Does asymmetry matter in the relationship between exchange rate and remittance? Evidence from a remittance recipient country based on ARDL and NARDL

Akhtar, Sharmin and Masih, Mansur

INCEIF, Malaysia, INCEIF, Malaysia

28 December 2018

Does asymmetry matter in the relationship between exchange rate and remittance? Evidence from a remittance recipient country based on ARDL and NARDL

Sharmin Akhter[1] and Mansur Masih[2]

Abstract

The relationship between the exchange rate and remittance has been addressed in the literature. The results of these research papers, however, have been conflicting in terms of causal relationship between these variables. Even when some researches have proven the causality between them, they assume linear and symmetric relationship between them. In our paper, we first test their cointegrating relationship by using time series technique of Autoregressive Distributed Lags (ARDL) and then test the linear and symmetric assumption in their relationship based on Nonlinear AutoRegressive Distributed Lag (NARDL). We used 42 years of annual data from 1976 to 2017 of Bangladesh collected from the World Development Indicators database. We used Bangladesh, as it is one of the top ten remittance receiving country in the world. This paper finds that exchange rate significantly impacts remittance in the long run. It also finds that the relationship between the exchange rate and remittance is nonlinear and asymmetric in both long and short run. Policy makers may follow semi-fixed exchange rate policy to maximise the remittance income of the country, while managing exchange rate risk through other economic variables.

Key words: Exchange rate, Remittance, Asymmetry, Nonlinear ARDL, Causality, Co-integration

[1]Graduate student in Islamic finance at INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia.

[2] **Corresponding author**, Professor of Finance and Econometrics, INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia. Email: mansurmasih@inceif.org

1. Introduction

International migrant remittances have increased significantly over the last two decades. Migrants are now sending earnings back to their families in developing countries at levels above US$441 billion, a figure three times the volume of official aid flows. (World Bank Group, 2016). However, for the first time in recent history, remittance flows to developing countries have dropped for two successive years. Remittances declined by an estimated 2.4 percent, to $429 billion, in 2016, after a decline of 1 percent in 2015. (World Bank Group, April 2017). Thus, this issue is undoubtedly important for further rigorous academic inquiries in greater depth and detail.

Some studies have provided evidence that rising levels of remittances, as any other massive capital inflow, can appreciate the real exchange rate in recipient economies (Amuedo-Dorantes and Pozo, 2004; Lopez et al, 2007), and therefore generate a resource allocation from the tradable to the non-tradable sector (Acosta et al, 2007). This phenomenon is usually labelled as the "Dutch disease". In contrast, some researchers have found exchange rate influence remittance flow of the recipient country due to perceived exchange rate risk, motive of remittance by the immigrant workers. (Rahman & Mustafa, 2013; Higgins et al., 2004). Hence the causal relationship between remittance and exchange rate is not conclusive that requires a need for investigation.

There is an empirical controversy between exchange rate and remittance. Some researchers have found that appreciation of home currency results in reduction of remittance flow while depreciation of home currency results in increase in remittance inflow (Lin, 2010; Nekoei, 2013). Meanwhile, Acosta et al. (2009) empirically proves that increase in remittance results in real exchange rate appreciation. This controversy motivates us to explore the relationship between exchange rate and remittance.

A lot of literature has tried to investigate the causal relationship between exchange rate and remittance but almost none has tried to investigate the relationship of linearity and symmetry between these two variables. Apergis & cooray (2017), investigated and concluded that changes in real exchange rates asymmetrically affect poverty through remittances. Rahman et al. (2013) used Johansen co-integration in exploring the relationship between these variables which do not test for asymmetry. Therefore, this research will contribute to the literature in the following ways. First, as the relationship is inconclusive, the paper fills this gap by examining

the nonlinear symmetry relationship in Bangladesh. Bangladesh is chosen as it is one of the top remittance receiving country in the world. Second, previous researches mostly try to investigate co-integration and causality. But this research will use the most suitable time series technique "Nonlinear Auto-Regressive Distributed Lag (NARDL) model proposed by Shin et al. (2014), to investigate the nonlinear symmetric or asymmetric relationship between exchange rate and remittance using the data of Bangladesh from year 1976 to 2017 obtained from the World Development Indicators database.

The findings of this research would help policymakers in many ways. First, the research finds out the sensitivity of remittance to exchange rate so that the policymakers could take this sensitivity into account in designing the remittance and exchange rate policy. Second, the asymmetric relationship will help policymakers see the benefit and cost of exchange rate increase and decrease on remittance.

The research found that exchange rate has a significant impact on remittance in the long run. The relationship between these variables is nonlinear and asymmetric in both long run and short run. The exchange rate is asymmetrical in that the appreciation results in a stronger impact on remittances compared to depreciation.

Our research has the following sections: 2. Theoretical framework, 3. Empirical Literature, 4. Data and methodologies, 5. Results and discussion, 6. Conclusion and policy implications.

2. Theoretical literature of the issues

The Salter-Swan-Corden-Dornbusch paradigm functions as the theoretical underpinning to analyse the impact of capital inflows on the real exchange rate in developing economies. The model displays a mechanism by which an increase in massive capital inflows through remittances can cause a real exchange rate appreciation. (Lopez et al 2007). This capital inflow will increase real household income that will result in expansion of aggregate demand which will result in higher relative price for non-tradable goods. This spending effect will result in movement of resources away from tradable sector. This raises the relative price of non-tradable goods stemming from a real exchange rate appreciation. This phenomena is known as "Dutch disease" where appreciation of the currency makes the export more expensive on international markets which result in decrease in competitiveness of the tradable sector. . Acosta et al (2007)

develop a micro founded dynamic stochastic general equilibrium model that also considers an additional transmission mechanism where increase in household income results in shrinking of labour supply leading higher production cost and further contraction of the tradable sector. Both the real exchange rate and the ratio of tradable to non-tradable output therefore serve as summary indicators of Dutch disease.

However, remittance and exchange rate can also show bidirectional relationship. Some studies find that the exchange rate affects remittances, while others find that remittances affect the exchange rate. The high percentage of the variation in remittances explained by the exchange rate suggests that households convert a fraction of the remittances received into local currency. On the other hand, exchange rate can affect remittance flow as well. Depreciation of home-currency against host-country currency motivates immigrants to send more foreign currencies if they decide to create a domestic capital base that they can access on return for investment and enjoying a better standard of living. On the contrary, if they decide to provide a fixed amount of local currency to support families and friends back at home, they will correspondingly reduce the remittances in foreign currencies. Hence, home currency depreciation may have either positive or negative effects on remittances in foreign currency term. (Rahman & Mustafa, 2013). Therefore, logically a bidirectional causality between remittances and exchange rate is a noticeable possibility (Vargas-Silva, 2009).

