CAUSAL CHAINS BETWEEN SAVINGS INVESTMENT AND GROWTH: EVIDENCE FOR LATIN AMERICA AND THE CARIBBEAN

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ABSTRACT

This paper investigates causal links between savings, investment and growth in the Latin American and Caribbean economies over the period 1960 - 2007. It uses both the Johansen maximum likelihood estimation and autoregressive distributed lag framework to explore long- and short- run causality. It finds that causal links differ across countries; being fashioned both by adjustment to long-run equilibrium and stochastic shocks. The existence of a long-run stationary relationship between savings and investment, with causality running from saving to investment is a fairly consistent finding. The link from saving and investment to growth is much less uniform across countries.

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Key words: Savings, investment, growth, causality

1.0 Introduction

Neoclassical growth theory posits a close association between domestic saving, investment, and growth. It offers a rationale for using policy to increase the saving rate, which in turn stimulates higher levels of investment and, subsequently, economic growth. This is the basis of the financial liberalisation thesis, namely that the removal of the various constraints on the financial system will encourage higher saving, which will lead to more investment and hence increase growth. At the centre of the debate is the question of 'causation': whether any exists and if so in what direction.

Apart from its implications for the effectiveness of any financial liberalisation programme, the direction of causality is linked also to the debate on fiscal policy. If causality does run from saving to investment and growth, then raising the rate of investment requires increased national saving. This may justify using fiscal policy to reduce both public and private consumption and to encourage saving through tax breaks and other incentives. On the other hand, if one believes that it is investment that is the prime mover, then the problem is how to get businesses to increase their investment spending. Policies should be geared towards raising both the level and efficiency of investment. Yet if causality runs from growth to saving or investment, as many empirical studies have reported (for example, Carroll and Weil, 1994), the policy efforts should be directed at removing any impediments to growth. Although there is a large body of empirical literature examining the correlation between these aggregates, very few studies have dealt with the issue of causality and even fewer have examined the relationship for developing countries.

This paper examines the causal relationships between savings, investment and growth for Latin American and Caribbean economies. It extends the empirical research on this topic with respect to developing countries, and seeks to resolve the conflicting evidence reported by Sinha and Sinha (1998, 2004) with respect to the Latin America and Caribbean (LAC) region. Sinha and Sinha (1998) employ the Johansen maximum likelihood estimation (MLE) framework for cointegration, while the latter utilises a combination of nonlinear and ordinary least squares. One concern with the MLE approach to cointegration is that it tests for the absence of long-run relationships under the restrictive assumption that the variables are integrated of order 1, *I(1)*. However, if any of the regressors is *I(0)* or fractionally integrated then statistical inferences from the trace and maximum eigenvalue tests are unreliable because the likelihood testing procedure for the cointegrating rank can be sensitive to the presence of stationary variables (Rahbek and Mosconi, 1999). Hence, there must be certainty as to the order of integration of the underlying variables prior to proceeding with the analysis. In light of this concern, we use two approaches to cointegration; MLE and the autoregressive distributed lag (ARDL) framework (Pesaran et al., 2001). The advantage of the latter is that it allows testing for cointegration irrespective of whether the regressors are purely *I(0)*, purely *I(1)* or mutually cointegrated. Given the possible uncertainty concerning the stationary properties of the variables for some of the countries under review, this is attractive for modelling purposes, as is the small sample properties of the ARDL approach. Using both procedures we investigate the long- and short-run causal relationships among domestic saving, domestic investment and economic growth for the individual countries.

The rest of the paper is organised as follows: The next section provides a review of the theoretical issues and of the empirical evidence. Section 3 describes the methodological approach, while section 4 discusses the estimation procedures and results. Section 5 presents the conclusions and implications of the study.

2.0 Review of Theoretical Issues and Empirical Evidence

The view that causality runs from saving to investment to growth is consistent with classical and neoclassical growth models, while the hypothesis that investment causes saving, leading to growth, is predominately associated with Keynesian macroeconomics. Indeed, alternative theoretical perspectives are capable of producing reverse and bi-directional causality.

In classical macroeconomics the growth of output depends first and foremost on investment, which in turn depends on the rate of saving and is therefore endogenous. In this framework, the interaction between the demand for and the supply of loanable funds determines the level of investment. The demand for loanable funds or investment demand is a positive function of the real interest rate. The supply of loanable funds or saving is a negative function of the real interest rate. Accordingly, an outward shift in the investment demand function will lead to a rise in investment rates and an increase in the equilibrium levels of investment and saving, the magnitude of which depends on the interest sensitivity of saving. However, investment can also increase as a result of an outward shift of the saving curve. If the investment demand schedule is perfectly inelastic investment is independent of saving, and if the saving schedule is perfectly inelastic saving constrains investment.

Keynesian and neo-Keynesian macro-models assign only a passive role to savings. According to these models, the main lever that moves the economy on the path of economic growth is investment, which is induced by the "animal spirit of entrepreneurs". Growth and the investment ratio are related through the required incremental capital-output ratio (the amount of extra investment required to produce an additional unit flow of output at a given interest rate) and the acceleration principle and the degree of capital utilisation. In steady-state (long-run equilibrium) the actual growth rate of the economy will coincide with its warranted growth rate (where planned savings match planned investment and capital is fully employed) and its natural growth rate (where there is full employment of labour), at a level equal to the inverse of the incremental capital-output ratio. Moreover, in equilibrium investment must grow at a rate equal to the product of the saving ratio and the productivity of capital. The model therefore establishes a long-run relation between saving and investment ratios and also between the investment ratio and growth. When the economy is in disequilibrium, the adjustment mechanism is one in which saving adjusts to an independently determined amount of investment; the "Keynesian hypothesis" (Kaldor, 1957). Hence, causality should be found to run from investment to saving, that is, investment should be weakly exogenous.[1]

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[1] The definition of weak exogeneity used here is consistent with that of Engle et al., (1983), where a variable X_t is said to be weakly exogenous, within the context of the system defined (in this case the relationship between saving and

In the neoclassical growth theory (Solow – Swan model) an increase in the saving ratio will generate higher growth but only in the short-run. Steady-state (or long-run) growth will not be affected by the saving or investment ratio, although the steady-state output level will. The rate of capital accumulation affects growth only in the transition to steady-state; long-run growth is determined solely by the rate of technological change, which is assumed to be exogenous. In a neoclassical world we would expect data on saving and investment ratios to have a long-run relationship, with causality running from the former. In steady state, output and capital per unit of effective labour grow at the exogenous rate of technological process, while the levels of output and the capital stock expand at the steady-state rate of the combined rates of population growth and technological process. Therefore, the model predicts that long-run growth is independent of the saving rate.

If the economy is on its long-run equilibrium growth path and there is an increase in the saving rate, the saving schedule will shift outwards so as to give rise to a temporary rise in the growth rate of the economy. Thereafter, the growth rate will gradually diminish over time, returning to its original level. Hence, according to the neoclassical model, country data should show a long-run positive relationship between the saving ratio and the level of per capita output, but not between the saving ratio and growth in per capita output. However, in the short-run, changes in the saving ratio precede changes in both the level and growth of per capita output.

One of the reasons why the saving (investment) ratio does not matter for long-run growth in the neoclassical model is because of the assumption of an exogenously determined rate of technological process. Thirlwall (2003) argues that if an increase in the savings (investment) ratio is allowed to raise the rate of growth of labour-augmenting technological process, then the ratio of saving (investment) does matter for long-run growth. Relaxing the assumption of diminishing returns to capital embodied in the production function will also change the conclusions.

investment), if changes in that variable, ΔX_t , fail to respond to the defined long-run disequilibrium.

Romer (1987) shows that under constant returns to capital the effect of saving on growth in the long-run is positive.

The Ramsey-Cass-Koopmans version of the neoclassical model discards the assumption of an exogenous saving rate, which is central to the Solow-Swan model, and adds a demand side that explicitly incorporates the optimising behaviour of consumers. However, the resulting temporal relationship between the saving ratio and the growth rate is less clear. Carroll and Weil (1994) show that the predictions of the model depend on its parameter values. For example, if consumers are assumed to be forward-looking then a link can also run from growth to saving; when growth is exogenously higher, consumers will feel wealthier and will consume more and save less. Hence, a negative relationship runs from growth to saving.

Intertemporal consumption theory also suggests a strong relationship between saving and growth, although the causal nature is ambiguous. For example, the life cycle model of saving (Modigliani, 1970) predicts that high growth causes high saving. Assuming that the saving rate is the same across cohorts, then productivity growth will make the young better off relative to the retired and there will be growth in aggregate saving in the economy. This is because the former group is accumulating wealth, while the latter is spending by reducing their wealth. However, Carroll and Summers (1991) note that this result only holds if the income growth rate for each cohort is equal to the aggregate growth rate. They suggest that a more realistic assumption is to allow each household income growth rate to be equal to the aggregate rate plus a household-specific growth rate (reflecting seniority, occupation and other household-specific factors). Then, under reasonable parameter values an exogenous increase in aggregate growth will make each cohort want to consume more and save less. Hence, there will be a negative relationship running from growth to saving. Attanasio et al., (2000) point out that where individual savers are modelled explicitly as forward-looking, the model predicts that causality will run from saving to growth with possibly a negative sign, the reason being that rational individuals will anticipate declines in future income and therefore increase savings in the current period.

Theory is inconclusive about the causal relationships between saving, investment and growth. Establishing causality is, therefore, an empirical matter, though theory does indicate that caution should be exercised in interpreting causality results. For example, in the Solow-Swan model, where an increase in saving results in an instantaneous jump in the growth rate which gradually decreases over time, one might not find any positive Granger causality running from saving to growth. Yet, as Vanhoudt (1998) points out, this is perfectly consistent with the theoretical model since Granger causality tests control for lagged growth. In fact, the theory is actually predicting negative causality: increases in the saving rate precede falling growth after controlling for lagged growth and current saving. Furthermore, care must be taken to distinguish between correlation and causality. An exogenous shock to a model parameter can result in instantaneous changes in saving (investment) and output followed by a gradual adjustment to the new equilibrium. In which case what is being observed is correlation as opposed to causality. However, if the new equilibrium is attained by, say, output making the necessary adjustments in each period, then output is said to be "caused" by that disequilibrium.

Empirical Evidence

One strand of the empirical literature has focused on the relationship between saving and investment to assess the degree of integration of international financial markets.[2] In an open economy, the association between domestic saving and investment depends on the degree of capital mobility. In principle, if capital mobility is unrestricted, a country's saving will flow to wherever a higher return on investment is offered. Thus increases in domestic saving may not necessarily be translated into higher investment, but be reflected in a larger current account surplus. On the other hand, if international capital mobility is limited then higher saving will stimulate higher domestic investment and

[2] For example, Feldstein and Horioka (1980), Coakley et al. (1996), Jansen (1996) and Schmidt (2003).

growth. Most of the work in this area has focused on correlation rather than causality.[3]

Most of the empirical research in this area has been inspired by the seminal work of Feldstein and Horioka (FH) (1980), who estimate the following equation:

$$(I/Y)_t = \beta_0 + \beta_1 (S/Y)_t + \varepsilon_t \qquad (1)$$

where I/Y is the ratio of domestic investment to GDP, S/Y is the ratio of national saving to GDP, and ε is an error term. If the value of β_1 is equal or close to 1 then the two ratios are highly correlated, which means that the main source of finance for domestic investment is domestic saving. The authors interpret such a result as implying perfectly immobile capital internationally. The case of β_1 equal to 0 implies that capital is perfectly mobile internationally. Using data on 16 industrial countries, FH estimate eq. 1 and cannot reject the hypothesis that β_1 is equal to 1. They conclude that among these major industrial countries capital was highly immobile. This is a difficult conclusion to accept for developed countries[4] and numerous commentators have challenged the interpretation of the results and of eq. 1, including, inter alia, Murphy (1984), Finn (1990), Dooley et al. (1987) and Coakley et al. (1996). Nevertheless, these and subsequent studies have confirmed FH's results of a high correlation for industrialised countries over varying time periods and using different econometric techniques.

