(4,15)	0.4746
Obs*R-squared	7.329830	Prob. Chi-Square(4)	0.1195

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/30/17 Time: 14:13
Sample: 1978 2014
Included observations: 37
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.018832	0.070014	0.268982	0.7916
C(2)	0.760697	3.267906	0.232778	0.8191
C(3)	-0.169576	0.822695	-0.206123	0.8395
C(4)	0.256660	0.646442	0.397035	0.6969
C(5)	-0.162085	1.089713	-0.148741	0.8837
C(6)	-6.310117	9.289973	-0.679240	0.5073
C(7)	-7.948015	14.58463	-0.544958	0.5938
C(8)	-6.127644	12.02688	-0.509496	0.6178
C(9)	-5.035852	12.79780	-0.393494	0.6995
C(10)	-6.649461	13.64556	-0.487298	0.6331
C(11)	6.855772	34.09074	0.201104	0.8433
C(12)	7.840021	31.75620	0.246882	0.8083
C(13)	0.465407	7.692474	0.060502	0.9526
C(14)	15.23944	438.5801	0.034747	0.9727
C(15)	-726.7694	1913.512	-0.379809	0.7094
C(16)	1024.182	2425.276	0.422295	0.6788
C(17)	-530.9792	1511.716	-0.351243	0.7303
C(18)	-32.49555	118.4548	-0.274329	0.7876
RESID(-1)	-0.920582	3.344450	-0.275257	0.7869
RESID(-2)	-0.190278	0.381904	-0.498237	0.6255
RESID(-3)	-0.509558	0.390503	-1.304876	0.2116
RESID(-4)	-0.480914	0.401685	-1.197243	0.2498

R-squared	0.198104	Mean dependent var	0.000000
Adjusted R-squared	-0.924552	S.D. dependent var	18.72252
S.E. of regression	25.97341	Akaike info criterion	9.638346
Sum squared resid	10119.27	Schwarz criterion	10.59619
Log likelihood	-156.3094	Hannan-Quinn criter.	9.976030
F-statistic	0.176460	Durbin-Watson stat	2.082360
Prob(F-statistic)	0.999818		

2. Heteroskedasticity Tests

Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.047583	Prob. F(20,16)	0.4686
Obs*R-squared	20.97907	Prob. Chi-Square(20)	0.3984
Scaled explained SS	7.501930	Prob. Chi-Square(20)	0.9947

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/30/17 Time: 14:16
Sample: 1978 2014
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4022.146	5353.060	-0.751373	0.4633
GDP(-1)	-2.295792	6.225320	-0.368783	0.7171
ODA(-1)	-186.8592	194.6259	-0.960094	0.3513
CAPITAL(-1)	170.4243	278.9498	0.610950	0.5498
POPLG(-1)	-647.3674	9708.019	-0.066684	0.9477
GDP(-2)	-2.677819	7.849666	-0.341138	0.7374
GDP(-3)	7.695602	6.487008	1.186310	0.2528
GDP(-4)	-6.905654	7.133606	-0.968045	0.3474
GDP(-5)	7.919689	5.455991	1.451558	0.1660
ODA(-2)	128.1970	217.4604	0.589519	0.5637
ODA(-3)	-115.4529	222.4529	-0.518999	0.6109
ODA(-4)	219.5739	192.0088	1.143562	0.2696
ODA(-5)	238.5780	186.6494	1.278215	0.2194
CAPITAL(-2)	-234.5552	311.9238	-0.751963	0.4630
CAPITAL(-3)	228.8284	257.3921	0.889027	0.3872
CAPITAL(-4)	-202.2138	240.7063	-0.840085	0.4132
CAPITAL(-5)	151.7398	157.2671	0.964854	0.3490
POPLG(-2)	354.0182	28946.88	0.012230	0.9904
POPLG(-3)	7822.916	38353.49	0.203969	0.8409
POPLG(-4)	-10393.10	27361.20	-0.379848	0.7091
POPLG(-5)	2810.952	8827.230	0.318441	0.7543

R-squared	0.567002	Mean dependent var	341.0588
Adjusted R-squared	0.025754	S.D. dependent var	569.4236
S.E. of regression	562.0433	Akaike info criterion	15.79784
Sum squared resid	5054283.	Schwarz criterion	16.71215
Log likelihood	-271.2601	Hannan-Quinn criter.	16.12018
F-statistic	1.047583	Durbin-Watson stat	2.471773
Prob(F-statistic)	0.468576		

3. Harvey

Heteroskedasticity Test: Harvey

F-statistic	1.661351	Prob. F(20,16)	0.1532
Obs*R-squared	24.97409	Prob. Chi-Square(20)	0.2024
Scaled explained SS	30.42615	Prob. Chi-Square(20)	0.0632