The effect of exchange rate on remittance is not absolute. It can influence remittance positively or negatively or both ways. Straubhaar (1986) finds that exchange rates and interest rates positively influence the remittances of Turkey. Concerning exchange rate uncertainty, Higgins et al. (2004) conclude that increased exchange rate volatility depresses remittances. This could be because of the relationship between remittances and the exchange rate is likely to depend on the currency that the household uses to consume goods and services.

Remittance is not fully dependent on the exchange rate. Immigrants consider a lot of variables before they decide how much they want to remit to their home country. Besides sending money for family expenses immigrants also send money to back home for investment purpose. Therefore, investment motives migratory flow can contribute to inconclusive result of the impact of exchange rate on remittance. Many of these studies find evidence that immigrants are responding to portfolio variables, sending larger levels of remittances to their countries of origin when home rates of return rise, Faini, (1994). This is because migrant workers are

sensitive to the potential economic returns that their remittances may have while 'parked' in their countries of origin. On the other hand, if the motive of the remittance is to support families and friends, depreciation of home currency will not increase the remittance amount rather they will reduce the remittances in foreign currencies correspondingly. Hence, depreciation of home currency may have either positive or negative effects on remittance in foreign currency term.

Other literature has highlighted that relationship between exchange rate and remittance is affected by macroeconomic variables. Both home country and host country macroeconomic variable affects the relationship. Vargas-Silva and Huang (2006) use vector error-correction models (VECMs) and find that remittances respond more to host-country macroeconomic variables than to those of various home countries in Latin America. Volatility of exchange rate influence immigrants' remittance behaviour. Higgins et al. (2004) investigate data for nine countries using GARCH model and conclude that increased exchange rate volatility depresses remittances.

Even though exchange rate and remittance have co-integrating relationship, it does not confirm their definite causality relationship in long run. Workers' remittance may affect the real exchange rate through a variety of macroeconomic channels that are operative in any specific country. This macroeconomic channels will determine the quantitative and qualitative effect of remittance on the real exchange rate. Therefore, there could be bidirectional long run causal relationship existing between them. Larger inflows of remittance may tend to cause appreciation of home currency against dollar, then it can adversely affect the export of home countries' export sector. Larger inflows of remittances may outweigh contraction in the export sector by fuelling expansionary mass consumption spending, boosting private investment, mitigating balance of payment problems, etc., at macro level. Bougha-Hagbe (2006) estimated that devaluation of home currency increased remittances in short term but in long term it reduced the confidence of migrants on domestic economy. Therefore, the long run causality can be bidirectional depending on the macro policy a country adopts.

There are no profound literature discussing the symmetric or asymmetric relationship between exchange rate and remittance. Form personal intuition it can be symmetric if the perfect market exists where there are no information asymmetry, no other economic constraints, political stability and worker send money through legal frame. Therefore, increase and decrease in exchange rate will affect the remittance sending behaviour proportionately. However in real

life it is unlikely to have perfect market structure. Therefore, the relationship could be asymmetric as workers may take home currency depreciation as positive news as they will get extra money they may choose to send additional amount due to the human behaviour on reacting strongly when events perceived to be a good news. On the other hand, home currency appreciation may be perceived as a bad news and they may even send less or delay the remittance as a reaction to the bad news. The changes in the exchange rate may be asymmetrical. The depreciations may foster a stronger impact on remittances compared to appreciations. This depreciation will lead to increase the foreign exchange reserves and improve a country's current account balance. Similarly, exchange rate depreciations promote higher levels of investments by immigrants, as many migrants invest their remittance income in small scale businesses, real estate and other assets that help reduce the poverty level. (Apergis & cooray, 2017). However, this relationship should be empirically analysed which will be the contribution of this paper.

3. Empirical literature to the issues

Literature documents that changes in exchange rate affect remittance receipts. Lin (2010) finds that a percentage point real appreciation in the Tongan currency against the remitting country currency is related with a 2 percentage point fall in remittance receipts into Tonga. Nekoei (2013) in a study of Mexican workers in the US, suggests that a 10% appreciation of the US dollar leads to a fall in migrants annual earnings by 0.92 percent, while Yang (2008) in a study of the response of Filipino migrants to exchange rate shocks, notes that stronger positive shocks, i.e. an appreciation of a migrant's currency against the Philippine peso, leads to larger increases in households' remittances receipts. A 10% increase in Philippine Pesos per unit of foreign currency was found to increase Peso remittances by 6%.

However, the effect of exchange rate varies in long run and short run. Rahman et al. (2013) examined the long-run and short-run effects between emigrants' nominal remittances in U.S. dollars into Mexico and the Peso using Johansen cointegration model and found that changes in the exchange rate lead to larger effects on changes in remittances in the long run as compared to short run. He also found significant short run interactive net positive feedback between these variables.

On the other hand, the causality relationship between exchange rate and remittance is inconclusive. Olubiyi and Kehinde (2015) using a choice-theoretical model find that the real

exchange rate negatively effects remittances. Hence, an expected depreciation of the real exchange rate lead to a fall in remittance inflows. Another research, using Autoregressive Distributed Lag (ARDL), Rahman and Banerjee (2011) found that changes in nominal exchange rate, per capita nominal GDP differential and Saudi interest rate cause changes in remittances from Saudi Arabia to Bangladesh. On the other hand, Acosta et al. (2009) found at 10 percent significant level, Increase of 1 percentage point in the remittances-to-GDP ratio generates a real exchange rate appreciation of 0.4 percentage points. Meanwhile, using variance decomposition and impulse response analyses, Vargas-Silva (2009) suggests the existence of bi-directional relationship between remittances and exchange. The causality link is not absolute for these two variables.

Even though a lot of literature works on causality relation on exchange rate and remittance in the context of "Dutch disease". Lartey, Mandelman and Acosta (2012) using disaggregated sectorial data for developing and transition countries show that rising levels of remittances have spending effects that may lead to real exchange rate appreciation, and resource movement effects that favour the non-tradable sector at the expense of tradable good production. However there is almost none to analyse symmetric and asymmetric relationship between these two variables. Real depreciations exerted a stronger (negative) effect on remittances than real appreciations. (Apergis & cooray, 2017). Therefore this conflicting result emphasises the need for more empirical research to find out the relationship between exchange rate and remittance. Rahman and Banerjee (2011) uses ARDL while Rahman et al. (2013) uses Johansen's co-integration method in exploring the relationship using LRSM which does not test for asymmetry. Thus, our paper applies NARDL method which gives more reliable result.

