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Do Remittances Promote Labor Productivity in Mexico? A DOLS and FMOLS Analysis, 1970-2017

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Abstract
This paper investigates the impact of remittance flows on economic output and labor productivity for Mexico during the 1970-2017 period. The findings suggest that remittance flows to Mexico have a positive and significant effect on economic output and labor productivity. The paper is organized as follows: First, it gives an overview of remittance flows in absolute terms, relative to GDP, in comparison to FDI inflows, and in terms of their regional destination. Next, the paper reviews the growing literature that assesses the impact of remittances on investment spending and economic growth. Third, to motivate the discussion of the empirical results, the paper presents a simple endogenous growth model that explicitly incorporates the potential impact of remittance flows on economic output and labor productivity. Fourth, it presents a modified empirical counterpart to the simple model that tests for unit roots and performs both a Johansen cointegration test and a Gregory and Hansen cointegration test with an endogenously determined regime shift. FMOLS and DOLS long-run estimates for the period in question suggest that remittance flows to Mexico have a positive and significant effect, albeit small, on both the levels of economic output and labor productivity. The concluding section summarizes the major results and discusses potential avenues for future research on this important topic.

JEL Classification numbers: C10, F01, 010, 054.
Keywords: ADF unit root test, DOLS, FDI inflows, FMOLS, Gregory-Hansen cointegration single-break test, Gross fixed capital formation, Johansen Cointegration test, KPSS no unit root test, labor productivity, and remittance flows.

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1 Introduction

In recent decades, remittance flows to Latin America and the Caribbean in general, and Mexico in particular, have increased dramatically, even surpassing their FDI inflows for selected years, including the most recent 2019-21 period. Figure 1 below shows that remittance flows to Latin America and the Caribbean increased steadily from US$21.3 bn in 2001 to US$61.5 bn in 2006 and an estimated US$131bn in 2021, up 25 percent from 2020! The onset of the Great Recession in 2008-09 led to a significant reduction in these flows before they leveled off in 2010 and moved upward again to an estimated $68bn in 2015, before surging during the 2019-21 period as a result of the impact of COVID-19, hurricanes Grace and Ida, and the recovery of the U.S. labor market to pre-pandemic levels. These events have incentivized both documented and undocumented migrants in the US to send remittances individually and collectively (via Town Home Associations in the US) to their relatives and loved ones in Mexico and Central America. Figure 1 also shows that these flows are relatively more stable than other private and official flows, such as foreign direct investment (FDI), portfolio investment, and official development assistance (ODA) flows. Insofar as Mexico is concerned, it is the largest recipient of remittance flows in Latin America (and the third largest recipient in the world, after India and China) and, not surprisingly, it also recorded a dramatic increase in these flows for the period under review, from a level of US$24.8 bn in 2015 to an estimated level of US$43bn in 2020.

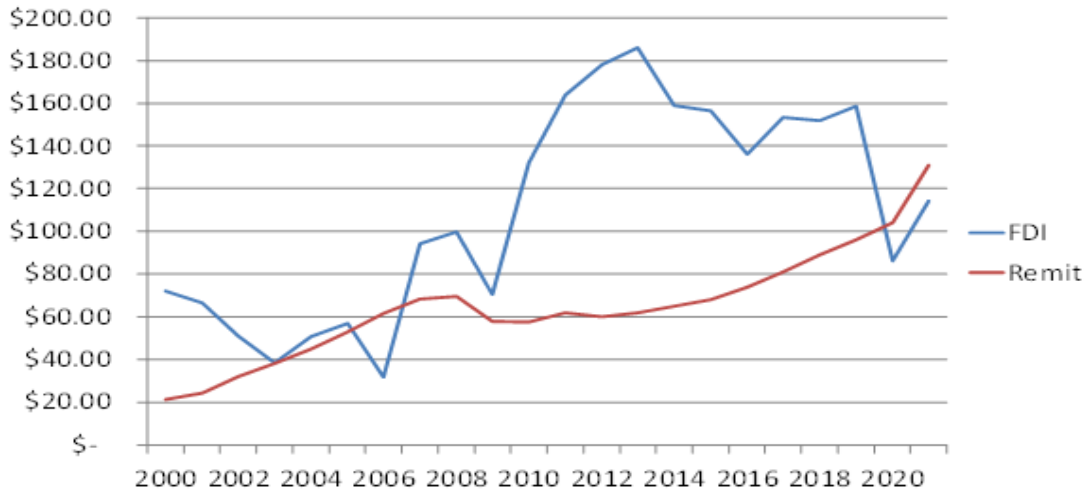

Figure 1. FDI and Remittance Flows to Latin America, 2000-2021 (Billions of dollars).

Beginning in 2011 remittance flows to the country rose again, particularly during the 2017-2020 interval, and have averaged close to US$29 bn over the 2011-2020 period. This figure is only slightly below Mexico's average FDI inflows for the aforementioned period at US$32bn (see ECLAC, 2021; World Investment Report, 2021). In fact, remittance flows have become such an important source of foreign exchange earnings for the country over the last decade that they rank third, just behind Mexico's earnings from maquiladoras (assembly-line industry) and oil (see Canas et. al., 2007).

Given the magnitude of these flows, both in absolute and relative terms, a growing literature has emerged that attempts to assess empirically the economic determinants of these flows to the region and individual countries, as well as their impact on economic growth, investment, savings, and poverty—to name a few. However, there are relatively few extant studies—and a handful for Mexico—that try to assess over a

sufficiently long time span the economic impact of these flows on a country's level of economic output and labor productivity. In this study we attempt to address this gap in the literature by estimating, via a modified production function, whether *remittance flows have a positive impact* on economic output and labor productivity. The layout of the paper is as follows: First, the paper gives an overview of remittance flows to Mexico during the 1980-2021 period in absolute terms, relative to GDP, and in terms of their regional destination. Second, it reviews the growing literature that attempts to assess empirically the impact of remittances on economic growth for selected developing countries, including several in Latin America and the Caribbean. Third, to motivate the discussion it presents a simple endogenous growth model that explicitly incorporates the potential impact of remittance flows on the level of economic output and labor productivity. The fourth section presents a modified empirical counterpart to the simple model presented in Section III and, using unit root tests and single-break cointegration analysis with a level (and trend) shift, generates FMOLS and DOLS long-run estimates for the modified production and labor productivity functions. The concluding section summarizes the major results and discusses potential avenues for future research on this important topic.