The high correlation between saving and investment ratios may result from a number of plausible macroeconomic factors which have nothing to do with capital mobility (for example Westphal, 1983; Baxter and Crucini, 1993). For instance, a positive shock to productivity could lead to higher levels of investment, since capital is more productive, and

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3 Coakley et al. (1998) provides a comprehensive survey of this literature.

4 Since it appears that financial markets in the countries of the Organisation for Economic Cooperation and Development (OECD) were already highly integrated and, from a theoretical viewpoint, most open-economy macro models assume that, in the absence of capital controls and with floating exchange rates, capital mobility was high. This came to be known as the Feldstein-Horioka puzzle.

raise savings as wages are temporarily high. This would result in co-movements in saving and investment. Therefore, Dooley et al. (1987) and others posit, because of the procyclical nature of both savings and investment, empirical studies on the relationship between the two must take endogeneity into account.

Feldstein and Bacchetta (FB) (1991) attempt to deal with the endogeneity issue by estimating the following equation:

$$\Delta\left(I/Y\right)_t = \alpha_0 + \alpha_1\left[\left(S/Y\right)_{t-1} - \left(I/Y\right)_{t-1}\right] + \xi_t \tag{2}$$

One may hypothesise that a country's domestic investment rate responds to the previous period's 'saving-investment' gap (a_1 captures the speed of adjustment). It can be viewed as estimating the short-run responses that maintain the long-run relationship in eq. 1 (Schmidt, 2003). FB's results for 23 OECD countries suggest that a nation's investment rate is the equilibrium correcting term (since it responds endogenously to the 'saving-investment' gap) and therefore saving 'causes' investment. They also find that saving did not respond to the gap.[5]

Jansen and Schulze (1996) and Schmidt (2003) contend that eqs 1 and 2 are intimately related and that estimating them separately constitutes a mis-specification error. Particularly, eq. 1 is mis-specified because it ignores the dynamic adjustment process which would maintain the long-run relationship. Moreover, it is subject to 'spurious' regression issues typical of non-stationary series. Although eq. 2 is not subject to the problems of spurious regression, it is still mis-specified since it assumes that the long-run relationship between domestic saving and investment rates is [1.0, -1.0], and restricts the short-run correlation between the ratios to be zero, thereby limiting the dynamic structure.[6]

[5] This is done by estimating equation 2 with $\Delta\left(S/Y\right)_t$ as the dependent variable.

[6] Equation 2 is a restricted form of the more general error-correction representation in equation 3 by assuming $\Psi_2 = \Psi_3 = 0$.

Jansen (1996) therefore combines the two equations into a more general error-correction equation of the form:

$$\Delta(I/Y)_t = \psi_0 + \psi_1\left[(S/Y)_{t-1} - (I/Y)_{t-1}\right] + \psi_2\Delta(S/Y)_t + \psi_3(S/Y)_{t-1} + \zeta_t \qquad (3)$$

where Ψ_1 measures the speed of adjustment of the investment rate to the previous year's saving-investment gap (if statistically significant it is taken as evidence of cointegration between the saving and investment rates). Ψ_2 measures the short-run correlations and captures the extent to which shocks to saving in the current period pass through to investment in the current period, while Ψ_3 allows for the cointegrating relationship to differ from unity. Jansen produces estimates for 23 OECD countries which suggest that the ratios are cointegrated and that, in general, national investment responds endogenously. These results for the OECD have been confirmed by various authors including Hussein (1998). Moreno (1997) finds similar results for the US and Japan, with causality running from saving to investment.

Unlike the results for industrial countries, the few studies for developing countries suggest that the causal relationship between the two aggregates is not common across countries.[7] Sinha (2002) addresses the causality issue for 11 Asian countries within the Johansen MLE framework and using data spanning 1955 to 1999. His results suggest that only for Myanmar and Thailand are the ratios cointegrated, with the saving ratio responding to disequilibrium: that is, causality runs from investment to saving. He also reports that growth in the saving rate causes growth in the investment rate for Sri Lanka and Thailand, while the reverse holds for Hong Kong, and bi-directional causality exists for Malaysia and Singapore. These findings are inconsistent with an earlier study by Anoruo (2001) on five Asian countries, four of which are in the Sinha sample (Malaysia, Philippines, Singapore and Thailand), plus

[7] There are other studies on developing countries examining the saving-investment relationship, but they focus on assessing the degree of correlation in accordance with the FH puzzle without addressing the issue of causality (Dooley et al., 1987; Wong, 1990; Montiel, 1994). The general conclusion is that developing countries have, on average, lower saving-investment correlations than the results reported for industrialised countries.

Indonesia. Anoruo also uses the Johansen MLE approach, with a sample covering 1960-1996. He finds a long-run relationship for all five countries, with causality running for investment to saving in Indonesia and Singapore, in the opposite direction in the Philippines and Thailand, and in both directions in Malaysia. Anoruo's short-run analysis suggests causality from investment to saving in Malaysia, bi-directional for Thailand, while no significant influences were found for the other countries.

Sinha and Sinha (1998) address the question of cointegration between saving and investment ratios for the LAC countries by estimating eq. 3, but ignore the issue of causality and short-run behaviour. Using the Johansen MLE approach, they find a long-run association between saving and investment in Ecuador, Honduras, Jamaica and Panama, but conclude that the variables are not cointegrated in Colombia, Dominican Republic, El Salvador, Guatemala, Mexico and Venezuela. The ratios for the Dominican Republic are deemed to be stationary and hence not cointegrated.[8] The ratios for the other five countries, although *I(1)*, fail the "trace" test statistic for cointegration.

The authors extend their work to include 123 countries from different regions in a later paper (Sinha and Sinha, 2004). They estimate eq. 3 by ordinary least squares (OLS) and use an autoregressive procedure, estimated by nonlinear least squares, for problems of serial correlation. The sample period is not given; however it contains 17 Latin American countries of which six have cointegrating ratios. Honduras and Panama are now listed among those for which there is no long-run relationship between the two ratios, while El Salvador is now identified as having one.

The sample also contains four Caribbean countries, Barbados, Guyana, Jamaica and Trinidad and Tobago. They find a long-run relationship for Guyana and Trinidad and Tobago, but none for Jamaica, the opposite of what was reported in the previous paper. The results for Barbados are discarded because the Jarque-Bera statistic indicates a

[8] According to the ADL approach to cointegration, if the saving ratio for Dominican Republic is I(d), where $0<d<1$, it is still possible to find cointegration but not when using the conventional trace test since that test is no longer reliable.

problem of non-normality at the 5% level of significance. It should be noted that estimating eq. 3 with OLS is in fact assuming that the long-run relationship given in eq. 1 is characterised by $\beta_0 = 0 \; and \; \beta_1 = 1$. These restrictions should be determined by the data rather than imposed.

The results on cointegration in the Sinha and Sinha (2004) study are at variance with an earlier study by Schneider (1999). Although Schneider did not address causality, his results on the saving-investment correlations in LAC countries suggest that for most of the countries the ratios are cointegrated over the period 1970-97. Van Rensselaer and Copeland (2000) arrive at similar conclusions, using data spanning 1972-1996. Both studies use the Engle-Granger two-step approach to cointegration analysis.

Another line of research has concentrated on the issue of causality between saving and growth (for example, Carroll and Weil, 1994; Attanasio et al., 2000; Andersson, 1999). Results from these studies have questioned the traditional notion of higher saving leading to faster growth through capital accumulation. They tend to find growth driving saving, especially in the short-term. Others have also asked the question as to whether or not investment is necessary for growth or, put differently, should increases in the investment rate precede increases in the growth rate. Again, the results indicate that in the short-run, investment may be a consequence, rather than a cause, of growth.

One of the most comprehensive empirical works on the topic is that of Carroll and Weil (1994). Using data on the OECD from the 1960s to late 1980s, they conclude that the data consistently support the notion that high income growth is followed by, rather than preceded by, high saving. Furthermore, higher saving is not followed by higher growth, at least in the medium-run. To the extent that there is any causality running from saving to growth, it is with a negative sign which, they argue, is consistent with optimal growth theory in which consumers have advance knowledge about income growth rates.

The results of Carroll and Weil are consistent with the study by Rodrik (2000). Rodrik utilises data on 20 developing countries over the period 1960-1994 and finds strong evidence that in the very short-run growth precedes saving. As for the reverse relationship, he reports a negative effect from saving to growth. However, as Vanhoudt (1998) argues, such a result is in keeping with the predictions of the neoclassical model. Andersson (1999) examines the issue for Sweden (1950-1996), the UK (1952-1996) and the USA (1950-1997) and finds that the causal relationships between saving and GDP differ across the countries, with mutual causality between saving and growth for the UK, causality from saving to growth for Sweden and no causality for the USA. He concludes that, given the different structures of these economies and the possible different channels of temporal interdependence, it is not reasonable to expect commonality in the results.

This view of growth causing saving has also found support in a study by Gavin, Hausmann and Talvi (1997) on LAC. However, it is only after a sustained period of high growth that saving rates increase, and they may do so with considerable delay. Similar results are reported in Sinha and Sinha (1998) for Mexico (1960-1996). They conclude that GDP growth positively Granger-causes both private and public saving, but find no evidence of reverse causality. The growth to saving causality has been confirmed for other developing countries by different authors; for example, Sahoo et al. (2001) for India, Akinboade (1998) for Botswana and World Bank (1993) on the East Asian miracle. The latter reports that growth causes saving for Indonesia, Japan, Korea, Thailand and Taiwan, and ambiguity for Hong Kong and Malaysia.

On the question of causality between the investment ratio and growth, Blomstrom et al. (1996) find that GDP growth induces subsequent investment more than investment induces subsequent growth. This result contradicts works by De Long and Summers (1991), Mankiw et al. (1992), Barro and other earlier studies, which conclude that the investment ratio exerts a major influence on growth.

The above studies, with the exception of Andersson (1999) and Sinha and Sinha (1998), utilise panel data. For causality analysis, this requires the estimation of dynamic panel-data models with lags of the dependent variable included as regressors. However, a major drawback is the use of the lagged dependent variable as an instrument. Andersson (1999) argues that this imposes a severe limitation on the analysis, since the timing of the variables is the main focus of the investigation. He recommends the use of a VAR approach for the causality tests as a way to circumvent this problem since then the variables will be allowed to be determined simultaneously. He also argues that the assumption of parameter homogeneity across countries, commonly used in the estimation of panel models, may be too restrictive since it imposes a common temporal growth/saving relationship on all countries.

3.0 Econometric Methodology

We employ both the Johansen MLE and the Pesaran et al. ARDL approaches to cointegration analysis to investigate the causal relationships between domestic saving, domestic investment and growth in the LAC. The Johansen MLE is the preferred approach, but in the event that there is uncertainty concerning the stationarity properties of the series the ARDL is utilised. Statistical inference from the trace and maximum eigenvalue tests in the MLE may be unreliable. The ARDL approach allows testing for the existence of cointegration when it is not known with certainty whether the regressors are purely *I(0)*, or purely *I(1)*.

The Johansen MLE framework begins with a vector autoregressive (VAR) representation of the form:

$$x_t = \eta + \sum_{i=1}^{p} \Pi x_{t-i} + \varepsilon_t \tag{4}$$

where x is an $n \times 1$ vector of variables, some of which may be *I(1)* or *I(0)*, η is an $n \times 1$ vector of deterministic variables, Π is an $n \times n$ coefficient matrix and ε is an $n \times 1$ vector of disturbances with normal properties. If there exists a cointegrating relationship among the *I(1)* variables then eq. 4 may be reparameterised into a vector error correction model (VECM):

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-i} + \Pi x_{t-1} + \varepsilon_t \tag{5}$$

where Δ is the first difference operator, and Φ is an $n \times n$ coefficient matrix. The rank, *r*, of Π determines the number of cointegrating relationships. If the matrix Π is of full rank (*n*) or zero, the VAR is estimated in levels or in first differences respectively, since there is no cointegration amongst the variables. However, if the rank of Π is less than *n* then there exist $n \times r$ matrices β (the cointegrating parameters) and α (the adjustment matrix, which describes the weights with which each variable enters the equation such that $\Pi = \alpha\beta'$, and eq. 5 provides the more appropriate framework. The Π matrix is estimated as an unrestricted VAR and tested to see whether the restriction implied by the reduced rank of Π can be rejected.