4. Data and methodology

Following the existing literature in the area of study this research focuses on four variables. Two main or focus variables are exchange rate and remittance while two control variables are gross domestic products and domestic credit to private sector. The research applies yearly data from year 1976 to 2017 of Bangladesh. Annual Data is obtained from the World Development Indicators database. Table below summarises the variables used in this study

Variable	Symbol	Proxy
Exchange Rate	EXR	USD per national currency
Remittance	REM	Remittances as share of GDP
Gross domestic product	GDP	GDP per capita
Domestic credit to private sector	DCP	Domestic credit to private sector as share of GDP

Variable	Obs	Mean	Std. Dev.	Min	Max
OBS	42	21.5	12.26784	1	42
EXR	42	47.71384	21.78629	14.3955	81.8529
REM	42	4.581429	2.916166	.19	10.59
GDP	42	5.883095	1.959169	1	9.11
DCP	42	22.52357	13.24952	2.97	47.58

From this empirical table of data we can see we have 42 observation. The mean and the standard error of the variables EXR, REM, GDP and DCP are 47.71, 4.58, 5.88 and 22.52; 21.78, 2.92, 1.96 and 13.24 respectively.

This study used combined standard time series techniques consisting of autoregressive distributed lags model (ARDL) and non-linear ARDL. Unlike OLS , time series technique does not assume causality, it allows the data to decide the causality chain among variables. It tests long term relationship between variables. These are among the advantages of time series technique in comparison to the standard regression analysis.

Firstly, unit root test is performed on the level and differenced forms of the variables. This step is important because co-integration tests in the standard time series technique require all variables to be non-stationary. Stationary variables are defined as variable that have constant mean, variance and covariance. Stationary variables entail no theoretical relationship hence co-integration test cannot be performed. Hence the variables should be transformed in non-stationary for co-integration test. There are three tests to be conducted namely Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and KPSS tests. ADF test (Dickey and Fuller, 1979) takes care of autocorrelation only whilst PP test (Phillips and Perron, 1988) takes care of both autocorrelation and heteroscedasticity. The null hypothesis of both tests ADF and PP is that the variable is non stationary. Conversely, the null hypothesis of KPSS test is the exact

opposite, variables are stationary. Once it is confirmed that variables are non-stationary we move to step 2, VAR.

VAR order selection can be performed to determine to optimum number of lag for variables used in the study. This step is crucial since VAR is used in Johansen co-integration test. In VAR we try to see which lag order gives us the highest AIC and SBC we take that lag order. If the results are conflicting we generally take lower order assuming no autocorrelation. After this step we move to step 3, co-integration test.

There are 4 co-integration tests with various advantages and limitations. The most old but the foundation of co-integration, Engle-Granger co-integration test is performed, to determine whether variables in this study are theoretically related or not (Engle and Granger, 1987). This is essential to ensure any relations between the variables are not in fact spurious. However, Engle-Granger test can only determine whether variables are co-integrated or not but it cannot identify the number of co-integrating vectors. Therefore, Johansen test is performed since this method is more advanced than Engle-Granger test. Johansen test can identify the exact number of co-integrating vectors and gives all possible co-integrating vectors in the model. (Johansen, 1991).

Although, Engle-Granger and Johansen can determine whether the variables move together in the long run or not but it requires all variables to be non-stationary which is less realistic with real life data. Furthermore, the result of co-integration tests depends on the number of lags chosen and whether or not trend is included in the test. In other words, changing the number of lags will give different result. Another issue with Johansen test is it is bias towards accepting the null hypothesis of no co-integration. Since p-value of 10% is used, i.e. error that is acceptable if null hypothesis is rejected is only 10%, this means 90% of the time the null hypothesis will be accepted.

Therefore, to overcome the shortcomings of Johansen test this paper will proceed with ARDL technique introduced by Pesaran et al. (2001), a more advanced technique compared to the standard time series. ARDL does not require all variables to be stationary and it also does not suffer from biasness like the Johansen test. ARDL is a bound testing approach that can be used even for small sample size. ARDL test comprised of two main stages, the first stage is using F-test to determine whether there is long run relationship between the variables. The calculated F-statistic will be compared against the upper and lower critical values as determined by

Pesaran et al. (2001). If the F-statistics fall above the upper boundary, the null hypothesis of no co-integration can be rejected and it can be concluded that the variables move together in the long run. However, if it falls below the lower boundary, the null hypothesis cannot be rejected and there is no co-integration between the variables. It is also possible for the F-statistics to fall within the upper and lower bound which will result in inconclusive answer to the co-integration. These results hold regardless of the stationarity of the variables.

Once it is confirmed that there is a long run co-movement between the variables, the second stage in ARDL technique is estimating the long-run coefficients of the variables.

After this in step 4, LRSM test is performed which gives long run coefficient of variables against the theoretical expected value so that we can decide the significance of variables in our model.

The next step is Vector Error Correction Method (VECM), where error correction term is estimated to determine whether a variable is exogenous or endogenous. If an error correction term is found to be significant, this means the dependant variable actually depends on the error correction term, hence it is an endogenous variable. On the other hand, if the error correction term is insignificant, this can be interpreted as the dependant variable being exogenous or a leader. The coefficient of the error term will show the speed of adjustment to equilibrium, where a greater absolute value means a faster adjustment and vice versa. In addition, a positive coefficient means the variable will move away from the equilibrium in the long run while a negative sign means the variable will return to the equilibrium.

Although VECM can determine the endogeneity or exogeneity of a variable, it does neither tell the relative strength nor rank the variables. Thus, this study will perform variance decomposition (VDC) analysis to determine the relative strength, and this step is crucial for policy makers. There are two ways to perform VDC test, either generalised or orthogonalised VDC. Orthogonalised VDC is inferior since it is not unique and depends on the particular ordering of the VAR, but generalised VDC is unique and does not depend on the ordering of the variable. Additionally, orthogonalised approach assumes when a variable is shocked, other variables in the system are switched off. Generalised VDC on the other hand does not make such restrictive assumptions. Therefore, this study will use generalised VDC as it is more realistic. Next, impulse response function (IRF) will be conducted to see the VDC result in graphical illustration. VDC and IRF shows the impact of shocking one variable to others.

Therefore, the next step, Persistence profile is necessary to see impact of shocks from external source to the co-integrating vectors and to see the time horizon required for variables to get back to equilibrium.

Notwithstanding the advantages of ARDL technique in preceding discussion, ARDL also suffer from some weaknesses. Firstly, it assumes linearity and symmetrical adjustment. Linearity means proportionate change i.e. 1% change in independent variable will lead to *x*% change in the dependant variable at all times. On the other hand, symmetrical means constant speed of adjustment from equilibrium i.e. a variable will increase and decrease at the same speed. These two assumptions are too restrictive and unrealistic especially for economic variables in this global era. Therefore, this study is going to relax these two assumptions of ARDL by going into non-linear ARDL (NARDL), a more advanced technique introduced by Shin et al. (2014).