2 Overview of Remittance Flows to Mexico

Although remittance flows to Mexico did not increase dramatically until the decade of the 2000s, they were by no means inconsequential during the decades of the 1980s and 1990s as shown in Table 1 below. Between 1980 and 1990 remittance flows practically tripled from US$1.04 bn to US$3.1 bn, and then more than doubled between 1990 and 2010, from US$3.1 to US$22 bn. Notably, for a number of years during the early 1990s and 2000s, remittance flows rivaled or exceeded Mexico's inflows of FDI. From a relative standpoint, remittances increased as a share of gross domestic product (GDP) from a mere 0.5 percent of GDP in 1980 to a high of 3.1 percent of GDP in 1990, before falling somewhat during the decade of the 1990s to a stable and relatively high annual average of 1.4 percent of GDP. More importantly, perhaps, given remittances' potential role in financing private capital formation, remittance flows as a proportion of Mexico's gross domestic capital formation (GDCF) rose from 4.3 percent in 1980 to 9.7 percent in 1990, and then stabilized at an annual average of about 9 percent of GDCF for the decade of the 1990s. The rapid growth in remittance flows to Mexico during the 1990s can be explained, in part, by the 1994-95 peso crisis which dramatically increased migratory flows to the U.S. in search of employment opportunities; the plentiful job opportunities associated with the rapid economic growth experienced by the U.S. economy during the 1995-1999 period; andthe credit-driven boom in U.S. construction activity during the 2003-2007 period where a disproportionate number of migrants find employment.

Table 1: Remittance Flows to Mexico in Absolute and Relative Terms, 1980-2021.

Year Remit.	(US$, bn)	Remit.(% GDP)	Remit. (% of GDCF)	FDI Inflows (US$, bn)
1980	1.04	0.54	4.3	1.62
1990	3.10	1.33	9.7	3.72
2000	7.53	1.33	7.6	13.04
2002	11.03	1.90	9.5	22.16
2004	19.90	3.24	15.8	19.22
2006	26.88	3.65	16.5	13.56
2008	26.30	3.84	16.6	21.26
2010	22.00	2.83	13.0	17.60
2011	24.00	2.70	12.1	26.00
2012	23.00	2.60	11.2	23.00
2013	22.00	2.30	10.6	18.90
2014	23.65	2.00	8.4	44.60
2015	24.79	2.24	9.6	36.22
2016	27.00	2.66	11.6	38.87
2017	30.29	2.78	12.5	33.13
2018	33.68	2.93	13.4	37.84
2019	36.44	3.07	14.5	29.68
2020[a]	42.90	3.94	22.4	31.38
2021[b]	54.00	4.18	20.6	31.62[c]

Sources: Nacional Financiera, S.A. *La Economia Mexicana en Cifras*, various issues; and INEGI. [a]Figures for 2020 are preliminary and subject to revision. [b]Forecast by the World Bank Group (2022), *Migration and Development Brief No. 36*, Figure 5.12, p.42. [c]UNCTAD, *World Investment Report 2022*, Annex Table 1, p. 213.

During the decade of the 2000s, up until the year 2007, i.e., before the adverse effects of the Great Recession of 2008-09 began to be felt, Table 1 shows that remittance flows to Mexico increased dramatically, both in absolute terms and relative to GDP and gross domestic capital formation (GDFC). For example, in 2002 remittance flows amounted to US$11.03 bn and represented 1.90 percent of GDP and 9.5 percent of GDFC; by 2006 they had shot up to US$26.9 bn, which represented 3.7 percent of GDP and 16.5 percent of GDFC. In fact, Mexico was by far the largest beneficiary of remittance flows in all of Latin America and the Caribbean, and among the relatively larger economies of the region it was, with the exception of Peru, the biggest recipient in relation to its gross domestic product (and GDFC) over the entire 2004-2019 period. The importance of these flows is further revealed by comparing them with FDI inflows to Mexico for the period under review. As can be seen from Table 1, remittance flows began to rival FDI inflows in 2004 and exceeded them by a significant margin after 2004, particularly during the recessionary years of 2008-2013 period. However, with the robust recovery of the U.S. (and Mexican) economy after 2013, FDI flows to Mexico were reinvigorated and exceeded remittance flows until 2017. Thereafter, the slowdown in the Mexican economy and the devastating impact of the COVID-19 pandemic on rural and urban communities

in Mexico has incentivized migrant workers in the US to send additional resources to their relatives and loved ones in Mexico. In fact, Table 1 reveals a dramatic resurgence in these remittance flows for the years 2019 and 2020 to $36 and $43bn, respectively, and, according to the World Bank (2022) the forecast for 2021 is an unprecedented $54 bn, far surpassing FDI inflows of $31.6 bn!

From a regional standpoint, Canas *et. al.* report that the lion's share of remittances were sent to the middle income (and poor) central western-states of Michoacan, Guanajuato, Morelos, Zacatecas, and Estado de Mexico (all at least 5% of gross state product). Several of the poorer southern states (Oaxaca, Guerrero and Chiapas) also received significant amounts of remittance flows (at least 5% of GSP). Only the wealthier border-states (Sonora, Chihuahua, Coahuila, and Nuevo Leon) received lower remittance flows (below 1% of GSP) because relatively few low-skilled workers emigrate to the United States from these states. Although the Banco de Mexico supplies information on the regional destination of remittance flows within Mexico, the United States does not systematically track the origins of these flows within the United States. However, the IDB's annual survey of remittance flows to Latin America gives us some indication of where these flows originated from because they ranked, not surprisingly, California first ($13.2 bn), Texas second ($5.2 bn), and New York third ($3.7 bn) (see Canas et. al., p. 4).