Test Equation:
Dependent Variable: LRESID2
Method: Least Squares
Date: 05/30/17 Time: 14:23
Sample: 1978 2014
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.244155	20.24627	0.407194	0.6893
GDP(-1)	-0.028725	0.023545	-1.219967	0.2402
ODA(-1)	-1.458669	0.736111	-1.981589	0.0650
CAPITAL(-1)	-0.665133	1.055040	-0.630434	0.5373
POPLG(-1)	23.59535	36.71753	0.642618	0.5296
GDP(-2)	-0.003045	0.029689	-0.102576	0.9196
GDP(-3)	0.051833	0.024535	2.112591	0.0507
GDP(-4)	-0.027703	0.026981	-1.026779	0.3198
GDP(-5)	0.027118	0.020636	1.314139	0.2073
ODA(-2)	-1.134605	0.822475	-1.379500	0.1867
ODA(-3)	0.863611	0.841358	1.026449	0.3199
ODA(-4)	1.260613	0.726213	1.735873	0.1018
ODA(-5)	-0.210078	0.705943	-0.297585	0.7698
CAPITAL(-2)	-1.180052	1.179754	-1.000253	0.3321
CAPITAL(-3)	1.879983	0.973505	1.931149	0.0714
CAPITAL(-4)	-1.179576	0.910396	-1.295674	0.2135
CAPITAL(-5)	0.808679	0.594813	1.359551	0.1928
POPLG(-2)	-86.76647	109.4825	-0.792515	0.4397
POPLG(-3)	140.1535	145.0600	0.966176	0.3483
POPLG(-4)	-100.6748	103.4851	-0.972843	0.3451
POPLG(-5)	24.21549	33.38622	0.725314	0.4787

R-squared	0.674975	Mean dependent var	4.061506
Adjusted R-squared	0.268694	S.D. dependent var	2.485783
S.E. of regression	2.125752	Akaike info criterion	4.642934
Sum squared resid	72.30115	Schwarz criterion	5.557239
Log likelihood	-64.89428	Hannan-Quinn criter.	4.965270
F-statistic	1.661351	Durbin-Watson stat	2.415947
Prob(F-statistic)	0.153242		

4. ARCH

Heteroskedasticity Test: ARCH

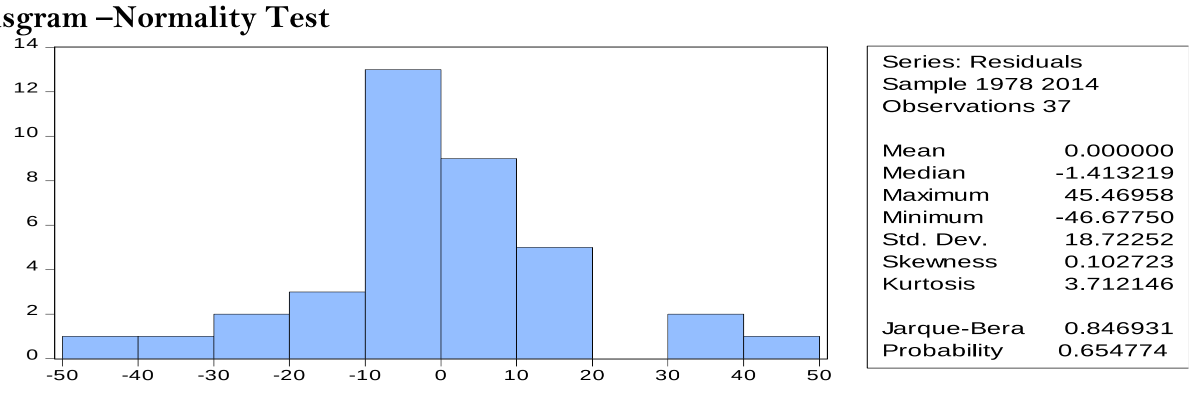
F-statistic	0.843695	Prob. F(4,28)	0.5094
Obs*R-squared	3.549594	Prob. Chi-Square(4)	0.4704

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/30/17 Time: 14:27
Sample (adjusted): 1982 2014
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	280.1903	160.9962	1.740353	0.0928
RESID^2(-1)	0.302805	0.193264	1.566797	0.1284
RESID^2(-2)	-0.015255	0.202813	-0.075215	0.9406
RESID^2(-3)	0.227692	0.255746	0.890306	0.3809
RESID^2(-4)	-0.228803	0.258363	-0.885588	0.3834

R-squared	0.107563	Mean dependent var	378.9030
Adjusted R-squared	-0.019927	S.D. dependent var	592.5022
S.E. of regression	598.3766	Akaike info criterion	15.76505
Sum squared resid	10025528	Schwarz criterion	15.99179
Log likelihood	-255.1232	Hannan-Quinn criter.	15.84134
F-statistic	0.843695	Durbin-Watson stat	1.944376
Prob(F-statistic)	0.509383		

5. Hisgram –Normality Test



Appendix H: Wald Test

Null Hypothesis: $\Delta ODA_{t-1} = \Delta ODA_{t-2} = \Delta ODA_{t-3} = \Delta ODA_{t-4} = 0$

Test Statistic	Value	df	Probability
F-statistic	0.113678	(4,19)	0.9761
Chi-square	0.454714	4	0.9778
Null Hypothesis Summary			
Normalised Restriction (= 0)		Value	Std. Err.
ΔODA_{t-1}		0.944205	8.258765
ΔODA_{t-2}		2.950476	11.39025
ΔODA_{t-3}		4.675114	9.968084
ΔODA_{t-4}		0.230430	7.172901

Restrictions are linear in coefficient