NARDL has many advantages as it does not assume linearity or symmetric adjustment. Instead, it enables testing linear and non-linear co-integration while differentiating the short run and long run effects of regressors to the dependant variable. If relationship between the focus variables is found to be symmetry, ARDL model is correct and can be used for further discussion. The next section of the paper will discuss the results of each tests performed.

5. Empirical results and discussions

Table 1: ADF test for log-form and first-difference form

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
LOG FORM	LEXR	ADF(2)=AIC	60.0129	-2.395	-3.571	Non-Stationary
		ADF(1)=SBC	56.2585	-2.594	-3.472	Non-Stationary
	LREM	ADF(5)=AIC	21.7994	-1.014	-2.924	Non-Stationary
		ADF(5)=SBC	16.2571	-1.014	-2.924	Non-Stationary
	LGDP	ADF(5)=AIC	11.0070	-0.269	-2.924	Non-Stationary

		ADF(5)=SBC	5.4647	-0.269	-2.924	Non-Stationary
	LDCP	ADF(1)=AIC	39.0240	-1.953	-3.000	Non-Stationary
		ADF(1)=SBC	36.6487	-1.953	-3.000	Non-Stationary
1ST DIFF. FORM	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
	DEXR	ADF(1)=AIC	59.3384	-6.490	-3.687	Stationary
		ADF(1)=SBC	56.2278	-6.490	-3.687	Stationary
	DREM	ADF(3)=AIC	23.5550	-4.105	-2.944	Stationary
		ADF(2)=SBC	20.3773	-3.823	-2.941	Stationary
	DGDP	ADF(4)=AIC	12.0566	-5.763	-2.919	Stationary
		ADF(4)=SBC	7.3906	-5.763	-2.919	Stationary
	DDCP	ADF(1)=AIC	35.5023	-3.883	-3.076	Stationary
		ADF(1)=SBC	33.1693	-3.883	-3.076	Stationary

Table 2: PP test for log-form and first difference form

LOG FORM	VARIABLE	T-STAT.	C.V.	RESULT
	LEXR	-0.037	-3.551	Non-stationary
	LREM	-4.248	-2.932	Stationary
	LGDP	-6.230	-2.932	Stationary
	LDCP	-3.755	-2.932	Stationary
1ST DIFF	VARIABLE	T-STAT.	C.V.	RESULT
	DEXR	-6.676	-3.452	Stationary

	DREM	- 9.314	- 2.961	Stationary
	DGDP	- 34.579	- 2.961	Stationary
	DDCP	- 8.745	- 2.961	Stationary

Table 3: KPSS test for log-form and first difference form

LOG FORM	VARIABLE	T-STAT.	C.V.	RESULT
	LEXR	0.156	0.172	Stationary
	LREM	0.463	0.388	Non-stationary
	LGDP	0.415	0.388	Non-stationary
	LDCP	0.472	0.388	Non-stationary
1ST DIFF. FORM	VARIABLE	T-STAT.	C.V.	RESULT
	DEXR	0.138	0.172	Stationary
	DREM	0.377	0.388	Stationary
	DGDP	0.216	0.388	Stationary
	DDCP	0.368	0.388	Stationary

Based on ADF test, all variables are non-stationary in its log level form while they are stationary in the first differenced form. PP tests, all variables are non-stationary in its log level except EXR while all are stationary in the first differenced form. However, KPSS yield a mixture of result where EXR are found stationary and rest are non-stationary in log form and all are found to be stationary the first differenced form. Based on KPSS, this study cannot proceed with Engle-Granger or Johansen co-integration tests as they require all variables to be non-stationary. Therefore, ARDL will be used in the later section as it does not require all variables to be non-stationary to identify whether there is long run relationship between the variables. Nevertheless, this study will use the ADF and PP tests at this juncture to enable carrying out Engle-Granger and Johansen tests.

VAR order selection:

Table 4: Order of vector autoregression

Order	AIC	SBC	Adjusted LR test
2	117.3281	87.384	0
1	112.4385	95.8029	32.1378[.010]
0	88.9196	85.5925	92.9361[.000]

Prior to the co-integration tests, it is required to identify the order of vector autoregression (VAR), and this information is crucial for the next step. Since the data is yearly hence low frequency we used 2 VAR. The selection criteria used are based on Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). AIC is less concerned on over parameter and tend to choose higher order of VAR and based on the data, AIC use 2 lags. SBC on the other hand is more concerned on over parameter and tend to choose lower order of VAR1. Since the result is conflicting we take the lower order which is 1.

Co-integration tests: Engle-Granger and Johansen tests

Table 5: stationary test of residual

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.2195	12.1942	11.1942	10.4024	10.9178
ADF(1)	-2.7018	13.4619	11.4619	9.8784	10.9092
ADF(2)	-2.4647	13.4637	10.4637	8.0884	9.6347
ADF(3)	-2.0845	13.6613	9.6613	6.4943	8.5559
ADF(4)	-2.3166	14.2748	9.2748	5.3160	7.8931
ADF(5)	-2.7899	15.6576	9.6576	4.9070	7.9995
95% critical value for the Dickey-Fuller statistic = -4.4151					

Based on Engle-Granger (E-G) co-integration test, this study found no co-integration between the variables. As ADF (1) is giving highest AIC and SBC both and we compare the correspondent t statistics (-2.7018) with critical value (-4.4151). Since T is lower than CV which means non- stationary. Hence no co-integration is found in Engle-Granger test. This can be attributed to the nature of variables used in this study where according to KPSS, there is a mixture of stationary and non-stationary variables, hence rendering the Engle-Granger test to be invalid. Therefore we proceeds to Johansen co-integration test.

Table 6: co-integration test based on maximal eigenvalue and trace of the Stochastic Matrix

Co-integration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix					
Null	**Alternative**	**Statistic**	**95% Critical Value**	**90% Critical Value**	**Result**
r = 0	r = 1	72.823	31.790	29.130	1co-integration
r<= 1	r = 2	50.601	25.420	23.100	2 co-integration
r<= 2	r = 3	15.3804	19.22	17.18	
Co-integration LR Test Based on Trace of the Stochastic Matrix					
Null	**Alternative**	**Statistic**	**95% Critical Value**	**90% Critical Value**	**Result**
r = 0	r>= 1	145.977	63.000	59.160	1 co-integration
r<= 1	r>= 2	73.154	42.340	39.340	2 co-integration
r<= 2	r = 3	22.5532	25.77	23.08	

To overcome the limitation of E-G co-integration, we perform Johansen's co-integration test. This table the null hypothesis of no co-integration is rejected at 5% significant level based on both Maximal Eigenvalue and Traces. After that, the null hypothesis of one co-integration against alternative hypothesis of two co-integration could also be rejected at 5% significant level. Thus, we conclude that there is 2 co-integration. However, we will use 1 co-integration as Johansen test is not robust due to the assumption of same lag for all variables. ARDL relaxes the assumption and this research will focus on result the latest technique of co-integration which are ARDL and NARDL.