3 The Impact of Remittance Flows on Economic Growth and Development

Remittances are expected to have a positive effect on the economic growth of the recipient countries when they complement national savings and augment the total pool of financial resources for local investment projects. In this connection, Solimano (2003) and Orozco (2004) report that migrants in the United States, including Ecuadorans, Guatemalans, Mexicans, and Salvadorans, have formed permanent associations known as Home Town Associations (HTAs) which regularly send donations back to their communities to finance investments in small businesses and infrastructure projects such as water treatment plants, roads, bridges, and schools. To the extent that these flows become "institutionalized," their positive effects on growth are likely to become more permanent.[i]

Similarly, Ratha (2003) found that remittances had a positive and significant effect on investment in receiving countries such as Mexico, Egypt, and Sub-Saharan Africa. In this connection, Aitymbetov (2006) discovered that approximately 10 to 20 percent of remittances were used as some form of investment in Kyrzastan, and thus had a positive impact on the economy. Giuliano et al. (2006) also conclude that remittances help boost the growth rate of the economy in less financially developed countries by providing credit which would otherwise not be available. Insofar as Mexico is concerned, investigators have found that remittances are used to finance investment in micro-enterprises. For example, Woodruff (2006) found that there is, in general, a positive relation between investment spending and the growth of micro-enterprises. Woodruff determined that between 10 to 20 percent of remittance flows are invested in micro-enterprises and that this could have a significant impact on the long-term growth of these labor-intensive enterprises.

More recent studies have also found a positive and statistically significant relationship between remittance flows and economic growth. For example, Salahuddin and Gow (2015) find that migrants' remittances play a positive role in spurring economic growth for some of the largest recipient countries, including India, Bangladesh, Pakistan and the Philippines from 1977-2012. Giuliano and Ruiz-Arranz (2009) found that remittances had a significant positive effect on economic growth in developing countries for the period 1975-2002. Meyer and Shera (2017) also find econometric evidence for six high remittances receiving countries in Europe that these flows have a positive impact on growth and that this impact increases at higher levels of remittances relative to GDP. Kumar (2013) explored the effects of remittances on economic growth in Guyana, a developing country in South America, further confirming the positive effect of remittances on economic growth. Similarly, Sharma and Ramirez (2009), using the Fully-Modified OLS (FMOLS) methodology, report panel estimates for selected upper and lower income Latin American and Caribbean countries which suggest that remittances have a positive and significant effect on economic growth in both groups of countries. In addition, the interaction of remittances with a financial development

variable reveal that these two variables act as substitutes, namely, the impact of remittances is more pronounced in the presence of the financial development variable. Finally, Fayissa and Nsiah (2012) use panel unit root and cointegration tests to investigate the relationship between economic growth and remittances for 64 African, Asian, and Latin American-Caribbean countries during 1987–2007. They found that remittances and economic growth have a positive relationship with each other.

However, the positive effects of remittances on economic growth are not readily accepted by other scholars working on this topic. Chami et al. (2005) report a negative correlation between remittances and growth, while, in a more recent IMF panel study for 84 countries, Barajas et al. (2009) find that workers' remittances have little or no effect on long run economic growth. By and large, remittances were found to be counter-cyclical in nature. For example, Chami et al. argue that remittances act like compensatory transfers and, hence, do not aid in the process of economic growth. Amuedo-Dorantes and Pozo (2006) argue that remittances could undermine export sectors of the recipient countries, thereby reducing international competitiveness. They also contend that remittances are intended for consumption rather than investment. This finding is also supported by the work of Solimano (2003). He reports that in the case of Ecuador around 60 percent of remittances are spent on food, medicines, house rents, and other basic commodities (p. 16).

As indicated above, a possible negative effect on growth associated with remittances may result from the possibility of a "Dutch Disease" effect via an induced real appreciation of the domestic currency for countries with sizable remittance flows. For example, Acosta et al. (2008) report (unbalanced) panel estimates for 109 developing and transition economies over the 1990-2003 period which suggest that rising levels of remittance flows lead to real exchange appreciation and resource movements that favor the non-tradable sector at the expense of the tradable sector (see also Chami et al., 2010). To the degree that this happens, traditional and non-traditional exports (and import-competing industries) may be adversely affected, thus undermining investment spending and growth. Moreover, there are several economic, institutional and social factors which have a potential effect on the size of remittance flows, and thus economic growth. The size of the migrant population, the length of stay away from their home country, the migrants' income and that of family members back home, volatility of exchange rates, the economic freedom of the source country, the transfer costs, and the migrants' motivation to go back (see Canas et al., 2007).

4 Conceptual Model

As indicated above, remittance flows may have either positive or negative effect on the long-term growth prospects of a country. To the degree that they contribute to the financing of private capital formation, they augment both the stock of private capital and the productivity of labor, thus enhancing the country's long-term economic growth. On the other hand, if remittances are primarily channeled to finance current consumption, then they reduce current investment spending, thereby reducing the stock of private capital and the country's long-term growth prospects. Of course, it is possible that remittance flows are used by family members to finance expenditures on education and/or vocational training, and to the extent that they do, then they contribute to the formation of human capital, thus promoting future economic growth.

Following the lead of Barro (1990), De Mello (1997), and De Vita (2004), remittance flows can be treated as a form of foreign capital that generates positive or negative externality effects to the domestic economy. It can be explicitly modeled via an augmented Cobb-Douglas production function of the following form:

$$Y = A\, f\,[L, K_p, E] = A\, L^{\alpha}\, K^{\beta}\, E^{(1-\alpha-\beta)} \tag{1}$$

where Y is real output, K_p is the private capital stock, L is labor, and E refers to the positive or negative externality generated by additions to the stock of foreign capital in the form of remittance flows. α and β are the shares of domestic labor and private capital respectively, and A captures the efficiency of production. It is also assumed that α and β are less than one, such that there are diminishing returns to the labor and capital inputs.

The externality, E, can be represented by a Cobb -Douglas function of the type:

$$E = [L, K_p, K_r^{\gamma}]^{\theta} \tag{2}$$

where γ and θ are, respectively, the marginal and the intertemporal elasticities of substitution between private and foreign capital in the form of remittance flows. Let $\gamma > 0$, such that a larger stock of remittances generates a positive externality to the economy; i.e., knowledge or technological progress is an accidental by-product of capital investment by relatively small firms in the form of remittances. If $\theta > 0$, intertemporal complementarity prevails and, if $\theta < 0$, additions to the stock of foreign capital in the form of remittances crowd out private capital over time and diminish the growth potential of the host country.

Combining equations (1) and (2), we obtain,

$$Y = A\, L^{\alpha + \theta(1 - \alpha - \beta)}\, K_p^{\beta + \theta(1 - \alpha - \beta)}\, K_r^{\gamma\theta(1 - \alpha - \beta)} \tag{3}$$

If we take logarithms and time derivatives of equation (3), we can also generate the following dynamic production function:

$$g_y = g_A + [\alpha + \theta(1-\alpha-\beta)]g_L + [\beta + \theta(1-\alpha-\beta)]g_{Kp} + [\gamma\theta(1-\alpha-\beta)]g_{Kr} \tag{4}$$

where g_i is the growth rate of i = Y, A, L, K_p, and K_r. Equation (4) states that (provided γ and $\theta > 0$) additions to the stock of foreign capital in the form of remittances will augment the elasticities of output with respect to labor and capital by a factor $\theta(1-\alpha - \beta)$.