The test statistics for determining the cointegrating rank of the Π matrix are the trace statistic given by

$Q_t = -T \sum_{i=T-1}^{k} \log(1-\lambda_i)$, for $r = 0,1,\ldots,k-1$ and $\lambda_i =$ the i^{th} largest eigenvalue

and the maximum eigenvalue statistic, which is given by

$$Q_t = -T\log(1-\lambda_{T-1}) = Q_T - Q_{T+1}$$

The issue of the causal relationship between the variables can be tested through an examination of the Φ_i and *a* in eq. 5. Specifically, if Δx_{it} fails to respond to the defined long-run disequilibrium, i.e. $a_i = 0$, then x_{it} is said to be weakly exogenous. Strong exogeneity requires, in addition to weak exogeneity, that Δx_{j}. also fails to respond to the incorporated (ϱ) lags of Δy_{it} An alternative way to see this is to expand the VECM (eq. 5) for the case of saving and investment, $x = \left[I/Y \quad S/Y\right]'$, as:

$$\begin{bmatrix} \Delta(I/Y)_t \\ \Delta(S/Y)_t \end{bmatrix} = \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} + \begin{bmatrix} \sum_{i=1}^{l} \delta_{1i} & \sum_{i=1}^{m} \gamma_{1i} \\ \sum_{i=1}^{l} \delta_{2i} & \sum_{i=1}^{m} \gamma_{2i} \end{bmatrix} \begin{bmatrix} \Delta(I/Y)_{t-i} \\ \Delta(S/Y)_{t-i} \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} [\beta_1 \quad \beta_2] \begin{bmatrix} (I/Y)_{t-1} \\ (S/Y)_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \qquad (6)$$

where α captures the speed of adjustment from a state of disequilibrium, defined by the last period's investment-saving gap [$gap = (I/Y)_{t-1} - \beta_1 - \beta_2 (S/Y)_{t-1}$], towards long-run equilibrium. If saving and investment are cointegrated, then deviations from the long-run equilibrium in the short-run will feed back on the changes in one or both variables in order to force movement back towards long-run equilibrium.[9] Hence, one way to examine causality (or endogeneity of the dependent variable) is through the statistical significance of the a coefficients. For example, if a_1 is statistically insignificant then the investment ratio is weakly exogenous since it does not respond to disequilibrium. Alternatively, if a_1 is significant then the change in the investment ratio is driven directly by this long-run equilibrium error and long-run causality is said to run from saving to investment. Additionally, if $\sum \gamma_{1i}$ is significant then changes in saving cause changes in investment (i.e. short-run causality runs from saving to investment). Non-significance of both measures indicates strong exogeneity of the investment ratio. The same analysis holds when saving is the dependent variable. It is worth stressing here that the term "long-run causality" should not be interpreted in a temporal sense since deviations from equilibrium are partially corrected between each short period. If, for example, there is unidirectional causality from saving to investment then there are two possible scenarios. Investment could be responding in the short-term to deviations from the long-term equilibrium, implied by the cointegrating relationship, in order to restore the long-run equilibrium and we would say that long-run causality runs from saving to investment. However, investment could also be responding to short-term stochastic shocks in saving, in which case we would say that short-run causality runs from saving to investment.

Pesaran et al. (2001) show that under certain conditions the autoregressive distributed lag models may be used for the estimation of long run relationships. They prove that once the order of the ARDL has been determined, OLS may be used for the purpose of estimation and identification. The presence of a unique long-run relationship is crucial for valid estimation and inference. Such inferences on long- and short- run parameters may be made, provided that the ARDL model is correctly augmented to account for contemporaneous correlations between the stochastic terms of the data generating process included in the ARDL estimation. Hence, ARDL estimation is possible even where explanatory

[9] If the gap > 0, the adjustment back to equilibrium would require the saving ratio to rise and/or the investment ratio to fall. For gap < 0, the opposite responses would occur.

variables are endogenous. Moreover, ARDL remains valid irrespective of the order of integration of the explanatory variables.

The ARDL framework can be implemented by modelling eq. 3 as a conditional ARDL- ECM:

$$\Delta\left(I/Y\right)_t = c_0 + \omega_1\left(I/Y\right)_{t-1} + \omega_2\left(S/Y\right)_{t-1} + \sum_{i=1}^{p}\upsilon_i\Delta\left(I/Y\right)_{t-i} + \sum_{j=1}^{q}\nu_i\Delta\left(S/Y\right)_{t-i} + \varsigma_t \tag{7}$$

where c_0 is the drift component, and ς_t are white noise errors. To test for the existence of a long-run relationship, an *F*-test is employed to assess for the joint significance of the coefficients of the lagged levels in eq. 7 (so that $H_0 : \omega_1 = \omega_2 = 0$). Two asymptotic critical value bounds are provided in Pesaran et al. (2001) to test for cointegration when the independent variables are *I(d)* (where $0 \le d \le 1$): a lower value assuming the regressors are *I(0)*, and an upper value assuming purely *I(1)* regressors. If the *F*-statistics exceed both critical values we can conclude that a long-run relationship exists. If it falls below the lower critical values, we cannot reject the null hypothesis of 'no cointegration'. If the statistics fall within their respective bounds, inference would be inconclusive.

Once cointegration is confirmed, the conditional long-run model for $\left(I/Y\right)_t$ can be recovered from the reduced form solution of eq. 7:

$$\left(I/Y\right)_t = \Theta_0 + \Theta_1\left(S/Y\right)_t + \tau_t \tag{8}$$

where $\Theta_0 = c_o/\omega_1,\ \Theta_1 = -\omega_2/\omega_1$. These coefficients are obtained by first estimating eq. 8 by OLS and then using the model selection criteria to determine the optimal structure for the ARDL specification of the short-run dynamics. With both the long-run and short-run coefficients in hand, causality analysis can be done as before.

4.0 Estimation and Results

This study utilises annual data from the World Bank *World Development Indicators 2009 (WDI2009)* for the following Caribbean countries:

Barbados, Guyana, Jamaica and Trinidad and Tobago spanning the period 1960 to 2007, the Organisation of Eastern Caribbean States[10] (OECS) over the period 1977 to 2007, and for the following Latin America countries; Argentina, Brazil, Chile, Colombia, Costa Rico, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, Peru, Uruguay, and Venezuela, over 1960 to 2007.

The usual procedure in growth empirics and causality analyses is to work with rates. In this regard, there is often the question as to whether or not it makes sense to examine a ratio for a unit root since a ratio cannot take a value greater than one. In our view, it is possible to construct a process with time varying variance that does not necessary explode (for example, random walks with reflecting barriers are bounded but they are considered *I(1)* processes). Nevertheless, so as not to be caught up in the debate, we conduct our investigation on the totals of the variables in real terms using the GDP deflator; gross domestic saving,[11] gross domestic investment (gross capital formation) and GDP.

We begin by examining the stationary properties of the ratios. First, we test for the order of integration using the Augmented Dickey-Fuller, ADF test for a unit root. We also apply the Phillips-Perron, PP test to confirm the results of the ADF test. The ADF test corrects for higher order serial correlation by adding lagged differenced terms on the right-hand side and, in small samples, and the resulting reduced degrees of freedom can affect the power of the test. The PP test makes a correction to the t-statistic to account for the serial correlation in the errors. One potential problem with both the ADF and PP tests is that they take a unit root as the null hypothesis. In this regard, Blough (1992) notes that unit root tests have a high probability of falsely rejecting the null of non-

[10] The OECS is a nine-member grouping comprising Antigua and Barbuda, Commonwealth of Dominica, Grenada, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Montserrat, Anguilla and the British Virgin Islands. The latter three are still British dependent territories, while Anguilla and the British Virgin Islands are only associate members of the OECS.

[11] Gross domestic saving is define as GDP less final consumption expenditure and gross capital formation is measured as outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals.

stationarity when the data generation process is close to a stationary process. We also utilise, therefore, the KPSS test described in Kwiatkowski et al. (1992) in order to confirm the validity of the ADF and PP test results.

The results from the stationarity tests are available from the authors on request. If the variables for a country are confirmed to be *I(1)* by the three tests (the ADF and PP fail to reject the null and the KPSS does) then we use the Johansen MLE approach for that country. If however there is ambiguity concerning the stationarity properties of one of the series (both either reject or fail to reject the null) then we move on to the ARDL framework since it is possible that the series is neither *I(0)* or *I(1)* but fractionally integrated, that is, *I(d),* where $0<d<1$. The final possibility is that both series are *I(0)* (the ADF and PP reject the null and the KPSS fails to do so), in which case conventional regression analysis is suitable.

Except for a few cases, the three tests are in agreement that for each country the series are *I(1).* For Guyana and Peru the ADF and PP tests suggest that the saving variable may be *I(1)*, while the KPSS test points to stationarity. In the case of Jamaica, Argentina and Venezuela, the disagreement is with respect to both the saving and investment series. Therefore, in analysing the causal chains for these countries we utilise the ARDL procedure, while for the others we employ the Johansen MLE approach.

Causality analysis for the saving-investment relationship

The results of the Johansen MLE test for the number of cointegrating relationships are presented in Table A1 (appendix). In each case the appropriate lag length is chosen using the Akaike information (AIC), Schwarz Bayesian (SB) and Hannan-Quinn (HQ) criteria. The procedure involves estimating an unrestricted VAR and testing for the appropriate lag length by ensuring the selected VAR behaves well and satisfactorily describes the data (passes all the necessary diagnostic tests including that of mis-specification and normality of the residuals). Once we have attained data congruency, we move to determine the cointegration rank as outlined in Johansen (1988) and Johansen and

Juselius (1990). For the ARDL approach, the results for the bounds tests for cointegration are contained in Table A2 (appendix). To ensure that the results are not overly sensitive to the lag length, we present the bounds tests for p and q equal to 1, 2 and 4 (with annual data it is expected that the optimum length will be either 1 or 2). Note also that if a long-run relationship is confirmed between the two series then it is necessary to check for reverse causality. Only then (in the absence of reverse causality) can we confirm which is the forcing variable and the direction of causation.

The evidence suggests that, with the exception of El Salvador and Uruguay, all countries had a cointegrating relationship between saving and investment over the sample period. In the case of Uruguay, although we did find a data congruent VAR(2), our search for cointegration failed to uncover a stable relationship. For El Salvador we could not reject the null hypothesis of no cointegration over the full sample period; however, closer inspection indicated that the two series moved closely together between 1960 and 1980 but have since diverged, with saving declining and investment rising. We therefore tested for and found cointegration in the sub-period 1960-80 for El Salvador.

Table 1 depicts the cointegration results between saving and investment for each country. The second column gives the long-run coefficient with investment as the dependent variable. Hence, β is the long-run elasticity of real gross domestic investment with respect to real gross domestic saving. However, an r beside the coefficient denotes that it refers to the opposite, that is, the long-run elasticity of real gross domestic saving with respect to real gross domestic investment. The third and fourth columns show the 'speed of adjustment to long-run' parameter; α_1 is the estimated adjustment coefficient in the investment equation and, if significant, implies that investment responds to long-run disequilibrium,[12] hence investment is endogenous and is 'caused' in the long run by saving, while α_2 holds the same meaning for the saving equation. Columns 5 and 6 give the Wald tests for short-run causality;

[12] Disequilibrium in this case is defined as the $i - s = gap$. A positive (negative) gap exists if saving has fallen (risen) relative to investment, in which case the significant a_1 implies that investment must fall (rise) to restore equilibrium and positive long run causality is said to run from saving to investment.

column 5 examines the impact of lagged changes in investment on current changes in saving, while column 6 shows the effect of lagged changes in saving on current changes in investment. The diagnostics tests are given in columns 7-11.