Co-integration tests: Autoregressive distributed lags (ARDL)

Table 7: F-Statistics for testing the existence of Long-Run relationship (Variable Addition Test)

Model	**F STATISTICS**	**P VALUE**	**Critical bound at 95%**		**Conclusion**
			I(0)	I(1)	
EXR(EXR,REM,GDP, DCP)	1.6413	[.205]	3.539	4.667	No cointegration
REM(EXR,REM,GDP, DCP)	2.1737	[.111]			No cointegration
GDP(EXR,REM,GDP, DCP)	3.5693	[.025]			inconclusive
DCP(EXR,REM,GDP, DCP)	4.0831	[.015]			inconclusive

According to the bound test with null hypothesis of no co-integration, the test result shows that F-statistics for exchange rate and remittance falls below the lower bound hence no long term relationship. However, for GDP and DCP fall within the bound hence inconclusive. Since its inconclusive we look at the p value and both case p value is below 5% hence we can reject null and conclude that there are two co-integration. Hence variables are related in long run.

Table 8: ARDL Bounds Test for the existence of a Level Relationship

EQUATION	F STATISTICS	95%		90%	
		I(0)	I(1)	I(0)	I(1)
EXR(EXR,REM,GDP, DCP)	4.1171	3.5645	4.7456	2.9412	4.026
REM(EXR,REM,GDP, DCP)	17.0285	3.5645	4.7456	2.9412	4.026
GDP(EXR,REM,GDP, DCP)	17.1532	3.5645	4.7456	2.9412	4.026
DCP(EXR,REM,GDP, DCP)	8.5964	3.5645	4.7456	2.9412	4.026

The results of the tests for existence of a level relationship between the variables, we can rule out any possibility of a spurious relationship between the variables. At 10% significance level, the F-statistics for all variables are above the Pesaran et. Al (2001) critical values giving compelling evidence of co-integration between remittance and exchange rate.

The empirical results thus far support that exchange rate can impact remittance in Bangladesh. In order to achieve more remittance the government policies should revolve around maintaining exchange rate. Exchange rate maintaining can also help to improve GDP by impacting net export of the country. Additionally, since government should strengthen financial development as it is also integral part of remittance through the legal channels

Table 9: Results for Estimated Long-Run Coefficients using the ARDL Approach

Estimated Long Run Coefficients using the ARDL Approach

Regressors	EXR	REM	GDP	DCP
EXR	1	0.15713*	0.075617	0.51491***
	(None)	(0.089319)	(0.069976)	(0.10854)
REM	5.6111***	1	-0.57173**	-3.5051**
	1.9314	(None)	0.2779	1.5411

Note: * denotes significant at 10 percent level, ** denotes significant at 5 percent level and *** denotes significant at 1 percent level.

According to the results of the ARDL estimated long run coefficients, all variables have significant impact to remittance of Bangladesh. It shows that at 1 percent significant level for every 1% depreciation of Bangladesh currency will increase remittance by 5.61%, at 5 percent significant level for every 1% increase in GDP will decrease remittance by 0.57% and at 5 percent significant level for every 1% increase domestic credit to private sector, remittance will decrease by 3.51%.

Regardless, the limitation of ARDL is that it assumes that the adjustment of the error Correction term is both linear and symmetric. Therefore, we decided to test the variables using the non-linear ARDL technique which relaxes these limitations.

NARDL Test for long-run co-integration using bounds testing procedure

We will now look at our two focus variables: exchange rate (independent variable) and remittance (dependent variable) because we want to zoom in on the asymmetric relationship of exchange rate and remittance control variables which we have already analysed in ARDL. This could give us clearer picture of the relationship. And we have used strata for our NARDL Analysis.

NARDL model enables the investigation of the short-run and long-run relationship when these linkages may be non-linear and asymmetric. NARDL model will decompose exchange rate into its positive ΔEXR_{t-i}^{+} and negative ΔEXR_{t-i}^{-} partial sums for increases and decreases. Introducing the short-run and long-run asymmetries in the standard ARDL model leads to the following general form of NARDL model :

$$\Delta REM_t = \alpha_0 + \alpha_1 REM_{t-1} + \alpha_2 EXR_{t-1}^{+} + \alpha_3 EXR_{t-1}^{-}$$

$$+ \sum_{i=1}^{p} \beta\, \Delta REM_{t-i} + \sum_{i=0}^{q} \beta\, \Delta EXR_{t-i}^{+} + \sum_{i=0}^{q} \beta\, \Delta EXR_{t-i}^{-}$$

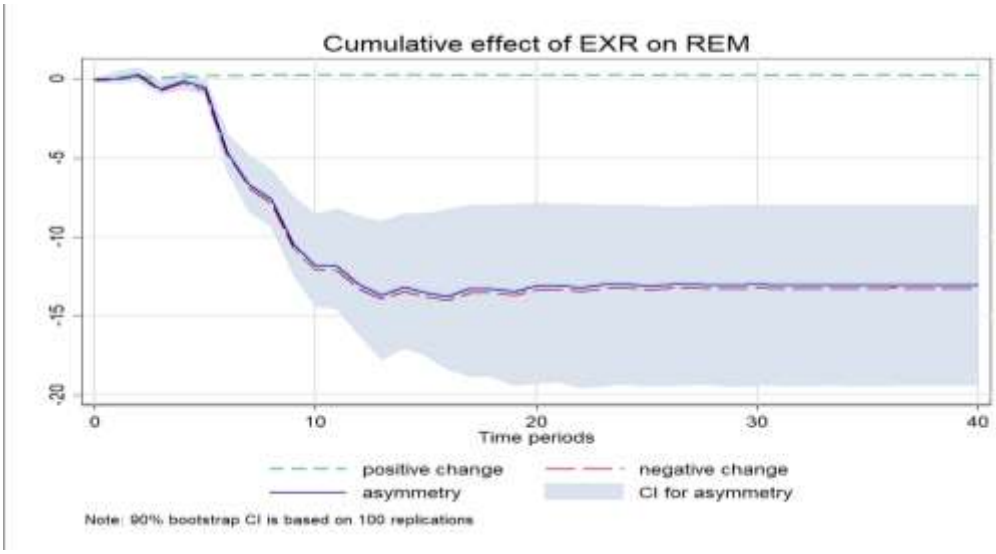
Table 10: Results from NARDL co-integration and asymmetry test