5 Empirical Model

Mexico has a sufficiently long (and official) time series data set (extending back to the decade of the fifties and sixties) for a number of key variables, including private investment spending and FDI inflows, so that using a perpetual inventory method capital stock data can be generated for the different types of capital. Insofar as remittance flows are concerned, there is annual data going back only to the decade of the seventies, so it is not possible to generate a capital stock measure for this variable. Nevertheless, there are still a sufficient number of data points (48) to test empirically whether these flows have a beneficial or adverse impact on economic growth.

Official data on the economically active population (EAP), rather than just population data per se, are also available for the period under review. This study is thus among the first, other than Woodruff's (2006) at the micro level, to test empirically whether remittance flows have a positive or negative effect on economic output (and labor productivity) in Mexico during the 1970-2017 period. The most general formulation of the production function is given below,

$$Y = \alpha + \beta_1 L + \beta_2 K_p + \beta_3 K_f + \beta_4 R + \beta_5 D_1 + \beta_6 D_2 + \varepsilon_t \tag{5}$$

Y represents the natural log of real GDP (1970 pesos); L, as indicated above, refers to the natural log of the EAP; K_p denotes the natural log of the stock of private capital (1970 pesos);K_f denotes the log of the stock of FDI capital (1970 pesos); R is the natural log of remittance flows (1970 pesos); D_1 is a dummy variable that equals 1 for the crises years of 1976, 1982-83, 1987, 1995, 2001, and 2009, and 0 otherwise; D_2 equals 1 for the petroleum-led expansion of 1978-81, and 0 otherwise; Finally, ε_t is a normally distributed error term.

The economic rationale for the inclusion of the additional variables in equation (5) and the interpretation of their respective coefficients is given below. The coefficients represent the annual percentage change in real GDP associated with a respective percentage change in the variables in question. Following the lead of Blomstrom and Wolff (1994) equation (5) was also estimated as a labor productivity equation by defining

the variables in per capita terms using the economically active population.[ii] The problem of reverse causality (endogeneity) associated with some of the included variables is addressed by utilizing the FMOLS (and DOLS) estimators discussed in the next section. The sign of β_1 is anticipated to be positive in both the real GDP and labor productivity specifications. β_2 is expected to be positive, while the sign of β_3 can be positive or negative depending on whether the stock of FDI is likely to complement private capital formation if they bring needed financing and transfer managerial and technological knowhow (see Huang, 2004). In this connection, the impact of remittance flows will be beneficial to long-term growth if, like FDI inflows, they contribute to financing private capital formation and are directed to investments in human capital and economic infrastructure rather than consumption expenditures *per se*. In view of these ambiguous effects, the signs of, β_3 and β_4 are indeterminate. B_5 is anticipated to have a negative sign for obvious reasons. B_6 is expected to be positive because of the high rates of economic growth associated with the short-lived petroleum boom of 1978-81.

The economic data used in this study were obtained from official government sources such as *INEGI* (various issues), Nacional Financiera, S.A., *La Economia Mexicana en Cifras*, the Banco de Mexico, *Informe Anual* (various issues), and the World Bank's *Migration and Development Brief* (various issues). Private and public investment data for Mexico have been obtained from International Finance Corporation, *Trends in Private Investment in Developing Countries: Statistics for 1970-2000* [2002].[iii] The private and foreign (FDI) capital stock data were generated using a standard perpetual inventory model assuming an estimate of the rate of depreciation of 5 percent.

6 Empirical Results

Initially, conventional unit root tests (without a structural break) were undertaken for the variables in question given that it is well-known that macro time series data tend to exhibit a deterministic and/or stochastic trend that renders them non-stationary; i.e., the variables in question have means, variances, and covariances that are not time invariant. In their seminal paper, Engle and Granger (1987) showed that the direct application of OLS or GLS to non-stationary data produces regressions that are misspecified or spurious in nature. Consequently, this study tested the variables in question for a unit root (non-stationarity) by using an Augmented Dickey-Fuller test (ADF) (Dickey-Fuller, 1981) with a constant and deterministic trend.

It is important to acknowledge that when dealing with historical time series data for developing countries such as Mexico or Chile investigators are often constrained by the relatively small number of time series observations (usually in annual terms). This is the case in this study where the sample size is below the threshold level of 50 observations recommended by Granger and Newbold (1986), and thus may compromise the power of the unit root (and cointegration) tests—not to mention distort the size or significance of the tests as well (see Charemza and Deadman, 1997). However, a growing literature contends that the power of unit root (and cointegration) tests depends on the length or *time span* of the data more than the mere number of observations in the sample. That is, for a given sample size n, the power of the test is greater when the time span is large. Thus, unit root or cointegration tests based on 48 observations over 48 years have considerably more power than those based on 100 observations over 100 days (see Bahnam-Oskooee 1996; Hakkio and Rush, 1991).[iv]

Following the Doldado et al. (1990) procedure, Table 2 (part A) below presents the results of running an Augmented Dickey-Fuller test (one lag) on the variables in logarithmic form with a constant and a deterministic trend.[v] The results indicate that the null hypothesis of non-stationarity cannot be rejected for any of the variables in level form with a deterministic trend, suggesting that the variables in question do not exhibit a deterministic time trend throughout the period under review. In other words, the common practice of detrending the data by a single trend line will not render the data in question stationary because the trend line itself may be shifting over time (see Charemza and Deadman, 1997). [vi] When the ADF test is applied to these variables in first differences under the assumption of a constant and deterministic time trend, all of the variables become stationary at the five percent level of significance.