Table 1: Cointegration Results between Real Gross Domestic Investment and Saving

Country (1)	Long-run β (2)	Dynamics: α_1 $gap \rightarrow i$ (3)	Dynamics: α_2 $gap \rightarrow s$ (4)	Wald tests: $\sum \delta_{2i} = 0$ $i \rightarrow s$ (5)	Wald tests: $\sum \gamma_{1i} = 0$ $s \rightarrow i$ (6)	Diagnostic tests: R_1^2 (7)	R_2^2 (7)	SC_1 (8)	SC_2 (8)	FF_1 (9)	FF_2 (9)	N_1 (10)	N_2 (10)	DW_1 (11)	DW_2 (11)
Barbados	0.201 (0.04)	-0.326 (0.001)	0.140 (0.349)	0.349 (0.555)	1.266 (0.260)	0.72	0.49	1.66 (0.20)	0.02 (0.98)	0.22 (0.64)	0.10 (0.75)	1.52 (0.97)	0.56 (0.76)	1.60	1.98
Guyana[a]	0.407 (0.000)	-0.472 (0.000)	0.379 (0.409)	0.518 (0.472)	0.385- (0.058)	0.43	0.28	0.07 (0.79)	2.03 (0.16)	1.82 (1.77)	3.53 (0.06)	1.72 (0.42)	5.18 (0.07)	1.86	1.80
Jamaica[a]	0.570 (0.000)	-0.319 (0.000)	NA	0.091 (0.763)	0.033- (0.856)	0.87	0.10	0.00 (0.96)	0.67 (0.41)	2.21 (0.14)	0.01 (0.95)	1.30 (0.52)	0.87 (0.65)	1.91	2.24
Trinidad & Tobago	0.986 (0.000)	-0.427 (0.007)	0.184 (0.307)	No lags	No lags	0.19	0.03	0.06 (0.80)	0.01 (0.98)	0.03 (0.77)	1.86 (0.17)	0.46 (0.80)	0.05 (0.98)	2.07	1.99
OECS															
Antigua & Barbuda	0.611[r] (0.00)	-0.045 (0.601)	-0.354 (0.009)	No lags	No lags	0.54	0.41	1.70 (0.20)	0.34 (0.56)	0.20 (0.66)	0.20 (0.66)	0.34 (0.84)	0.77 (0.88)	1.56	1.71
Dominica	0.193 (0.018)	-0.754 (0.001)	0.473 (0.393)	1.269 (0.260)	0.269 (0.604)	0.43	0.14	3.40 (0.07)	0.27 (0.53)	0.01 (0.91)	1.07 (0.30)	4.74 (0.09)	3.98 (0.14)	2.31	2.10
Grenada	0.480 (0.000)	-0.308 (0.001)	0.536 (0.193)	0.571 (0.450)	0.010 (0.752)	0.73	0.41	0.01 (0.91)	2.21 (0.14)	2.84 (0.09)	2.48 (0.12)	2.77 (0.25)	0.01 (0.99)	1.73	2.06
St. Kitts & Nevis	0.752[r] (0.000)	0.040 (0.755)	-0.814 (0.000)	No lags	No lags	0.05	0.78	0.01 (0.91)	0.37 (0.54)	0.04 (0.85)	0.26 (0.61)	2.08 (0.35)	0.58 (0.75)	1.81	1.66
St Lucia	0.603 (0.000)	-0.426 (0.000)	0.144 (0.538)	0.110 (0.740)	2.571 (0.109)	0.51	0.60	0.00 (1.00)	0.12 (0.91)	1.66 (0.20)	0.98 (0.32)	0.09 (0.96)	0.53 (0.77)	1.98	2.01
St. Vincent & the Gren.	none	No cointegration		NA	NA	NA		NA		NA		NA		NA	

Table 1 (continued): Cointegration Results between Real Gross Domestic Investment and Saving

Country (1)	Long-run β (2)	Dynamics α_1 $gap \to i$ (3)	α_2 $gap \to s$ (4)	Wald tests $\sum \delta_{2i} = 0$ $i \to s$ (5)	$\sum \gamma_{1i} = 0$ $s \to i$ (6)	Diagnostic tests R_1^2 (7)	R_2^2 (7)	SC_1 (8)	SC_2 (8)	FF_1 (9)	FF_2 (9)	N_1 (10)	N_2 (10)	DW_1 (11)	DW_2 (11)
Argentina	0.995* (0.000)	-0.567 (0.010)	-0.096 (0.543)	No lags	No lags	0.28	0.12	2.94 (0.10)	0.84 (0.36)	0.01 (0.93)	0.25 (0.62)	0.55 (0.76)	0.45 (0.80)	1.45	1.69
Brazil	0.722 (0.000)	-0.646 (0.000)	-0.398 (0.007)	No lags	No lags	0.67	0.56	1.07 (0.30)	0.14 (0.70)	0.08 (0.78)	1.74 (0.19)	0.77 (0.68)	0.17 (0.92)	1.73	1.86
Chile	0.948* (0.000)	-0.489 (0.002)	0.142 (0.234)	No lags	No lags	0.28	0.52	0.32 (0.57)	0.20 (0.66)	0.40 (0.53)	0.15 (0.70)	0.06 (0.52)	0.71 (0.70)	2.11	2.05
Colombia	1.057* (0.000)	-0.248 (0.005)	0.133 (0.144)	No lags	No lags	0.58	0.27	0.58 (0.45)	0.01 (0.94)	0.51 (0.48)	2.01 (0.16)	0.66 (0.73)	0.24 (0.84)	1.78	2.00
Costa Rica	0.493r (0.000)	-0.005 (0.967)	-0.711 (0.009)	No lags	No lags	0.20	0.36	1.20 (0.27)	0.17 (0.67)	1.76 (0.19)	0.88 (0.35)	0.92 (0.63)	0.32 (0.85)	2.30	1.90
Dominican Republic	0.507 (0.000)	-0.419 (0.000)	0.238 (0.131)	1.269 (0.260)	8.873- (0.003)	0.73	0.56	0.90 (0.34)	0.53 (0.47)	0.28 (0.60)	1.46 (0.23)	0.83 (0.66)	1.93 (0.38)	1.75	2.14
Ecuador	1.029r (0.000)	0.196 (0.178)	-0.895 (0.000)	10.95- (0.001)	0.182 (0.670)	0.76	0.46	1.87 (0.17)	0.04 (0.85)	3.89 (0.05)	0.38 (0.54)	1.76 (0.42)	0.68 (0.71)	2.28	2.06
El Salvador *1960-2001*	none	No cointegration		0.538 (0.463)	0.928 (0.335)	0.14	0.83	0.97 (0.33)	3.08 (0.08)	0.19 (0.66)	0.70 (0.40)	0.56 (0.76)	0.22 (0.90)	1.88	2.43
El Salvador *1960-1980*	0.875r (0.000)	0.305 (0.330)	-0.804 (0.006)	No lags	No lags	0.19	0.83	1.09 (0.30)	1.15 (0.28)	3.32 (0.07)	2.85 (0.09)	1.85 (0.40)	0.91 (0.63)	1.29	1.53
El Salvador *1981-2001*	none	No cointegration		0.424 (0.515)	1.250 (0.263)	0.37	0.86	0.05 (0.82)	3.85 (0.05)	0.53 (0.47)	0.78 (0.38)	1.56 (0.46)	0.79 (0.68)	1.88	2.59
Guatemala	0.853 (0.000)	-0.589 (0.008)	0.122 (0.531)	No lags	No lags	0.17	0.04	0.05 (0.82)	0.44 (0.51)	0.76 (0.39)	0.02 (0.87)	0.18 (0.92)	0.71 (0.70)	1.93	2.13

Table 1 (continued): Cointegration Results between Real Gross Domestic Investment and Saving

Country (1)	Long-run β (2)	Dynamics: α_1 $gap \rightarrow i$ (3)	Dynamics: α_2 $gap \rightarrow s$ (4)	Wald tests: $\sum \delta_{2i} = 0$ $i \rightarrow s$ (5)	Wald tests: $\sum \gamma_{1i} = 0$ $s \rightarrow i$ (6)	Diagnostic tests: R_1^2 (7)	R_2^2 (7)	SC_1 (8)	SC_2 (8)	FF_1 (9)	FF_2 (9)	N_1 (10)	N_2 (10)	DW_1 (11)	DW_2 (11)
Honduras	0.772 (0.000)	-0.786 (0.000)	0.208 (0.452)	1.261 (0.261)	0.007 (0.979)	0.39	0.08	2.33 (0.13)	0.00 (0.98)	0.13 (0.72)	0.04 (0.84)	0.24 (0.89)	1.70 (0.43)	1.81	1.92
Mexico	0.734 (0.000)	-0.193 (0.045)	0.114 (0.190)	2.637 (0.104)	3.451 (0.063)	0.77	0.53	1.14 (0.29)	0.22 (0.64)	2.74 (0.10)	0.51 (0.47)	3.18 (0.20)	1.19 (0.55)	2.06	1.72
Paraguay	0.634 (0.000)	-0.205 (0.000)	-0.502 (0.000)	No lags	No lags	0.78	0.81	0.25 (0.62)	2.02 (0.22)	1.29 (0.26)	1.49 (0.22)	0.62 (0.74)	2.25 (0.33)	1.79	2.27
Peru	0.773 (0.000)	-0.528 (0.004)	-0.114 (0.523)	0.582 (0.445)	0.515 (0.473)	0.38	0.15	0.01 (0.91)	1.01 (0.31)	0.17 (0.68)	1.46 (0.23)	1.30 (0.52)	0.45 (0.80)	1.97	2.11
Uruguay	none	No cointegration		0.304 (0.582)	0.016 (0.900)	0.24	0.08	0.81 (0.37)	1.32 (0.25)	0.00 (0.99)	0.13 (0.72)	1.16 (0.56)	1.80 (0.41)	1.82	1.72
Venezuela	1.343 (0.006)	-0.861 (0.002)	0.090 (0.523)	3.484 (0.062)	0.439 (0.508)	0.46	0.17	2.64 (0.11)	1.27 (0.26)	0.66 (0.42)	1.77 (0.18)	0.74 (0.69)	0.48 (0.79)	2.10	2.06

Notes: p-values are in parentheses. The estimates are from the VECM represented by Equation 6 where the subscripts 1 and 2 refer to the investment equation and saving equation, respectively. Hence, β is the long-run elasticity of gross domestic investment with respect to gross domestic saving, however, an *r* beside the coefficient denotes that it refers to the opposite i.e. the long-run elasticity of gross domestic saving with respect to gross domestic investment. *SC* is the Lagrange multiplier test of residual serial correlation (Chi-square of degree 1). *FF* is the Ramsey's RESET test for incorrect functional form using the square of the fitted values (Chi-square of degree 1). *N* is the test for normality of the residuals based on the Jarque-Bera test statistic (Chi-square of degree 1). *DW* is the Durbin-Watson statistic. *a* – indicates that the estimation technique is ARDL. * indicates that the value is not significantly different from 1. Finally, *gap* represents deviation from long-run equilibrium and the respective α indicates (by its level of significance), which variable is responding to *gap* to restore the defined equilibrium. For example, a significant α_1 implies that the gap is defined as $i - s$. A positive (negative) gap exists if saving has fallen (risen) relative to investment in which case investment must fall (rise) to restore equilibrium and positive long run causality is said to run from saving to investment. Note that saving is the forcing variable in the relation. The reverse analysis holds when α_2 is significant.

The results confirm the existence of a long-run relationship between real gross domestic investment and real gross domestic saving for all the countries except Uruguay. As noted earlier, the results from previous studies on the existence of a long-run relationship between the ratios in the LAC region are quite mixed. Therefore in some cases our findings are in agreement and in others they are not; however, they are closer to those of Schneider (1999) who also reports a long-run relationship for all the countries in his study except Mexico. We are not surprised at our findings. The "flip-side" of the saving-investment relation is current account balance; findings of no long-run (steady-state) relationship imply that current account deficits do not converge to zero or a constant over time.