	F statistics	**Lower bound**	**Upper bound**	**Remarks**
Co-integration test	11.9172	4.903	5.872	Co-integration
	coefficient	**F-stat**	**P>F**	**Remarks**
Long run asymmetry	-	13.1	.001	Significant Asymmetry
Long run effect[+]	0.249	14.21	0.000	Significant positive
Long run effect[-]	-13.270	13.35	.0011	Significant negative
Short run asymmetry	-	20.88	0.000	Significant Asymmetry

The F-statistic of the NARDL co-integration shows an F-statistic greater than the upper boundary of the Pesaran et. al (2001) critical values thus confirming co-integration between the variables. We therefore, decide to test this relationship between the variables in the short run or long run. The results of the long run asymmetry test reveals that the test statistic is 13.1 with the p-value = 0.001. Thus, we reject the null hypothesis of long-run symmetry. Hence we conclude the variables are asymmetric in long run. Additionally, the short run asymmetry test is showing the test statics is 20.88 with the p-value=.000 thus we reject the null hypothesis of short run symmetry. Hence they are asymmetric in short run too. In summary, exchange rate and remittance hold asymmetric relationship in both short and long run. And result shows if Bangladesh currency depreciates by 1 % it increases remittance by .249%, while appreciation

of home currency results in decreases in remittance by 13.270% This could be because of unfavourable exchange rate (appreciation in home currency) migrant workers hold money with the expectation to get the exchange rate better and send money later together specially for the investment motive remittance. Our finding of asymmetric relationship is the same with the previous study where author establishes asymmetric relationship between exchange rate and poverty through remittance. (Apergis & cooray, 2017).

Graph below shows the cumulative effect of exchange rate on the remittance, the main focus of this research paper.



Co-integration tells us that there is a long-run relationship between variables. However, there could be a short-run deviation from the long-run equilibrium. Co-integration does not tell the process of short-run adjustment to bring about long-run equilibrium. Thus, we will proceed to error-correction model to examine the short-run dynamics later in this project.

Next, we used LRSM exact and over identifying methods to normalize the coefficients by imposing restrictions on the focus variable and subsequently testing insignificant variables.

Long Run Structural Modelling (LRSM)

Table 11: LRSM Exact identification and over identification

VRBL	PANEL A (A2=1)	PANEL B (A2=1; A3=0)
LEXR	-7.9581	-8.1124
	(2.9142)	(3.3185)

LREM	1.0000	1.0000
	(*NONE*)	(*NONE*)
LGDP	1.1103	0.00
	(0.75551)	(*NONE*)
LDCP	7.3411	7.4325
	2.9704	(3.3639)
Trend	-0.11863	0.086664
	(0.056087)	(0.050219)
CHSQ(1)	NONE	2.2893[.130]

LRSM panel A is exact identifying showing co-integrating relationship by normalising REM variable by putting coefficient of one of the focus variable as 1. In panel A, EXR, DCP both shows T-statistics higher than 2 hence significant except GDP being non-significant. Then we performed over-identification test by putting restriction on GDP and found EXR and DCP both remain significant. Therefore the restriction is correct as the p value is 13%. However, we have not drop variable GDP though it shows insignificant because the insignificant variable may be the variables that bring co-integration of all the variables.

Next, we move on to the vector error correction model. VECM helps us to identify the variables that are exogenous (leaders) and exogenous (followers). The coefficient of the variables represent the speed of adjustment of the variables to equilibrium. If the values are negative and between 0 and -1, it means that the variables have moderate to fast speed of adjustment to equilibrium. If it is 0 it means there is no equilibrium. And if it is positive, it means that the variable moves away from equilibrium in the long run.

Vector Error Correction Model (VECM)

Table 12: coefficients of error correction models

ecm1(-1)	**Coefficient**	**Standard Error**	**T-Ratio [P-value]**	**C.V.**	**Result**
DEXR	.0096483	.0067155	1.4367[.159]	5%	Exogenous
DREM	-.18091	.018008	-10.0463[.000]	5%	Endogenous
DGDP	.088031	.063215	1.3926[.172]	5%	Exogenous
DDCP	-.055774	.010430	-5.3472[.000]	5%	Endogenous

In VECM test, a p-value of less than 5% means the null hypothesis of exogenous variable is rejected, hence the variable is endogenous. Based on the VECM table, Exchange rate and GDP are exogenous while remittance and domestic credit to private sector are endogenous. Exchange rate is exogenous as Bangladeshi Taka against dollar as the demand and supply of currency is determined in global market. GDP is an exogenous as it is determined by indirect factors such as, institution, size of aggregate demand, saving rate and investment rate especially foreign direct investment that Bangladesh government have very little control on, as it is determined by global market. Remittance is a dependent variable. This could be because immigrants' decision to remit money is influenced by the exchange rate risk. Domestic credit to private sector is endogenous since depends on the capital inflow of the banking sector where remittance can be a source. However, VECM can identify absolute endogeneity and exogeneity but it does not give information on relative endogeneity and exogeneity. Hence we proceed to the next test Variance Decomposition (VDC) test.

Variance Decompositions (VDC)

Table 13: Orthogonalized Variance decompositions

ORTHOGONOLIZED APPROACH							
Horizon	Variables	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
10	LEXR	97.46%	0.01%	0.00%	2.53%	97.46%	1
	LREM	21.84%	34.30%	0.03%	43.83%	34.30%	4
	LGDP	0.21%	20.03%	77.69%	2.07%	77.69%	2
	LDCP	38.43%	8.41%	0.04%	53.12%	53.12%	3
Horizon	Variable	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
20	LEXR	97.18%	0.02%	0.00%	2.80%	97.18%	1
	LREM	22.44%	32.05%	0.03%	45.47%	32.05%	4
	LGDP	0.14%	19.96%	77.63%	2.27%	77.63%	2
	LDCP	44.70%	9.30%	0.03%	45.97%	45.97%	3
Horizon	Variable	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
30	LEXR	97.08%	0.02%	0.00%	2.90%	97.08%	1
	LREM	22.64%	31.31%	0.03%	46.01%	31.31%	4

	LGDP	0.11%	19.93%	77.61%	2.34%	77.61%	2
	LDCP	47.16%	9.64%	0.03%	43.17%	43.17%	3

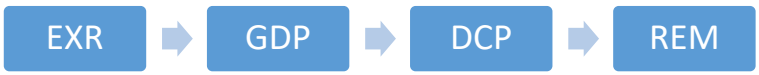
As per the result of from orthogonalised approach we can see that exchange rate is the most exogenous and remittance is the most endogenous while GDP is relatively independent with domestic credit to private sector. However, orthogonalised may give bias causality chain as the chain is influenced by the particular ordering of variables and it also assumes when a particular variable is shocked all other variables in the model is switched off. Therefore, we move to generalised approach of VDC.