In view of the relatively low power of the ADF unit root tests when the data generating process is stationary but with a root close to the unit root, Table 2 (part B) presents the results of running a KPSS stationarity test (Kwaitkowski et al., 1992). This test has a no unit root (stationary) null hypothesis, thus reversing the null and alternative hypotheses under the Dickey Fuller test. It is used as a confirmatory test because in the presence of insufficient information, due to a relatively small sample size, it defaults to the stationary data generating process. The reported results in both level and differenced form under the assumption of a deterministic trend are consistent with those reported in Table 2 (part A). For example, the null hypothesis of *no unit root* can be rejected for all the variables in level form at the 5 percent level of significance; i.e., they appear to follow a random walk with (positive) drift. In the case of first differences, however, the null hypothesis of stationarity cannot be rejected for all variables at least at the 5 percent level. Thus, the evidence presented suggests that the variables in level form follow primarily a stochastic trend as opposed to a deterministic one, although the possibility that for given subperiods they follow a mixed process cannot be rejected.

Table 2: Part A. ADF Unit Root Tests for Stationarity with constant and time trend, sample Period 1970-2017

Variables	Level	First Difference	5% Critical Value
Y	-2.13	-7.65*	-3.50
L	-0.43	-6.92*	-3.50
K_p	-2.33	-7.03*	-3.50
K_f	-1.68	-3.71*	-3.50
R	-2.62	-8.39*	-3.50

MacKinnon (1966) critical values for rejection of hypothesis of a unit root.
* Denote significance at the 5 percent level.

Table 2: Part B. KPSS (LM) No Unit Root Tests for Stationarity with constant and time trend, Sample Period 1970-2017

Variables	Levels	First Difference	5% Critical Value[1]
Y	0.16*	0.05	0.14
L	0.23*	0.08	0.14
K_p	0.22*	0.09	0.14
K_f	0.18*	0.12	0.14
R	0.21*	0.08	0.14

Asymptotic critical values for rejection of null hypothesis of no unit root (LM-Stat.).
*Denotes significance at 5 percent level

6.1 Cointegration Analysis with Regime Shift

To determine whether there exists a stable and non-spurious (cointegrated) relationship among the regressors, this study employed the cointegration method first proposed by Johansen (1988). The Johansen method was chosen over the one originally proposed by Engle and Granger (1987) because it is capable of determining the number of cointegrating vectors for any given number of non-stationary series (of the same order), its application is appropriate in the presence of more than two variables, and more important, Johansen (1988) has shown that the likelihood ratio tests used in this procedure (unlike the DF and ADF tests) have well-defined limiting distributions.
To save space, Table 3 below reports the Johansen maximum L.R. test for cointegration for only the output equation.[vii]

Table 3: Johansen Cointegration (Trace) Test, 1970-2017

Eigenvalue	Likelihood Ratio	5%	P-value	No. of CE(s)
0.459	55.05	47.85	0.009	None
0.245	25.52	29.79	0.143	At most 1
0.192	11.98	15.49	0.157	At most 2
0.035	1.73	3.84	0.188	At most 3

Series: Y, L , Kp , Kf , and R.
Test assumptions: Intercept (no trend) in CE and VAR; D1, and D2 are treated as exogenous variables.
Estimations undertaken with Eviews 11.0.

The first column of the table gives the eigenvalues in descending order, while the second column reports the corresponding trace statistics generated from the maximum L.R. test statistic. The next two columns report, respectively, the 5 percent critical and p-values. Finally, the last column gives the null hypotheses, ranging from no cointegrating relationships up to at most four cointegrating vectors. It can be ascertained from the L.R. ratio statistics that, in the presence of a constant in the cointegrating and VAR equation, there exists a linear combination of the I(1) variables that links them in a stable and long-run relationship.
In fact, the p-value reported in the table shows that the null hypothesis of no cointegrating vector can be rejected at least at the one percent level, thereby suggesting the presence of one cointegrating equation from which residuals (EC terms) can be obtained to measure the respective deviations between the current level of output and the level based on the long-run relationship.[viii] Similar results were obtained for the labor productivity function and they are available upon request.
Before turning to the DOLS and FMOLS long-run estimates, it should be noted that the cointegrating test performed in this study does not allow for structural breaks in the sample period, whether level (intercept) shifts or regime (intercept and slope) shifts. However, Gregory and Hansen (1996) have shown that ignoring these breaks reduces the power of conventional cointegration tests similar to conventional unit root tests and, if anything, should lead to a failure to reject the null hypothesis of no cointegrating vector, which is clearly not the case in the present study. Still, this study undertook a G-H cointegration test with a regime (intercept and slope) shift and the results, which are consistent with the Johansen cointegration test, are reported in endnote 9.[ix]

6.2 FMOLS and DOLS Models

Having shown that the individual variables in question are I(1), and that there is at least one unique linear combination of these non-stationary variables (in level form) that is stationary, eq. (1) can be estimated via long-run cointegration regression models. These include the fully modified ordinary least squares (FMOLS) proposed by Phillips and Hansen (1990) and the dynamic ordinary least squares (DOLS) model proposed by Stock and Watson (1993). In this study we utilize both methodologies because these estimators are extremely consistent even in the presence of both endogeneity and serial correlation of any order. The FMOLS estimator employs a non-parametric correction to eliminate the problems caused by the long-run

correlation between the cointegrating equation and stochastic regressor innovations, and thus generates asymptotically unbiased and fully efficient estimates. DOLS, on the other hand, uses leads and lagged differences of the explanatory variables to control for the endogenous feedback (Saikkonen, 1991).

That is, the DOLS estimator uses a parametric adjustment to the errors in order to obtain an unbiased estimator of the long-run parameters. While DOLS and FMOLS solve the problem of endogeneity and eliminate small sample finite bias, the application of the FMOLS approach essentially requires that all variables must have the same order of integration and that the regressors must not appear as co-integrated; DOLS, on the other hand, generates estimates of the long-run parameters irrespective of the order of integration and the existence or absence of cointegration. In this connection, Kao and Chiang (2000) show that, on the basis of Monte Carlo simulations, DOLS outperforms FMOLS estimators in terms of finite sample biases. In view of this, this paper utilizes the DOLS approach to verify the estimates obtained via the FMOLS estimator. The paper also undertakes stability tests on the parameters in question via a test developed by Hansen (1992). The regressions are run for the 1970-2017 period in view of the fact that reliable remittance data is only available beginning in 1970.

The long-run estimates for the various models estimated (with and without dummy variables to ensure robustness) are presented in Tables 4 and 5.