In terms of the dynamics governing these cointegrating relationships, for 16 of the 23 countries (Argentina, Barbados, Chile, Colombia, Dominica, Dominican Republic, Grenada, St. Lucia, Guatemala, Guyana, Honduras, Jamaica, Mexico, Peru, Trinidad and Tobago and Venezuela), the nature of the long-run relationship is such that when the system is in disequilibrium, investment adjusts to close the gap and saving can be treated as a 'long-run' forcing variable in the explanation of investment. That is, long-run causality runs from saving to investment in these countries (investment is endogenous and saving is weakly exogenous). For five countries, Antigua and Barbuda, St. Kitts and Nevis, Costa Rica, Ecuador and El Salvador, the direction of causality is reversed, while for Brazil and Paraguay bi-directional causality exists.

The results suggest a general absence of short-run causality between saving and investment in LAC. We find only one case (Ecuador) where lagged changes in investment impact on current changes in saving and also one case of the reverse (Dominican Republic). This is not to say that there is no short-run relationship between these variables since the above analysis suggests that changes in saving (investment) induced by disequilibria can cause changes in investment (saving). In fact, any shock to either saving or investment (or to the economy as a whole), to the extent that it causes them to move away from their steady-state, will induce changes in either one or both variables to restore equilibrium. It may be argued that to some degree this result, of a general absence of short-run causality, is influenced by our modelling procedure. In many cases, our model specification search resulted in a VAR(1), which transforms to a VECM(0) and thus excludes the possibility of short-run dynamics. However, in each case we also re-estimated the VECM using a general-to-specific approach with respect to the lags and in no case did any lag higher than that chosen in the specification search survive the deletion process.

Causality analysis for the saving-growth relationship

The Johansen test results for the number of cointegration vectors (if any) in the bi-variate relationship between real gross domestic saving and real GDP for each country are given in table A3 (appendix) and the bounds tests results for cointegration in Table A4. The results indicate that there exists, at most, one cointegrating vector for Antigua and Barbuda, Colombia, Costa Rica, Dominica, Dominican Republic, Grenada, Guatemala, Jamaica, St. Kitts and Nevis, Trinidad and Tobago and Uruguay. However, we could not reject the null hypothesis of no cointegration for the other countries in the sample.

The cointegration results and causality analysis between real gross domestic saving and real GDP are presented in Table 2.

Considering those countries for which we find a long-run relationship, the estimated *a* coefficients indicate that in Costa Rica, Dominican Republic, Grenada, St. Kitts and Nevis and Uruguay, it is gross domestic saving that responds to long-run disequilibrium. Hence, long-run causality runs from growth to saving in these countries. This result is consistent with the earlier studies, including Gavin, Hausmann and Talvi (1997). For Antigua and Barbuda, there is evidence of bi-directional temporal dependence between the two series, while for the others (Colombia, Dominica, Guatemala, Jamaica and Trinidad and Tobago) there is unidirectional long-run causality from saving to growth.

Table 2: Cointegration Results between Real Gross Domestic Saving and Real GDP

		Dynamics		Wald tests		Diagnostic tests									
Country (1)	Long-run β (2)	α_1 $gap \rightarrow s$ (3)	α_2 $gap \rightarrow g$ (4)	$\sum \delta_{2i} = 0$ $s \rightarrow g$ (5)	$\sum \gamma_{1i} = 0$ $g \rightarrow s$ (6)	R_1^2 (7)	R_2^2	SC_1 (8)	SC_2	FF_1 (9)	FF_2	N_1 (10)	N_2	DW_1 (11)	DW_2
Caribbean															
Barbados	none	No cointegration		2.77- (0.096)	0.001 (0.981)	0.54	0.22	2.59 (0.11)	0.79 (0.37)	0.57 (0.45)	0.39 (0.53)	0.52 (0.77)	0.99 0.61)	2.31	1.87
Guyana[a]	none	No cointegration		0.418 (0.517)	4.144+ (0.042)	0.40	0.42	0.03 (0.77)	2.80 (0.09)	0.17 (0.68)	1.28 (0.26)	0.95 (0.62)	0.27 (0.87)	2.02	1.67
Jamaica[a]	0.67[r] (0.001)	NA	-0.118 (0.000)	No lags	No lags	0.33	0.74	0.96 (0.33)	0.04 (0.84)	0.08 (0.78)	0.60 (0.44)	1.05 (0.59)	3.59 (0.17)	2.31	1.90
Trinidad & Tobago	0.59[r] (0.000)	0.366 (0.075)	-0.154 (0.000)	No lags	No lags	0.08	0.44	0.31 (0.58)	2.07 (0.15)	0.20 (0.66)	0.02 (0.90)	0.69 (0.71)	2.01 (0.37)	1.87	2.41
OECS															
Antigua & Barbuda	1.30 (0.000)	-0.250 (0.014)	-0.091 (0.001)	No lags	No lags	0.20	0.07	1.97 (0.16)	0.77 (0.38)	0.14 (0.16)	0.00 (0.96)	0.34 (0.84)	0.50 (0.78)	2.31	2.01
Dominica	0.127[r] (0.000)	-0.133 (0.882)	-0.273 (0.000)	No lags	No lags	0.59	0.88	1.11 (0.29)	0.11 (0.74)	1.05 (0.31)	2.26 (0.13)	5.68 (0.06)	1.15 (0.56)	1.93	1.81
Grenada	2.367 (0.000)	-0.880 (0.001)	-0.013 (0.448)	No lags	No lags	0.40	0.03	0.18 (0.68)	1.40 (0.24)	2.98 (0.08)	1.27 (0.72)	0.14 (0.94)	3.22 (0.20)	1.77	1.28
St. Kitts & Nevis	1.193 (0.000)	-0.755 (0.000)	-0.026 (0.297)	0.005 (0.944)	1.761 (0.184)	0.85	0.29	1.24 (0.27)	0.79 (0.37)	3.30 (0.07)	0.68 (0.41)	0.27 (0.88)	0.68 (0.71)	1.47	1.73
St Lucia	none	No cointegration		0.006 (0.981)	0.056 (0.813)	0.08	0.08	0.01 (0.91)	0.10 (0.76)	3.43 (0.06)	0.11 (0.75)	0.49 (0.79)	2.20 (0.33)	2.02	1.90

Table 2 (continued): Cointegration Results between Real Gross Domestic Saving and Real GDP

Country	Long-run	Dynamics				Diagnostic tests									
				Wald tests											
	β	α_1 $gap \to s$	α_2 $gap \to y$	$\sum \delta_{2i} = 0$ $s \to y$	$\sum \gamma_{1i} = 0$ $y \to s$	R_1^2	R_2^2	SC_1	SC_2	FF_1	FF_2	N_1	N_2	DW_1	DW_2
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)		(9)		(10)		(11)	
Argentina	none	No cointegration		No lags	No lags	na		na		na		na		na	
Brazil	none	No cointegration		0.524 (0.469)	12.21+ (0.000)	0.49	0.58	0.03 (0.77)	0.04 (0.84)	0.17 (0.68)	0.88 (0.35)	0.95 (0.62)	0.69 (0.71)	2.27	1.85
Chile	none	No cointegration		5.685+ (0.017)	0.078 (0.780)	0.41	0.68	2.43 (0.12)	0.17 (0.68)	0.46 (0.50)	5.43 (0.02)	2.80 (0.25)	1.40 (0.50)	1.67	2.07
Colombia	0.859[r] (0.000)	0.072 (0.492)	-0.087 (0.000)	No lags	No lags	0.02	0.34	0.07 (0.80)	1.28 (0.26)	1.61 (0.21)	1.40 (0.24)	0.38 (0.83)	0.43 (0.81)	1.92	1.64
Costa Rica	1.33 (0.000)	-0.637 (0.000)	-0.024 (0.312)	No lags	No lags	0.44	0.42	0.00 (0.93)	0.02 (0.88)	1.17 (0.28)	0.01 (0.92)	0.39 (0.98)	1.59 (0.45)	1.94	1.77
Dominican Republic	1.119 (0.000)	-0.563 (0.000)	-0.041 (0.146)	No lags	No lags	0.69	0.36	2.91 (0.09)	0.63 (0.43)	1.13 (0.29)	0.08 (0.78)	0.01 (1.00)	2.85 (0.24)	2.39	1.69
Ecuador	none	No cointegration		No lags	No lags	na		na		na		na		na	
El Salvador	none	No cointegration		0.606 (0.436)	7.998+ (0.005)	0.88	0.87	4.27 (0.04)	0.17 (0.89)	0.04 (0.84)	1.13 (0.29)	1.10 (0.25)	0.17 (0.92)	2.49	1.93
Guatemala	0.416[r] (0.000)	0.832 (0.212)	-0.248 (0.006)	7.455- (0.006)	3.424+ (0.064)	0.23	0.60	0.74 (0.39)	0.54 (0.46)	0.72 (0.40)	3.57 (0.06)	3.07 (0.22)	0.81 (0.67)	2.04	2.13
Honduras	none	No cointegration		No lags	No lags	na		na		na		na		na	

Table 2 (continued): Cointegration Results between Real Gross Domestic Saving and Real GDP

Country	Long-run	Dynamics				Diagnostic tests									
				Wald tests											
	β	α_1	α_2	$\sum\delta_{2i}=0$	$\sum\gamma_{1i}=0$	R_1^2	R_2^2	SC_1	SC_2	FF_1	FF_2	N_1	N_2	DW_1	DW_2
		$gap \rightarrow s$	$gap \rightarrow y$	$s \rightarrow y$	$y \rightarrow s$										
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)		(9)		(10)		(11)	
Mexico	none	No cointegration		0.045 (0.832)	0.034 (0.854)	0.51	0.56	4.27 (0.04)	1.15 (0.28)	0.04 (0.84)	0.14 (0.71)	1.10 (0.25)	0.52 (0.77)	1.60	1.78
Paraguay	none	No cointegration		No lags	No lags	na		na		na		na		na	
Peru	none	No cointegration		No lags	No lags	na		na		na		na		na	
Uruguay	1.031 (0.000)	-0.519 (0.000)	0.025 (0.377)	No lags	No lags	0.41	0.46	0.01 (0.92)	1.78 (0.18)	1.41 (0.23)	0.60 (0.44)	3.37 (0.19)	0.70 (0.70)	1.84	1.54
Venezuela	none	No cointegration		No lags	No lags	na		na		na		na		na	

Notes: p-values are in parentheses. The estimates are from the VECM represented by Equation 6 where the subscripts 1 and 2 refer to the saving equation and growth equation, respectively. Hence, β is the long-run elasticity of gross domestic saving with respect to GDP, however, an *r* beside the coefficient denotes that it refers to the opposite, i.e. the long-run elasticity of GDP with respect to gross domestic saving. SC is the Lagrange multiplier test of residual serial correlation (Chi-square of degree 1). FF is the Ramsey's RESET test for incorrect functional form using the square of the fitted values (Chi-square of degree 1). N is the test for normality of the residuals based on the Jarque-Bera test statistic (Chi-square of degree 1). DW is the Durbin-Watson statistic. a – indicates that the estimation technique is ARDL. * indicates that the value is not significantly different from 1. Finally, gap represents deviation from long-run equilibrium and the respective α indicates (by its level of significance), which variable is responding to gap to restore the defined equilibrium. For example, a significant α1 implies that the gap is defined as i – s. A positive (negative) gap exists if saving has fallen (risen) relative to investment in which case investment must fall (rise) to restore equilibrium and positive long run causality is said to run from saving to investment. Note that saving is the forcing variable in the relation. The reverse analysis holds when α2 is significant.

In terms of short-run causality, we find that lagged changes in saving caused growth in Chile and Guatemala, with positive and negative signs, respectively, while the reverse holds for Brazil, Guyana and El Salvador, with a positive sign. We were unable to detect any significant short-run causal chains for the other countries at the standard five per cent level of significance. These results, along with the above cointegration analysis, imply that for Barbados, St. Lucia, Argentina, Ecuador, Honduras, Mexico, Peru and Venezuela there is no causal relationship between saving and growth (at least at the 5% significance level).