Table 14: Generalised Variance decompositions

GENERALIZED APPROACH							
Horizon	Variable	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
10	LEXR	90.86%	2.10%	1.03%	6.01%	90.86%	1
	LREM	19.06%	36.10%	3.56%	41.29%	36.10%	3
	LGDP	15.95%	80.91%	2.96%	0.00%	2.96%	4
	LDCP	34.30%	3.64%	3.15%	58.91%	58.91%	2
Horizon	Variable	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
20	LEXR	90.41%	2.12%	1.01%	6.47%	90.41%	1
	LREM	19.69%	34.35%	3.17%	42.79%	34.35%	4
	LGDP	0.11%	15.96%	80.73%	3.19%	80.73%	2
	LDCP	39.54%	3.86%	3.57%	53.03%	53.03%	3
Horizon	Variable	LEXR	LREM	LGDP	LDCP	Self-dependent	Ranking
30	LEXR	90.24%	2.12%	1.00%	6.63%	90.24%	1
	LREM	0.11%	15.96%	80.73%	3.19%	15.96%	4
	LGDP	0.09%	15.97%	80.67%	3.27%	80.67%	2
	LDCP	41.57%	3.95%	3.73%	50.75%	50.75%	3

However, the first horizon give a bit different causality chain but it does shows our focus variable exchange rate is most exogenous. Since the horizon 20 and 30 shows the same ranking its stronger justification to accept causality based on this as it shows long term causality.

Casual chain from exogenous (left) to endogenous (right)



This result confirms that remittance cannot be used to control exchange rate as exchange rate is exogenous or determined by external factors. This can be explained by the fact that Bangladesh is relatively an open developing economy with high reliance on imports and exports. Therefore, Bangladesh government need to hit exchange rate to maintain particular target of remittance income for the country.

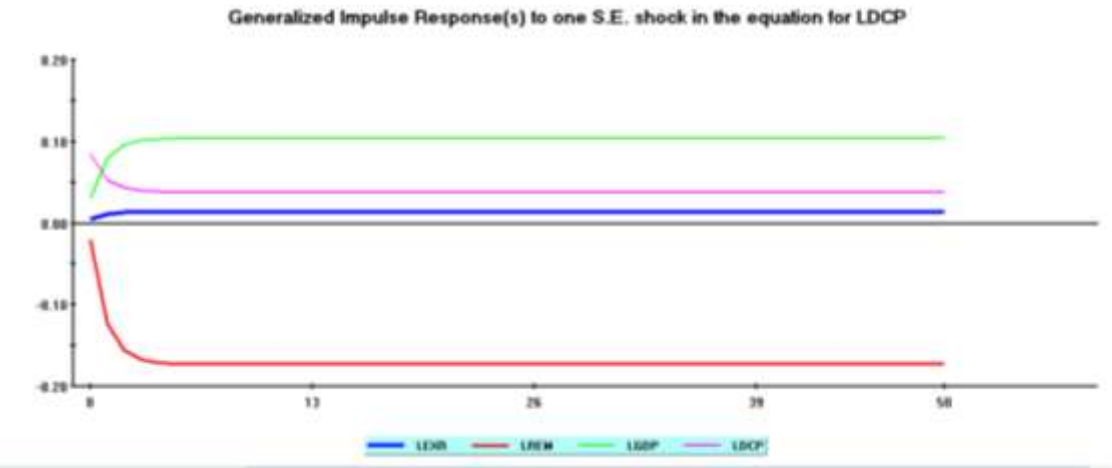
GDP comes next after exchange and this may be explained by the nature of GDP where it is influenced by a large number of factors and components, namely consumption by household, investment by firms, government expenditures and net exports. Therefore, it is possible for the Bangladesh government to influence GDP on its own since government expenditure is on an increasing trend and it can utilised its resources specially the textile industry to increase net export of the country.

Domestic credit to private sector comes after GDP and this can be explained by the fact that economic growth leads to the financial development by which immigrants feel safer and beneficial to send remittance back through formal channel i.e., the bank. Bangladesh government is focusing on financial development by including rural unbankable people through micro finance who are mostly received remittance. Therefore government can improve remittance income by providing reliable financial development.

Remittance is the most dependent variable. Exchange rate, GDP and domestic credit to private sector all together influence remittance. All these three dependent variables can push the investment motive migrant remittance where lower exchange rate can encourage more export, economic growth can help to expand financial development and immigrant feel confidence to invest money at back home which increases the remittance inflow of the country.

Impulse Response Functions (IRF)

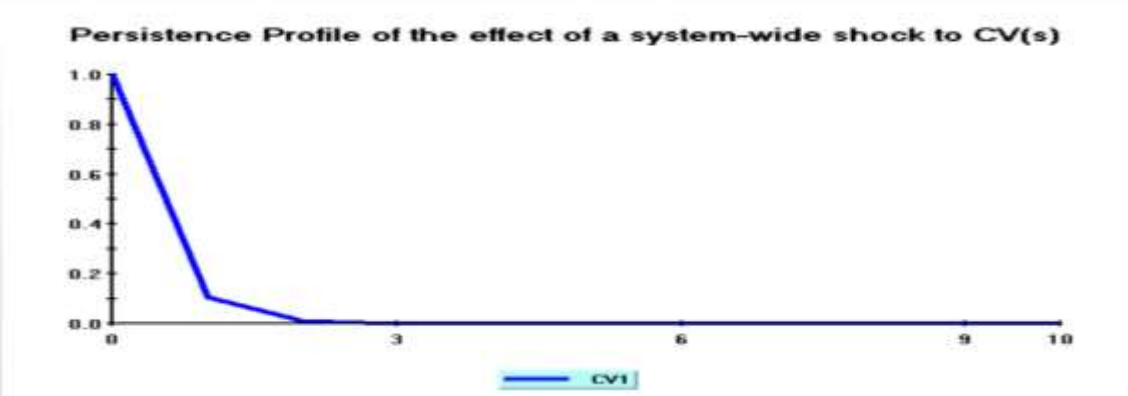
This paper continues with IRF analysis. IRF is same like VDC showing variable specific shocked. However, IRF displays the graphical response of one variable shocked to the other variables.



This graph shows the impact of a shock in domestic credit to private sectors to other variables. Since DCP is the most interest rate is the most endogenous or weakest, it can be seen that a shock in DCP will have least response compare to other independent variables in the model. It shows variable does not return to equilibrium even in 50 horizon.

Persistence Profile Function

Unlike the variable specific shock as displayed in Impulse Response, the persistence profile function is a system wide shock to check how long it takes for the whole system to recover and go back to equilibrium. From the graph below it shows if there is an external shocks for example global crisis, it will take less than 3 years for whole system to stabilise.