Table 4: Mexico, FMOLS and DOLS estimates, 1970-2017 (Dependent variable = Yt)

	FMOLS		**DOLS**	
Variables	**Equation (1)**	**Equation (2)**	**Equation (3)**	**Equation (4)**
Constant	0.52	1.29	0.09	1.04
	(0.88)	(2.67)**	(0.11)	(1.93)**
L	1.03	0.98	1.04	1.00
	(9.84)**	(11.90)**	(8.19)**	(11.42)**
K_p	0.37	0.31	0.40	0.32
	(10.09)**	(11.09)**	(11.21)**	(11.24)**
K_f	-0.25	-0.20	-0.26	-0.22
	(-8.34)**	(-8.09)**	(-7.04)**	(-7.27)
R	0.03	0.05	0.04	0.05
	(2.02)**	(3.73)**	(2.12)**	(4.35)**
D_1	---	-0.03	---	-0.03
		(-2.12)**		(-3.51)**
D_2	---	0.13	---	0.11
		(5.62)**		(4.86)**
Adj.R^2	0.99	0.99	0.99	0.99
S.E.	0.04	0.03	0.03	0.02
L.R. var.	0.002	0.001	0.001	0.000

t-ratios in parenthesis. *Significant at the 10% level; **significant at the 5% level. L.R. var. = Long-run variance. N=48 observations.

Table 5: Mexico, FMOLS and DOLS estimates, 1970-2017 [Dependent variable = (Y/L)t]

	FMOLS		DOLS	
Variables	**Equation (1)**	**Equation (2)**	**Equation (3)**	**Equation (4)**
Constant	2.81	2.83	2.68	2.75
	(15.06)**	(22.92)**	(14.77)**	(22.94)**
(K_p/L)	0.31	0.29	0.33	0.31
	(7.37)**	(10.35)**	(8.45)**	(11.40)**
(K_f/L)	-0.21	-0.19	-0.23	-0.21
	(-7.66)**	(-9.67)**	(-8.26)**	(-10.62)**
(R/L)	0.06	0.06	0.07	0.07
	(4.29)**	(6.13)**	(4.34)**	(6.67)**
D_1	---	-0.02	---	-0.03
		(-1.88)**		(-2.73)**
D_2	---	0.10	---	0.09
		(4.81)**		(5.28)**
Adj.R^2	0.80	0.85	0.85	0.92
S.E.	0.04	0.03	0.03	0.02
L.R. var.	0.002	0.001	0.001	0.000

t-ratios in parenthesis. *Significant at the 10% level; **significant at the 5% level. L.R. var. = Long-run variance. N=48 observations

Turning first to the FMOLS results for economic output in Table 5, it can be seen from eqs. 1 (without the dummies) and 2 (with dummies) that most of the variables in question have their anticipated signs—with the notable exception of K_f-- and are significant at least at the 5 percent level. For example, in eq. 1, a one percent increase in the economically active population (L) increases the level of the real GDP (Y) in the long run by 1.03 percent, while a one percent increase in the stock of private capital (K_p) generates a long-run rise of 0.37 percent in the level of real GDP, ceteris paribus. Insofar as the impact of remittance flows are concerned, the estimates for the equations with and without the dummy variables suggest that they have a positive, albeit small, and highly significant effect on economic output in the long run. The only quantitative variable that does not have the anticipated effect in the long run is that for the foreign (FDI) capital variable. It is negative in its impact on the level of real GDP in eqs. 1 and 2 and highly significant. This unexpected result could be due to substantial reverse transfers in the form of profits and dividends and/or tax concessions to TNCs operating in the country, thus diverting resources away from investment and economic growth; it could also arise from the common practice of TNCs importing a high proportion of their capital and intermediate inputs rather than using local or domestic resources, thus establishing few or no backward linkages to the host economy. Finally, the anticipated positive transfers from the transfer of technology may be minimized or eliminated altogether if the technology transferred is "too capital intensive" and/or subject to overly restrictive intellectual property rights such as prohibitive royalty payments and leasing fees charged by TNCs for the use of their technology (see Ram and Zhang, 2002; and Cypher, 2014). Turning to the dummy variables, the estimates suggest that they have the anticipated signs and are highly significant in eq. 2. For example, the sign on D_1 suggests that economic and/or political crises have had a negative and significant effect on real GDP, while the sign for D_2 indicates that the petroleum-led expansion of 1978-81 had a positive and highly significant effect on real GDP.

As can be readily seen from Table 4, the FMOLS estimates are corroborated by the more robust DOLS estimates for the equations with and without dummies (eqs. 3 and 4). For example, a one percent increase in remittance flows to the country increases the level of real GDP in the long run by 0.05 percent in Eq. 4. Moreover, a quick perusal of the standard error and long-run variance for the reported DOLS equations suggests that they are a better fit to the data. Hansen stability tests for all equations (available upon request) suggest that the null hypothesis of parameter stability cannot be rejected for any of the reported equations (p-values > 0.2). The residuals for all of the reported equations were also checked for normality via the Jarque-Bera test, and the null hypothesis that the residuals are normally distributed could not be rejected for any of the reported equations at the 5 percent level (available upon request).

Table 5 below reports FMOLS and DOLS results for the labor productivity (Y/L) function. As can be seen from the estimates without dummies in eqs. 1 and 3, the included regressors, except for the foreign capital per worker variable, have their anticipated effects and are significant at the one percent level. For example, in eq. 1 a one percent increase in the stock of private capital per worker generates an increase of 0.31 percent in labor productivity in the long run (for both the FMOLS and DOLS specifications). Again, remittances per worker have a small but significant long-run effect on labor productivity in both the FMOLS and DOLS specifications.

The dummy variables in eqs. 2 and 4 also have their anticipated signs and are significant in both methodologies. The adjusted R^2 s for the labor productivity functions are somewhat lower than those for economic output, but the standard errors and long-run variances are comparable (if not lower) than those reported in Table 4. Finally, as in the case for economic output, stability and normality tests for these labor productivity equations did not lead to a rejection of the null hypothesis at conventional levels of significance.

7 Conclusion

Mexico has recorded substantial remittance flows since the second half of the eighties and the decade of the nineties and beyond, particularly in relation to GDP, gross fixed domestic capital formation, and from a regional standpoint. Moreover, these flows have, since the decade of the 2000s, rivaled or even exceeded the country's FDI inflows. Remittance flows also exhibit a greater degree of stability and less susceptibility to the business cycle than FDI inflows which are often referred to as the "good cholesterol" of global (private) financial flows. The empirical evidence reported in this study suggests that remittance flows have a positive, albeit small, and significant long-run effect on both the levels of economic output and labor productivity. These results are consistent with findings reported by other investigators, such as Giuliano and Ruiz-Arranz (2009), Kumar (2013), Meyer and Shera (2017), and Salahuddin and Gow (2015).