Causality analysis of the investment-growth relationship

Table A5 (appendix) contains the results of Johansen tests for cointegration between real gross domestic investment and GDP, while Table A6 presents the results of the bounds tests. We find a long-run relationship for the following 15 countries; Antigua and Barbuda, Brazil, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Honduras, Mexico, Peru, St. Lucia, St. Vincent and the Grenadines and Trinidad and Tobago. In examining the dynamics governing these steady-state relationships, the α coefficients (given in table 3) suggest that for the Dominican Republic, Ecuador, El Salvador and St. Vincent and the Grenadines both variables respond to maintain equilibrium and hence bi-directional long-run causality exists for these countries. For Dominica and Trinidad and Tobago the results point to unidirectional long-run causality from investment to growth, while for the other 9 countries the evidence favours long-run causality that is unidirectional from growth to investment.

Table 3 also reports the results for the short-run causality analysis. We find six cases (Brazil, Chile, Ecuador, Guatemala, Honduras and Mexico) where lagged changes in GDP impact positively on current changes in investment. This result is consistent with the findings of Blomstrom et al. (1996), who argue that higher growth can create incentives to new investment by enhancing future growth expectations. There is only one case (St. Vincent and the Grenadines) of short-run causality running from investment to growth.

Table 3: Cointegration Results between Real Gross Domestic Investment and Real GDP

Country	Long-run	Dynamics				Diagnostic tests									
				Wald tests											
	β	α_1 $gap \rightarrow i$	α_2 $gap \rightarrow y$	$\sum \delta_{2i} = 0$ $i \rightarrow y$	$\sum \gamma_{1i} = 0$ $y \rightarrow i$	R_1^2	R_2^2	SC_1	SC_2	FF_1	FF_2	N_1	N_2	DW_1	DW_2
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)		(9)		(10)		(11)	
Caribbean															
Barbados	None	No cointegration		No lags	No lags	na		na		na		na		na	
Guyana	none	No cointegration		2.65 (0.103)	0.476 (0.490)	0.05	0.45	0.02 (0.89)	0.91 (0.34)	0.00 (0.98)	0.05 (0.82)	1.91 (0.39)	0.70 (0.74)	1.95	1.79
Jamaica	None	No cointegration		na	na	na		na		na		na		na	
Trinidad & Tobago	0.595[r] (0.000)	0.285 (0.110)	-0.123 (0.000)	No lags	No lags	0.60	0.31	0.00 (0.99)	0.22 (0.64)	0.47 (0.49)	1.47 (0.23)	0.93 (0.63)	1.14 (0.57)	2.00	2.10
OECS															
Antigua & Barbuda	1.419 (0.000)	-0.873 (0.003)	-0.044 (0.609)	0.174 (0.677)	0.007 (0.932)	0.80	0.74	0.44 (0.51)	0.40 (0.53)	0.00 (0.97)	0.05 (0.82)	1.22 (0.54)	3.22 (0.20)	2.13	2.06
Dominica	0.115[r] (0.000)	-0.168 (0.306)	-0.121 (0.000)	No lags	No lags	0.08	0.80	0.10 (0.75)	0.28 (0.60)	1.02 (0.31)	1.08 (0.30)	0.36 (0.84)	0.90 (0.64)	2.11	1.66
Grenada	1.447 (0.000)	-0.741 (0.000)	0.004 (0.918)	0.409 (0.523)	0.259 (0.610)	0.86	0.49	2.05 (0.15)	0.74 (0.39)	0.00 (0.99)	0.06 (0.81)	1.88 (0.39)	1.11 (0.57)	2.41	2.17
St. Kitts & Nevis	none	No cointegration		0.137 (0.712)	3.342+ (0.068)	0.14	0.20	0.12 (0.73)	0.96 (0.33)	0.11 (0.74)	0.23 (0.63)	1.58 (0.45)	1.00 (0.61)	1.89	1.73
St Lucia	1.364 (0.000)	-0.921 (0.000)	-0.055 (0.553)	0.597 (0.440)	8.022- (0.005)	0.58	0.10	0.00 (0.96)	0.08 (0.78)	0.17 (0.68)	0.32 (0.57)	1.20 (0.55)	0.92 (0.63)	1.90	1.75
St. Vincent & the Gren.	0.795 (0.001)	-0.554 (0.009)	-0.061 (0.049)	5.124+ (0.024)	3.743- (0.053)	0.39	0.77	0.92 (0.34)	0.86 (0.35)	0.00 (0.96)	2.25 (0.13)	0.74 (0.69)	0.26 (0.88)	1.77	2.28

Table 3 (continued): Cointegration Results between Real Gross Domestic Investment and Real GDP

Country	Long-run	Dynamics		Dynamics: Wald tests		Diagnostic tests									
Country (1)	β (2)	α_1 $gap \rightarrow i$ (3)	α_2 $gap \rightarrow y$ (4)	$\sum \delta_{2i} = 0$ $i \rightarrow y$ (5)	$\sum \gamma_{1i} = 0$ $y \rightarrow i$ (6)	R_1^2 (7)	R_2^2 (7)	SC_1 (8)	SC_2 (8)	FF_1 (9)	FF_2 (9)	N_1 (10)	N_2 (10)	DW_1 (11)	DW_2 (11)
Latin America															
Argentina	none	No cointegration		No lags	No lags	na		na		na		na		na	
Brazil	1.126 (0.000)	-0.451 (0.001)	-0.006 (0.899)	3.050- (0.081)	15.34+ (0.000)	0.65	0.64	1.15 (0.28)	1.87 (0.17)	3.27 (0.07)	0.23 (0.63)	1.38 (0.50)	1.58 (0.45)	2.04	1.61
Chile	none	No cointegration		0.708 (0.400)	12.40+ (0.000)	0.49	0.58	0.01 (0.94)	0.00 (0.99)	0.03 (0.86)	1.37 (0.24)	3.34 (0.63)	0.64 (0.73)	1.96	1.98
Colombia	1.103 (0.000)	-0.353 (0.003)	-0.003 (0.891)	1.106 (0.293)	0.181 (0.670)	0.60	0.48	0.00 (0.96)	0.37 (0.55)	1.79 (0.18)	0.12 (0.73)	1.22 (0.54)	0.27 (0.87)	1.93	2.08
Costa Rica	1.331 (0.000)	-0.279 (0.033)	0.031 (0.247)	No lags	No lags	0.37	0.54	2.39 (0.12)	0.06 (0.80)	0.19 (0.67)	1.33 (0.25)	1.73 (0.42)	1.16 (0.56)	2.34	1.88
Dominican Republic	1.125 (0.000)	-0.675 (0.000)	-0.124 (0.000)	No lags	No lags	0.78	0.57	0.51 (0.47)	3.38 (0.07)	0.05 (0.83)	0.28 (0.59)	0.26 (0.88)	4.35 (0.11)	1.79	1.42
Ecuador	0.924 (0.000)	-0.296 (0.004)	0.030 (0.046)	0.044 (0.833)	6.096+ (0.014)	0.68	0.87	4.29 (0.04)	1.16 (0.28)	0.08 (0.77)	1.72 (0.19)	3.05 (0.21)	0.31 (0.86)	1.30	1.67
El Salvador	1.687 (0.000)	-0.258 (0.000)	0.068 (0.000)	No lags	No lags	0.36	0.83	0.01 (0.93)	0.40 (0.53)	0.00 (0.95)	0.13 (0.59)	0.08 (0.96)	0.99 (0.61)	1.95	2.05
Guatemala	none	No cointegration		0.707 (0.400)	5.247+ (0.022)	0.22	0.40	2.65 (0.10)	3.41 (0.07)	0.14 (0.71)	1.70 (0.19)	0.97 (0.62)	2.28 (0.32)	1.74	1.72

Table 3 (continued): Cointegration Results between Real Gross Domestic Investment and Real GDP

	Long-run	Dynamics				Diagnostic tests									
				Wald tests											
Country (1)	β (2)	α_1 $gap \to i$ (3)	α_2 $gap \to y$ (4)	$\sum \delta_{2i} = 0$ $i \to y$ (5)	$\sum \gamma_{1i} = 0$ $y \to i$ (6)	R_1^2 (7)	R_2^2 (7)	SC_1 (8)	SC_2 (8)	FF_1 (9)	FF_2 (9)	N_1 (10)	N_2 (10)	DW_1 (11)	DW_2 (11)
Honduras	1.282 (0.000)	-0.404 (0.004)	-0.006 (0.795)	0.254 (0.615)	7.297+ (0.007)	0.62	0.17	0.01 (0.93)	0.14 (0.70)	0.02 (0.90)	2.79 (0.10)	1.18 (0.56)	1.52 (0.47)	1.94	2.02
Mexico	1.055 (0.000)	-0.276 (0.015)	0.019 (0.566)	2.653 (0.103)	3.857+ (0.050)	0.76	0.69	0.16 (0.69)	0.34 (0.56)	2.67 (0.10)	1.02 (0.31)	1.04 (0.59)	0.95 (0.62)	1.92	1.90
Paraguay	none	No cointegration		0.734 (0.391)	0.846 (0.358)	0.54	0.44	1.45 (0.23)	0.00 (1.00)	0.38 (0.54)	0.18 (0.67)	0.21 (0.90)	5.27 (0.07)	2.15	1.79
Peru	0.731 (0.000)	-0.527 (0.000)	-0.035 (0.205)	0.005 (0.943)	0.035 (0.851)	0.51	0.67	0.73 (0.39)	0.12 (0.73)	1.23 (0.27)	2.56 (0.11)	2.53 (0.28)	0.38 (0.83)	1.86	2.06
Uruguay	none	No cointegration		0.330 (0.566)	6.495+ (0.011)	0.50	0.50	1.23 (0.27)	0.58 (0.45)	0.22 (0.64)	0.14 (0.70)	1.39 (0.50)	0.39 (0.82)	1.70	1.74
Venezuela	none	No cointegration		No lags	No lags	na		na		na		na		na	

Notes: p-values are in parentheses. The estimates are from the VECM represented by Equation 6 where the subscripts 1 and 2 refer to the investment equation and growth equation, respectively. Hence, β is the long-run elasticity of gross domestic investment with respect to GDP; however, an *r* beside the coefficient denotes that it refers to the opposite, i.e. the long-run elasticity of GDP with respect to gross domestic investment. SC is the Lagrange multiplier test of residual serial correlation (Chi-square of degree 1). FF is the Ramsey's RESET test for incorrect functional form using the square of the fitted values (Chi-square of degree 1). N is the test for normality of the residuals based on the Jarque-Bera test statistic (Chi-square of degree 1). DW is the Durbin-Watson statistic. a – indicates that the estimation technique is ARDL. * indicates that the value is not significantly different from 1. Finally, gap represents deviation from long-run equilibrium and the respective α indicates (by its level of significance), which variable is responding to gap to restore the defined equilibrium. For example, a significant α1 implies that the gap is defined as i – s. A positive (negative) gap exists if saving has fallen (risen) relative to investment in which case investment must fall (rise) to restore equilibrium and positive long run causality is said to run from saving to investment. Note that saving is the forcing variable in the relation. The reverse analysis holds when α2 is significant.

Test of Robustness Using Panel Estimates

In this section we examine the robustness of our results using panel estimation techniques. This approach allows us to utilise both cross-sectional and time series information to test the causality relationships, which, by providing a larger number of observations, increases the degrees of freedom and reduces any collinearity among explanatory variables, and should lead to an improvement the efficiency of the causality test (Holtz-Eakin *et al.*, 1988 and Hurlin and Venet, 2001).

In this regard, there are basically two approaches to examining causality within a panel framework. The first, popularised by Holtz-Eakin *et al.* (1988), Weinhold (1996) and Nair-Reichert and Weinhold (2001), allows the autoregressive coefficients and regression coefficients slopes of the panel to vary. This reduces significantly the degrees of freedom and relies on the 'large time dimension' assumption to derive consistent estimates. The second, suggested by Hurlin and Venet (2001) and Hurlin (2004) treats these coefficients as constant and is perhaps more appropriate for our data set. The procedure, which is detailed in Hurlin (2004), is summarised below.