Conclusions and policy implications:

As findings of previous literature give inconclusive directional relationship between exchange rate and remittance, the result of this research shows a positive relationship between the variables in which increase in exchange rate (home currency depreciation) leads to increase in remittance. As many previous literature model and assume linear and symmetric relationship in investigating the casual relationship, which is not realistic due to asymmetric effect of exchange rate, this paper addresses this problem by modelling more advance technique NARDL which gives more robust result and we find they are asymmetric in long run and short run both based on 42 years of data from 1976 to 2017 of Bangladesh. We choose Bangladesh in our study as World Bank report shows Bangladesh is the 8th among top 10 remittance-earning countries in the world.

Depreciation of Bangladeshi Taka will improve remittance inflow of the country and the income of the whole country as Bangladesh's economy largely depends on exports. Our finding shows that remittance is quite sensitive to exchange rate. The long-run coefficient is significant, implying that relatively small depreciation will result in relatively larger remittance flow. However, policy makers need to take into account the cost of deprecation in other economic variables of the country.

NARDL result shows increase in exchange rate which implies depreciation of exchange rate has weaker impact on remittance compared to decrease in the exchange rate. Since appreciation of home currency significantly decreases remittance while depreciation of home currency does not proportionately increase remittance. Hence, government can choose to fix exchange rate policy by which remittance income can be maintained as depreciation of BDT gives very little impact on remittance. However, government should weigh the effect of fixed exchange rate on other macroeconomic variables for example current account imbalance, interest rate, probability of speculative attacks and failure to defend the currency. In addition to these, Dutch disease effects operate stronger in fixed exchange rate regime. Contrary, the Government of Bangladesh can go for semi-fixed exchange rate, where the currency can fluctuate within a small target level so government can control exchange rate better hence improve economy as a whole.

Moreover, this paper has come up with a causality chain for the focus variable exchange rate and remittance together with control variables GDP and domestic credit to private sectors (DCP). Causality chain shows to raise certain amount of remittance government first hit on exchange rate. This exchange rate even can impact GDP through export and import tendency

with exchange rate movement. As per long run coefficient, exchange rate has positive significant impact on remittance where GDP and DCP have negative significant impact on remittance. Hence government policy should weigh the impact carefully before deciding the economic policy.

Limitation of this paper is that it does not differentiate among the motives of remittance. The effect of exchange rate can be different based on the motives of remittance. If the remittance is mainly sent for family expenses which are mostly basic needs may not be significantly impacted by exchange rate. On the contrary, if the remittance is for investment purpose depreciating home currency may have stronger impact than appreciation. This investment motive of remittance can also be impacted by the real interest rate of the home country. We leave this for future research.

References

Acosta, Pablo A.; Baerg, Nicole Rae; Mandelman, Federico S. (2009); Financial development, remittances, and real exchange rate appreciation, *Federal Reserve Bank of Atlanta Economic Review*, 94(1), 1 -12.

Acosta, P.; Lartey, E.; Mandelman, F. (2007). .Remittances and the Dutch Disease,. Federal Reserve Bank of Atlanta Working Paper, 2007-2008.

Amuedo-Dorantes, C., & Pozo, S. (2004). Workers' remittances and the real exchange rate: a paradox of gifts. *World Development*, 32(8), 1407–1417.

Apergis, N., & cooray, A. (2018), Asymmetric real exchange rates and poverty: The role of remittance. *Emerging Markets Review*, 35, 111 -119.

Bougha-Hagbe, M. J. (2006). Altruism and workers' remittances: Evidence from selected countries in the Middle East and Central Asia (EPub). International Monetary Fund.

Dickey, D. A., and W. A. Fuller. 1979. Distribution of the estimators for autoregressive time series with unit root. *Journal of American Statistical Association,* 74: 427-431.

Engle, R and Granger, C. (1987) Co-integration and error correction: representation, estimation and testing, *Econometrica,* 55, 251-276.

Faini, R. (1994) Workers remittances and the real exchange rate; a quantitative framework, *Journal of Population Economics*, 7, 235–45.

Higgins, M., Hysenbegasi, A., and Pozo, S. (2004), "Exchange Rate Uncertainty and Workers' Remittances", *Applied Financial Economics*, 14, 403-411.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica, 59, 1551-1580.

Lartey, Emmanuel K.K.; Mandelman, Federico S. and Acosta, Pablo A. (2012), "Remittances, Exchange Rate Regimes and the Dutch Disease: A Panel Data Analysis", *Review of International Economics,* 20, 377-395.

Lin, H., 2010. Determinants of remittances: evidence from Tonga. IMF Working Paper, No.1, Asia and Pacific Department.

López, H.; Molina, L.; and Bussolo, M. (2007). .Remittances and the Real Exchange Rate. World Bank Policy Research Working Paper, 4213.

Nekoei, A., 2013. Immigrant's labour supply and exchange rate volatility. American Economic Journal: *Applied Economics*, 5, 144-164.

Olubiyi E and Kehinde K (2015) Does exchange rate affect remittances in Nigeria? *Review of Finance and Banking*, 7, 31-45.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16(3), 289-236.

Phillips, P.C, and Perron, P. (1988). Testing for unit root in time series regression. *Biometrika,* 75(2), 335-346.

Rahman, M. and Banerjee, P. (2011), "Dynamic Empirics of Expatriates' Remittances from Saudi Arabia to Bangladesh", *Southwestern Economic Review*, 38, 1-11.

Rahman, M., & Mustafa, A. F. (2013). Remittances exchange rate nexus: The USMexico CASE,. *Journal of Developing Areas,*, 47, 63-72.

Shin, Y., Yu, B., and Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Horrace, W.C. and Sickles, R. C.(eds), Festschrift in Honor of Peter Schmidt. Springer Science & Business Media, New York, 281-314

Straubhaar, T. (1986), "The Determinants of Workers' Remittances: the Case of Turkey", *Weltwirtschafliches Archive,* 122, 728-740.

Vargas-Silva, C. (2009), "The Tale of Three Amigos: Remittances, Exchange Rates and Money Demand in Mexico", *Review of Development Economics*, 13, 1-14.

Vargas-Silva, C. and Huang, P. (2006), "Macroeconomic Determinants of Workers' Remittances: Host versus Home Country Economic Decisions", *Journal of International Trade and Economic Development*, 15, 81-99.

World bank group. (2017). *Migration and Remittances: Recent Developments and outlook*. Migration and Development Brief number 27, April, 1 – 33.

Yang, D., 2008. International migration, remittances and household investment: evidence from Philippine migrants and exchange rate shocks. *Economic Journal*, 118, 591-630.