An important contribution of this study relative to the extant literature is that it undertook unit root tests utilizing both the conventional ADF as well as the confirmatory KPSS test. The estimates for the no unit root KPSS test are consistent with those reported for the unit root ADF test, and indicate that the series are non-stationary in level form and stationary when differenced once. This is an important finding because conventional unit root tests such as the ADF test tend to exhibit low power when the stationary alternative is true. Another important contribution to the extant literature is the reported finding via the Johansen test that there is a unique and stable relationship among the relevant variables in level form which keeps them in proportion to one another over the long run. Moreover, the Gregory and Hansen cointegration test with an endogenous structural intercept and slope break also indicates that the null of no cointegration can be rejected at the five percent level. This is also a significant and novel contribution because previous econometric studies relating to the impact of remittances in the Mexican case have failed to determine whether the estimated (cointegrated) relationships were spurious or not in the presence of a structural break. The reported DOLS and FMOLS long-run estimates suggest that the economically active population, the stock of private capital, and remittance flows have a positive and significant long-run effect on both the level of real GDP and labor productivity. Hansen stability tests for all equations suggest that the parameters are stable over the period in question. The estimate for the stock of foreign (FDI) capital variable, on the other hand, did not have the anticipated sign. The negative and significant long-run effect for this variable could be due to substantial reverse flows of profits and dividends that divert resources away from domestic

investment, few backward and forward linkages, inappropriate technology, competition that drives out current and potential domestic producers, and/or overly restrictive intellectual property rights. Clearly, this is an important and multifaceted research question that needs to be addressed fully by future investigators. Finally, the qualitative variables designed to pick up the effect of economic crises and the impact of the petroleum-led boom also have their expected signs and they are statistically significant. Although suggestive, the positive long-run estimates reported in this study for the remittance variable are by no means conclusive and need to be supported by micro-based case studies and/or sectorial (regional) studies. As more disaggregated data becomes available on a regional or sectorial basis, it will be possible to conduct panel cointegration studies to determine whether remittance flows have greater positive (or negative) effects on investment spending and labor productivity in certain regions or sectors of the Mexican economy. This should help policymakers and the home town associations alluded to earlier to funnel remittances to where they can have their maximum effect in terms of financing investment, promoting economic growth, and alleviating poverty.

References

Acosta, Pablo A. et al. 2008. "Remittances and the Dutch Disease." *Federal Reserve Bank of Atlanta, Working Paper2007-8a* (August), 1-22.

Aitymbetov, S. 2006. "Emigrant remittances: Impact on economic development of Kyrgyzstan." *ICEG Working Paper* (June), 1-20.

Bahamani-Oskoee, M. 1996. "Decline of the Iranian Rial during the post-revolutionary period: A Productivity Approach," *Journal of Developing Areas*, 30, 479-92.

Barajas, Adolfo et al. 2009. "Do Workers Remittances Promote Economic Growth?" *IMF Working Paper*, No. 153 (July), 1-22.

Barro, R.J. 1990. "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy*, 98, 5, 103-125.

Bloomstrom, M. and E. Wolff. Multinational Corporations and Productivity Convergence in Mexico. 1994. In *Convergence of Productivity: Cross-National Studies Historical Evidence,* edited by W. Baumol, R. Nelson, and E. Wolff. Oxford: Oxford University Press.

Canas, J., Coronado, R., & Orrenius, P. 2007. Explaining the increase in remittances to Mexico. *The Southwest Economy,* Federal Reserve Bank of Dallas, July/August.

Chami, R., Fullenkamp, C., & Jahjah, S. 2005. "Are immigrant remittance flows a source of capital for development?" *IMF Staff Papers, 53* (1), 57-70.

Chami, R., Barajas, A., Montiel, P., & Hakura, D. 2010. "Workers' remittances and the equilibrium real exchange rate: Theory and evidence," *IMF Working Papers, 10* (287), 1. https://doi.org/10.5089/9781455210947.001

Charemza, W.W. and D.F. Deadman. 1997. New Directions in Econometric Practice: General to Specific Modelling, Cointegration and Vector Autoregression. Cheltenham: Edward Elgar Publishers.

Cypher, J.M. 2014. *The Process of Economic Development, 4th ed.* New York: Routledge.

De Mello, Jr. Luiz R. 1997. "Foreign Direct Investment in Developing Countries and Growth: A Selective Survey." *Journal of Development Studies*, 34, 1 (October), 1-34.

De Vita, G. and K. Lawler. 2004. "Foreign Direct Investment and its Determinants: A Look to the Past, A View to the Future." In *Foreign Investment in Developing Nations,* edited by H.S. Kehal. New York: Palgrave Macmillan, Ltd.

Dickey, D., and W. Fuller, 1979. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica,* 49 (June), 1057-1072.

Doldado, J., T. Jenkinson, and S. Sosvilla-Rivero, 1990. "Cointegration and Unit Roots," *Journal of Economic Surveys,* 4: 249-73.

ECLAC. 2006-2021. Foreign Investment in Latin America and the Caribbean, Various Reports.

Ellerman, D. 2003. "Policy Research on Migration and Development," *World Bank Policy Research Working Paper,* No. 3117. Washington, D.C.: The World Bank.

Engle, R.F. and C.W.J. Granger. 1987. "Cointegration and Error Correction: Representation, Estimation, and Testing." Econometrica 55 (March), 251-76.

Fayissa, B. and C. Nsiah, 2012. "Financial Development and Remittances in Africa and the Americas: A Panel-Unit Root Tests and Panel Cointegration Analysis." Department of Economics and Finance Working Paper Series, Middle Tennessee State University, March: 1-22.

Guiliano, P. and Ruiz-Arranz, M. 2006. "Remittances, Financial Development, and Growth." IMF Working Papers, No. 05-234.

Gregory, A.W. and B.E. Hansen. 1996. "Tests for Cointegration in Models with Regime and Trend shifts." Journal of Econometrics 70, 1, 99-126.

Hakkio, C. S., and M. Rush. 1991. "Cointegration: How Short is the Long- run? Journal of International Money and Finance, 10, 571-81.