Consider the following time-stationary bi-variant VAR representation in panel form for N countries over T time periods:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{p} \beta_{i,k} y_{i,t-k} + \sum_{k=1}^{p} \phi_{i,k} x_{i,t-k} + \varepsilon_{i,t} \tag{9}$$

where the individual effects α_i are presumed fixed. It is assumed that the autoregressive coefficients β_k and the regression coefficients Φ_k's are constant for $k \in [1,N]$ and the parameters β_k are identical for all individuals, while the coefficients Φ_k could have individual dimensions. Hence, it is a fixed coefficients model with fixed individual effects. In addition, suppose that the lag orders k are identical for all cross-section units of the panel and the panel is balanced. Hurlin (2004) argues that causality testing in this framework also needs to take in consideration the different sources of heterogeneity between the individual units. The first source of heterogeneity is caused by permanent cross-sectional disparities.

Estimating the model ignoring heterogeneous intercepts could lead to a bias of the slope estimates and fallacious inferences about causality. The other source of heterogeneity relates to the regression coefficients Φ_k. Again, the imposition of homogeneity on Φ_k when its true nature is heterogeneous can lead to erroneous conclusions.

Consequently, the following procedure is recommended for causality analysis within the panel framework[13]. First, we begin by testing for homogenous and instantaneous non-causality (*HINC*), which is a test as to whether or not the Φ_k's are simultaneously zero for all individual *i* and all lag *k*. If the associated test statistic, Wald statistic, is given by:

$$F_{HINC} = \frac{(SSR_r - SSR_u)/Np}{SSR_u/\left[NT - N(1+p) - p\right]} \tag{10}$$

where SSR_u is the sum of squared residuals from equation 6 and SSR_r is the restricted sum of squared residuals under null hypothesis that Φ_k is zero for all *i* and *k*. If it is not significant (note that F_{HINC} does not follow a standard distribution when T is small, however, Hurlin (2004) provides the exact critical values), the *HINC* hypothesis is accepted. This result implies that the variable *x* is not causing *y* in all the countries of the sample. Hence, the non-causality result is then totally homogenous and the testing procedure goes no further.

If the *HINC* is rejected then two possibilities exist. The first is that there is a causal relationship between the two variables for each country and that this relationship is identical for all countries in the sample. This is termed homogenous causality (*HC*) and occurs if all the coefficients on the explanatory variable are not significantly different across countries, for all lags, and are statistically different from zero. In other words, we are testing whether the Φ_k's are identical, which is formally a test of

$H_0 : \phi_{i,k} = \phi_{j,k}\ \forall i, j \in \left[1, N\right], \forall k \in \left[0, p\right]$ against $H_1 : \phi_{i,k} \neq \phi_{j,k}\ \exists (i, j, k)$.
HC is rejected if the Wald statistic given by

[13] Hurlin and Venet (2001) contains an exposition of the various causality tests and their sample properties.

$F_{HC}=\frac{(SSR_r^{'}-SSR_u)/[(N-1)p]}{SSR_u/\left[NT-N(1+p)-p\right]}$ is significant (again, the critical values are provided in Hurlin (2004)), where $SSR_r^{'}$ is the residual sum of squares obtained from equation 6 under H_0.

If the *HC* hypothesis is rejected we move to the second (but more plausible) hypothesis, which is that the causal relationships differ across countries. In other words, we are testing whether or not the coefficients on the explanatory variable are significant for each country. This is referred to as heterogeneous non-causality (*HENC*) and is the test of $H_0:\phi_{i,k}=0\ \forall i\in\left[1,N\right],\forall k\in\left[0,p\right]$ against $H_1:\phi_{i,k}\neq 0\ \forall i\in[1,N],\forall k\in[0,p]$. Hence, we are testing if all the coefficients of the lagged explanatory variable for the individual country are equal to zero or not. The corresponding test statistic for this is given as $F_{HC}=\frac{(SSR_r^{''}-SSR_u)/p]}{SSR_u/\left[NT-N(1+2p)-p\right]}$ where $SSR_r^{''}$ is the residual sum of squares from equation 6 under the hypothesis that the *k* coefficients are equal to zero only for country *i*.

In implementing the above procedure, we estimate a fixed-effects model and used an F- Test (see Green, 1993) to confirm the fixed-effects specification against a common intercept model. In addition, to deal with possible issues of endogeneity with regards to growth, investment and saving we estimate the model using generalised method of moments (GMM). Furthermore, Judson and Owen (1999) show that the GMM procedure produces the most consistent estimator with respect to dynamic panels. However, they also demonstrate that the efficiency of the Anderson–Hsiao and least squares dummy variable estimators (two commonly used estimators for macro-panels) compare favorably when *T* is in the region of 20 to 30. We therefore use these estimators to check the robustness of our results. For the data we use our overall measure of financial development, *index*, plus the previous aggregates; saving, investment and real GDP. However, for the latter three we take the first difference of the natural logarithms in order to remove possible unit roots. We also split our data set in to two groups; separating the Caribbean from the Latin America Countries.

The results of the tests for *HINC* and *HC* hypotheses are presented in Table A-7. In each case the optimal lag length is chosen using the AIC. Except for group 2, in the case of financial development causing investment, the *HINC* hypothesis is strongly rejected. This implies that there exist a causal relation between saving and investment, saving and growth, and investment and growth. Given the rejection of the *HINC* hypothesis, the next step is to test whether the causality relationship is an overall causality for each group (that is, homogenous causality, *HC* hypothesis) or based on causality relations for individual countries (heterogeneous). The results confirm the presence of heterogeneous causality in both groups by the rejection of the *HC* hypothesis.

Based on the above results we move on the *HENC* hypothesis in which we are testing for the existence of heterogeneous causal relationships for each country. The results are given in Table A-8. The results do indeed confirm the heterogeneous nature of the causal relationships. Moreover, the results are consistent with the findings discussed above.

5.0 Implications and Conclusions

This paper examines the causal relationship between saving, investment and growth in the LAC region using both the Johansen MLE approach and the recently developed bounds testing procedure within the ARDL framework. The use of both approaches adds to the robustness of the findings, particularly since the latter allows us to test for cointegration when the order of integration of the variables is not known with certainty. Table 4 summarises the causal chains for the three aggregates. Two general conclusions can be drawn from our results. First, the causal chains between the three aggregates differ across countries. Second, these causal chains can be connected via different channels, either through adjustments to long-run equilibrium and/or via response to stochastic shocks. However, in the majority of countries the connection is through the variables adjusting to long-run equilibrium. These findings are in line with the discussion in the theoretical section where the predictions are diverse. In fact, the result of a long-run stationary relationship between domestic saving and investment for all but two of the countries is perhaps the most consistent with respect to the different growth theories. Thus, irrespective of the direction of causation, there exists for most of the countries a stable relationship over time between saving and investment. This finding, though at variance with some earlier empirical work on developing countries and in particular on LAC countries, is consistent with the theoretical growth literature which represents saving and investment as moving together. In terms of the direction of causation, we find that for 16 of the 25 countries the causal chain runs from saving to investment, which is in keeping with the neo-classical framework. While there are four cases of causality from investment to saving, which is consistent with the Keynesian model, there are also three instances of bi-directional causality.

For the 16 countries where causality runs from savings to investment and the four cases where there is bi-directional causality, policies to increase saving will eventually lead to higher investment with the latter adjusting to a new equilibrium caused by increased saving. For the other countries in our sample such policies are likely to be frustrated.

What is less clear from the theoretical section is the link between the saving and investment ratios and growth, and indeed our findings here are also mixed. The results for saving and growth indicate that causality runs from the latter to the former for Brazil, Costa Rica, Dominican Republic, El Salvador, Grenada, Guyana, St. Kitts and Nevis and Uruguay. Hence, for these countries the policy priority appears to be about removing or lowering supply-side constraints on growth rather than raising the saving rate. For Chile, Colombia, Dominica, Guatemala, Jamaica and Trinidad and Tobago, causality is from saving to growth, with the neo-classical policy recipe holding. For the other countries in our sample no discernible causal relationship between saving and growth holds. For the investment-growth relationship we find that growth precedes investment for 11 of the countries, and is bi-directional for three others. It is only for Dominica and Trinidad and Tobago that we find higher investment causing faster growth.

Table 4: Summary of Results of Causal Chains

	Long-run (responding to disequilibrium)			Short-run (responding to stochastic shocks)		
Caribbean	$s \cdots ? \cdots i$	$s \cdots ? \cdots y$	$i \cdots ? \cdots y$	$s \cdots ? \cdots i$	$s \cdots ? \cdots y$	$i \cdots ? \cdots y$
Barbados	$\xrightarrow{+}$	none	none	none	$\xrightarrow{-}$	Na
Guyana	$\xrightarrow{+}$	none	none	none	$\xleftarrow{+}$	None
Jamaica	$\xrightarrow{+}$	$\xrightarrow{+}$	none	none	na	Na
Trinidad and Tobago	$\xrightarrow{+}$	$\xrightarrow{+}$	$\xrightarrow{+}$	na	na	Na
Antigua & Barbuda	$\xleftarrow{+}$	$\overset{+}{\underset{+}{\rightleftarrows}}$	$\xleftarrow{+}$	na	na	None
Dominica	$\xrightarrow{+}$	$\xrightarrow{+}$	$\xrightarrow{+}$	none	na	Na
Grenada	$\xrightarrow{+}$	$\xleftarrow{+}$	$\xleftarrow{+}$	none	na	None
St. Kitts and Nevis	$\xleftarrow{+}$	$\xleftarrow{+}$	none	na	none	None
St. Lucia	$\xrightarrow{+}$	none	$\xleftarrow{+}$	none	none	$\xleftarrow{-}$
St. Vincent & the Grenadines	none	none	$\overset{+}{\underset{+}{\rightleftarrows}}$	na	na	$\overset{+}{\underset{-}{\rightleftarrows}}$
Latin America						
Argentina	$\xrightarrow{+}$	none	none	na	na	Na
Brazil	$\overset{+}{\underset{+}{\rightleftarrows}}$	none	$\xleftarrow{+}$	na	$\xleftarrow{+}$	$\xleftarrow{+}$
Chile	$\xrightarrow{+}$	none	none	na	$\xrightarrow{+}$	$\xleftarrow{+}$
Colombia	$\xrightarrow{+}$	$\xrightarrow{+}$	$\xleftarrow{+}$	na	na	None
Costa Rica	$\xleftarrow{+}$	$\xleftarrow{+}$	$\xleftarrow{+}$	na	na	Na
Dominican Republic	$\xrightarrow{+}$	$\xleftarrow{+}$	$\overset{+}{\underset{+}{\rightleftarrows}}$	$\xrightarrow{-}$	na	Na
Ecuador	$\xleftarrow{+}$	none	$\overset{+}{\underset{+}{\rightleftarrows}}$	$\xleftarrow{-}$	na	$\xleftarrow{+}$
El Salvador	$\overset{+}{\underset{+}{\rightleftarrows}}$ *	none	$\overset{-}{\underset{+}{\rightleftarrows}}$	none	$\xleftarrow{+}$	Na

Table 4 (Continued): Summary of Results of Causal Chains

	Long-run (responding to disequilibrium)			**Short-run (responding to stochastic shocks)**		
Guatemala	$\xrightarrow{+}$	$\xrightarrow{+}$	none	na	$\xleftarrow{+}$	$\xleftarrow{+}$
Honduras	$\xrightarrow{+}$	none	$\xleftarrow{+}$	none	na	$\xleftarrow{+}$
Mexico	$\xrightarrow{+}$	none	$\xleftarrow{+}$	none	none	$\xleftarrow{+}$
Paraguay	$\underset{+}{\overset{+}{\rightleftarrows}}$	none	none	na	na	None
Peru	$\xrightarrow{+}$	none	$\xleftarrow{+}$	none	na	None
Uruguay	none	$\xleftarrow{+}$	none	none	na	None
Venezuela	$\xrightarrow{+}$	none	none	none	na	Na

*Notes: na indicates that short-run dynamics are rule out because the model specification search favoured a VAR(1), which results in a VECM of order zero. none denotes that no statistical significant (at the 5% level) relationship was found. * indicates that the relationship only held over the period 1960-1980.*

Overall, the results show clearly defined linkages between saving, investment and growth for 17 of the 25 LAC countries. In most of these 17 cases (11 countries), and in line with a neo-classical growth model, saving is the main driving variable; that is, saving drives both investment and growth or it drives investment which in turn drives growth. It is for a smaller number of countries (six) that Keynesian conditions appear to hold, with investment as the main driving variable.

APPENDIX

Table A1: Test for Cointegration between Saving and Investment

		Maximal Eigenvalue		Trace	
Caribbean	**Lags**	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***
Barbados	3	16.903**	2.569	19.471**	2.569
Trinidad and Tobago	1	15.286**	1.987	17.273*	1.987
Antigua & Barbuda	1	16.323**	6.792	23.115**	6.792
Grenada	2	25.484**	6.085	31.569**	6.085
St. Kitts and Nevis	1	36.180**	.5712	36.751**	.5712
St. Lucia	2	16.303**	2.971	19.274**	2.971
Latin America					
Argentina	1	14.624*	3.625	18.249**	3.625
Brazil	1	19.760**	6.9390	26.699**	6.939
Chile	1	19.832**	0.115	19.947**	0.115
Colombia	1	16.261**	0.697	16.958*	0.697
Costa Rica	1	18.888*	6.296	25.183*	6.296
Dominican Republic	2	37.627**	9.387	47.014**	9.387
Ecuador	3	21.248**	2.896	24.143*	2.895
El Salvador -*1960-01*	1	8.056	0.620	8.676	0.620
El Salvador -*1980-80*	1	18.482**	5.939	24.421**	5.939
El Salvador -*1981-01*	2	13.395*	0.783	14.178	0.783
Guatemala	1	20.362**	5.147	25.509*	5.147
Honduras	2	26.219**	8.072	34.291**	8.072
Mexico	2	22.787**	1.374	24.161*	1.374
Paraguay	1	42.157**	0.195	42.352**	0.195
Peru	2	17.708**	6.020	23.728**	6.020
Uruguay	2	9.694	2.782	12.475	2.782

*Notes: critical values are taken from Pesaran et al. (1996) and allow for up to five exogenous I(1) variables in the VECM. * and ** denote statistically significant values at the 5% and 10% level, respectively.*

Table A2: Bounds Tests for Cointegration between Saving and Investment

	Regression of i on s			Regression of s on i		
Country	***1***	***2***	***4***	***1***	***2***	***4***
Guyana	7.672**	7.443**	6.106**	2.129	1.971	1.924
Jamaica	9.169**	10.068**	5.150**	2.852	4.117	2.577
Dominica	8.346**	9.806**	2.460	3.616	5.750**	1.749
Venezuela	6.103**	8.612**	3.514	1.782	1.072	1.074

*Notes: the relevant critical value bounds are given in Table C1(iii) page 300 (with an unrestricted intercept and no trend; number of regressor = 2), Pesaran et al (2001). They are 3.79 - 4.85 at the 95% significance level and 2.17 - 4.14 at the 90% significance level. * denotes that the F-statistic lies above the 90% upper bound and **denotes above the 95% upper bound.*

Table A3: Test for Cointegration between Saving and GDP

		Maximal Eigenvalue		Trace	
Caribbean	**Lags**	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***
Barbados	1	11.043	1.237	12.279	1.237
Trinidad and Tobago	1	29.069**	1.341	30.410**	1.341
OECS					
Antigua & Barbuda	1	17.078**	5.635	22.713**	5.635
Dominica	1	28.216**	1.456	29.671**	1.456
Grenada	1	13.644*	0.836	14.480	0.836
St. Kitts and Nevis	2	20.022**	3.306	23.329**	3.306
St. Lucia	1	16.526	4.972	21.498	4.972
Latin America					
Argentina	1	4.250	0.968	5.217	0.968
Brazil	2	17.395*	1.488	18.883	1.4878
Chile	2	4.534	0.053	4.587	0.053
Colombia	1	26.191**	2.881	29.072**	2.881
Costa Rica	1	18.522**	1.711	20.233**	1.711
Dominican Republic	1	23.536**	4.048	27.584**	4.048
Ecuador	1	13.441*	1.419	14.859	1.149
El Salvador	2	10.439	0.552	10.991	0.552

Table A3 (Continued): Test for Cointegration between Saving and GDP

		Maximal Eigenvalue		Trace	
Latin American	**Lags**	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***
Guatemala	2	27.479**	4.034	31.512	4.034
Honduras	1	6.009	2.911	8.920	2.911
Mexico	1	8.527	4.657	13.184	4.657
Paraguay	1	8.197	1.614	9.811	1.614
Uruguay	1	21.561**	0.075	21.637**	0.075

*Notes: critical values are taken from Pesaran et al. (1996) and allow for up to five exogenous I(1) variables in the VECM. * and ** denote statistically significant values at the 5% and 10% level, respectively.*

Table A4: Bounds Tests for Cointegration between Saving and GDP

	Regression of y on s			Regression of s on y		
	Order of Lag			*Order of Lag*		
Country	***1***	***2***	***4***	***1***	***2***	***4***
Guyana	1.892	1.692	1.782	1.757	2.729	1.845
Jamaica	4.838*	4.381*	3.565	4.099	3.660	1.780
Peru	1.884	2.347	0.612	1.249	1.671	0.095
Venezuela	0.621	0.337	5.090**	2.362	1.670	2.439

*Notes: the relevant critical value bounds are given in Table C1(iii) page 300 (with an unrestricted intercept and no trend; number of regressor = 2), Pesaran et al (2001). They are 3.79 - 4.85 at the 95% significance level and 2.17 - 4.14 at the 90% significance level. * denotes that the F-statistic lies above the 90% upper bound and **denotes above the 95% upper bound.*

Table A5: Test for Cointegration between Investment and GDP

		Maximal Eigenvalue		Trace	
Caribbean	**Lags**	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***	***r = 0 vs r = 1***	***r ≤ 1 vs r = 2***
Barbados	1	12.241	0.083	12.324	0.083
Guyana	2	9.464	2.030	11.494	2.030
Trinidad and Tobago	1	20.824**	1.370	22.194**	1.370
OECS					
Antigua & Barbuda	3	14.028*	4.056	18.083**	4.056
Dominica	1	23.400**	7.947*	31.367**	7.947*
Grenada	2	27.953**	0.015	27.968**	0.015
St. Kitts and Nevis	2	11.184	1.128	12.311	1.128
St. Lucia	2	19.774**	1.779	21.553**	1.779
St. Vincent & the Grenadines	2	14.652*	3.813	18.466**	3.813
Latin America					
Argentina	1	5.081	1.125	6.206	1.125
Brazil	2	16.409**	1.283	17.692*	1.283
Chile	2	8.401	0.037	8.438	0.037
Colombia	2	15.715**	4.676	20.391**	4.676
Costa Rica	1	14.022*	5.089	19.111**	5.089
Dominican Republic	1	39.247**	0.809	40.057**	0.809
Ecuador	2	25.340**	2.471	27.811**	2.471
El Salvador	1	35.531**	0.837	36.368**	0.837
Guatemala	2	11.212	0.835	12.047	0.835
Honduras	2	20.134**	3.538	23.672**	3.538
Mexico	2	28.174**	2.447	30.620**	2.447
Paraguay	1	11.423	0.689	12.112	0.689
Peru	3	16.711**	1.236	17.947**	1.236
Uruguay	2	9.077	0.030	9.107	0.030

*Notes: critical values are taken from Pesaran et al. (1996) and allow for up to five exogenous I(1) variables in the VECM. * and ** denote statistically significant values at the 5% and 10% level, respectively.*

Table A6: Bounds Tests for Cointegration between Investment and GDP

	Regression of y on i			Regression of i on y		
	Order of Lag			*Order of Lag*		
Country	***1***	***2***	***4***	***1***	***2***	***4***
Jamaica	3.843	2.609	2.703	2.577	2.050	1.991
Venezuela	3.711	4.226*	1.770	3.750	1.554	1.065

*Notes: the relevant critical value bounds are given in Table C1(iii) page 300 (with an unrestricted intercept and no trend; number of regressor = 2), Pesaran et al (2001). They are 3.79 - 4.85 at the 95% significance level and 2.17 - 4.14 at the 90% significance level. * denotes that the F-statistic lies above the 90% upper bound and **denotes above the 95% upper bound.*

Table A-7: Test for Homogenous Causality

	Homogenous Causality from						
		s to i	**i to s**	**s to y**	**y to s**	**i to y**	**y to i**
HINC	Group 1	5.56*	4.98*	3.65*	3.88*	4.68*	3.66*
	Group 2	5.86*	3.37*	2.54*	2.97*	2.85*	4.17*
HC	Group 1	5.13*	2.76*	2.97*	3.68*	4.36*	2.94*
	Group 2	4.54*	2.82*	2.61*	3.76*	3.96*	2.37*

*Notes: HINC denotes the homogenous and instantaneous non-causality hypothesis, HC refers to homogenous causality, * indicates significance at the 5% level. Group 1 consists of Barbados, Guyana, Jamaica, Trinidad and Tobago, and the OECS countries. Group 2 is made up of Argentina, Brazil, Chile, Columbia, Costa Rico, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, Peru, Uruguay and Venezuela.*

Table A-8: Test for Heterogeneous Causality

	Heterogeneous causality from					
	s to i	i to s	s to y	y to s	i to y	y to i
Barbados	3.92*+	0.50	1.09	1.84	0.40	0.26
Guyana	3.70*+	0.70	0.66	0.62*+	0.00	0.11
Jamaica	3.94*+	1.08	0.28	0.19	0.00	0.69
Trinidad and Tobago	17.49*+	7.32*+	2.73*+	1.18	4.79*+	0.50
Antigua and Barbuda	4.12*+	1.41	3.02*+	1.20	NA	0.18
Dominica	3.78*+	3.11*+	2.62*+	0.43	3.76*+	0.73
Grenada	5.23*+	0.04	0.09	3.76*+	NA	0.36
Kitts and Nevis	1.24	2.85*+	0.43	4.43*+	NA	0.54
Lucia	3.70*+	0.01	0.78	1.19	4.19*-	0.42
St. Vincent & Grenadines	0.03	0.85	0.70	0.05	NA	0.07
Argentina	12.79*+	0.83	13.33*+	0.11	1.78	0.06
Brazil	4.08*+	3.23*+	0.60	0.00	NA	0.76
Chile	6.55*+	0.91	0.00	1.94*+	3.32*+	8.24*+
Columbia	18.31*+	0.36	15.38*+	1.28	5.03*-	0.27
Costa Rico	3.33*+	0.03	0.46	14.97*+	1.15	4.01*+
Dominican Republic	1.10	0.76	0.01	4.31*+	3.71*+	3.52*+
Ecuador	0.01	8.63*+	0.08	3.41	4.21*-	3.68*+
El Salvador	1.33	0.92	0.35	0.54	1.56	18.36*-
Guatemala	10.86*+	0.04	2.98*+	0.63	1.04	1.12
Honduras	2.33*+	0.09	0.37	3.31*+	0.36	4.98*+
Mexico	10.54*+	0.44	0.08	3.56*+	0.05	2.05*+
Paraguay	11.12*-	0.36	0.78	1.23	1.26	0.70
Peru	2.49*+	0.41	0.14	3.19*+	5.43*+	4.67*+
Uruguay	10.86*-	0.79	2.04*-	2.41*+	13.57*-	2.51*+
Venezuela	6.10*+	0.42	0.23	1.92*+	NA	0.23

** denotes significance at the 5% level and the + or – indicates the overall sign of the coefficient.*

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