Johansen, Soren and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money." Oxford Bulletin of Economics and Statistics, 52 (May), 169-210.

Kao, C. and Chiang, M.H. 2000. "On the Estimation and Inference of a Cointegrated Regression in Panel Data." In: Baltagi, B., Ed., Nonstationary Panels, Panel Cointegration, and Dynamic Panels, JAI Press, Amsterdam, 161-178

Kumar, R. R. 2013. "Remittances and economic growth: A study of Guyana." Economic Systems, 37(3), 462–472. https://doi.org/10.1016/j.ecosys.2013.01.001

Kwaitkowski, D., Phillips, P.C.B., Schmidt, P., and Shin, Y., 1992. "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root," Journal of Econometrics, 54, 159-78.

Lee, J. and M.C. Strazicich. 2003. "Minimum Lagrange Multiplier Unit Root Test with Two Structural Breaks," The Review of Economics and Statistics, 85 (4), 1082-1089.

Meyer, D. and A. Shera, 2017. "The Impact of Remittances on Economic Growth: An Econometric Model," EconomiA, 18, 2, 147-155.

Mohapatra, D., D. Ratha, and A. Silwal. 2011. "Outlook for Remittance Flows 2011-13," Migration and Development Brief, No. 16. Washington, D.C.: The World Bank, May.

Mundaca, G. (2005). Can remittances enhance economic growth? the role of financial market development SSRN. Retrieved from http://ssrn.com/paper=799484

Nacional Financiera, S.A. La Economia Mexicana en Cifras. Mexico, D.F.: Nafinsa, various issues.

Orozco, M. 2004. "Mexican Hometown Associations and Development Opportunities," Journal of International Affairs, 57, 2, 1-20.

Perron, P. 1989. "The Great Crash, the Oil Price Shock and the Unit Root Hypothesis," Econometrica, 57, 1361-1401.

Ramanarayanan, A. 2009. "Ties that Bind: Bilateral Trade's Role in Synchronizing Business Cycles" Economic Letter, 4, 1, January, pp. 1-8. Federal Reserve Bank of Dallas.

Ram, R., and Zhang, K. H. 2002. "Foreign Direct Investment and Economic Growth: Evidence from Cross-Country Data for the 1990s," Economic Development and Cultural Change, 51, 205-215.

Ratha, D. 2003. "Workers' Remittances: An important and Stable Source of External Development Finance." Global Development Finance. Washington, D.C.: The World Bank.

Saikkonen, P. 1991. "Asymptotically Efficient Estimation of Cointegration Regressions. Econometric Theory," 7, 1-21. http://dx.doi.org/10.1017/S0266466600004217

Salahuddin, M. and Gow, J. 2015. "The Relationship between Economic Growth and Remittances in the Presence of Cross-Sectional Dependence," The Journal of Developing Areas, 49, 207-221. https://doi.org/10.1353/jda.2015.0007

Sharma, H. and M.D. Ramirez. 2009. "Remittances and Growth in Latin America: A Panel Unit Root and Panel Cointegration Analysis," Estudios Economicos de Desarrollo Internacional, 9 (1), 5-32.

Solimano, A. 2003. "Remittances by Emigrants: Issues and Evidence." Macroeconomias del Desarrollo, 26, Economic Development Division. Santiago: Chile, October.

The World Bank. 2010-2022. Migration and Development Brief, Various Issues. Washington, D.C.: Migration and Remittances Unit.

United Nations. 2021-2022. World Investment Reports 2021-2022: Trends and Determinants. Switzerland: United Nations.

Woodruff, C., 2006. Mexican microenterprise investment and employment: Role of remittances. INTAL-ITD Working Paper 26.

Endnotes

i. Ellerman (2003) reports that Mexican migrant associations send home between US $5000-$25, 000 per year, while migrant associations from El Salvador send home donations of about US $ 10,000 per year. Orozco (2004) identifies at least 2000 HTAs in the U.S., with the highest concentration in southern California and the Chicago Metropolitan area (p. 2). His field work indicates that, on average, Mexican HTAs send around $10,000 a year for a variety of rural projects, including health and education, public infrastructure, economic investment, church support, and recreation. He reports that these contributions are quite significant because in rural towns of less than 6000 inhabitants the annual municipal budget for public works is often less than $50,000 (p.4).

ii. For further detail see Blomstrom and Wolf (*op. cit*) who find that labor productivity growth in Mexico is positively associated with the degree of foreign concentration in a given industry (pp. 263-284).

iii. Investment and FDI data published by the OECD was cross-checked with that found in *INEGI* and *La Economia Mexicana en Cifras*, and no significant differences were discerned.

iv. For example, Hakkio and Rush (1991) contend that in nearly non-stationary time series "the frequency of observation plays a very minor role" in cointegration [and unit root] analysis because "cointegration is a long-run property, and thus we often need long spans of data to properly test it" (p. 579). They demonstrate this using Monte Carlo simulations for four popular tests. Similarly, Bahmani-Oskooee (1996) observes that in cointegration (and unit root) analysis using annual data over 30 years "is as good as using quarterly data over the same period" (p. 481).

v. The Doldado et al. procedure starts by estimating the most general (unrestricted) model (with a constant and a trend) before moving to the next more restricted model (a constant only), and so on. The order of the lag length was determined by applying both the AIC and SBC.

vi. A stochastic trend is one where the random component of the series itself, say variable x_t, contributes directly to the long run pattern of the series, either upward or downward. However, in the case of a deterministic trend the deviations from the non-stationary mean over time are quickly corrected. It is also possible for the variable in question to display both a stochastic and deterministic trend process over time. For further details see Charemza and Deadman, (1997, pp. 84-92).

vii. Estimates for the labor productivity function are consistent with those for the output function and are available upon request.

viii. The Gregory and Hansen (1996) cointegration test with endogenously determined level (intercept) and slope shift generated a minimum ADF* stat. = -5.61 [break point=1992] which is smaller than the tabulated 5 % critical value [-5.77 (1%); -5.28(5%); -5.02(10%)] reported by Gregory and Hansen. Thus, the null hypothesis of no cointegration with endogenously determined regime break is rejected at the 5 percent level of significance. It should be noted that the break date is found by estimating the cointegrating relationship for all possible break dates in the sample period. The Rats program selects the break date where the modified [trimmed] ADF* = inf ADF (τ) test statistic is at its minimum. All estimations were undertaken with Rats 10.0.