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Dynamic causal relationships among macroeconomic variables in developing economies: a panel co-integration/vector correction approach

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ABSTRACT

This paper applies "developed-country" empirical tests to a large, geographically-dispersed sample of 95 developing countries for the period 1996–2008. The goal is to identify, measure, sign and directionalize the dynamic casual relationships linking money, gross domestic product, the interest rate, the price level, the exchange rate, population and the saving rate. Panel co-integration with vector correction reveals statistically significant long-term equilibrium relationships among all variables except population and the saving rate, implying that the main sources of determined output come from the demand side. Results from the error correction model suggest that after a fiscal shock, gross domestic product reverts to its equilibrium within 20 quarters. In contrast, the money supply requires only 5 quarters to revert to equilibrium. The evidence implies that the money supply could potentially be used as one indicator of future movements in gross domestic product in a developing economy. Comparisons of the results from the present study with those from OECD economies suggest that macro-economics has reached a point where differences between "developed" and "developing" economies may be less than those within each bloc.

1. Introduction

Development economics has emerged as a field in economics since the independence of 19th century colonies was achieved from the late 1940s through the early 1960s. Nobel prizes have been awarded to at least five economists for their direct analyses of under-development. These include W Arthur Lewis (1960, 1979) for dualistic models of labour transfer, Simon Kuznets (1973,1977) for the quantification of the structural transformation away from agriculture, Theodore Schultz (1971,1980) for theories of human capital and farmer rationality, Gunnar Myrdal (1973a,1973b) for descriptions of underdevelopment in Asia, and Amartya Sen (1933,1997) for formulating the just rights of the poor. But other Nobel laureates, notably Robert Solow (1956), Douglass North

(1989),Wassily Leontief (1973), Ragnar Frisch (1926), and Jan Tinbergen (1954) have also formulated more inclusive theories with strong implications for poor economies.

This body of pioneering development theories clarifies what makes developing economies different from the European and American models upon which modern macroeconomics is based. It has been empirically validated and nuanced by applications to real-world economies by such applied economists as Chenery (1988), Mellor (1976), Hayami-Ruttan (1971), Kanbur (2006), and Ravallion (2007). To the extent that markets are more imperfect, international trade more fettered, information more subject to principal-agent problems, administrators more corrupt, poverty deeper, the safety net more tattered, and the State more over-involved than in industrialized economies, the domain of economic development studies has been justified, and must still be maintained.

However, it must never be forgotten that the goal of economic development theory is eventually to do itself out of a job; i.e. to help the set of low- and middle-income countries to achieve such high levels of income and economic performance that there will some day no longer be a need for development macroeconomists, but simply macroeconomists. The objective of the present paper is to take a mid-term progress reading of how far the developing economies have come in the last 60 years towards achieving that goal. We therefore intentionally subject a large sample of low- and medium-income countries to the same kinds of causal tests among the main macroeconomic aggregates that industrialized countries are subjected to. This has been done to a little extent in the past; but each of the handful of studies we cite in this paper has analyzed only one or two countries at a time, and has often used earlier, less incisive forms of econometric model. In the present paper we apply the advanced techniques of vector auto-regression and panel correction to determine how smoothly and integrally a wide range of 95 developing economies are functioning. We then perform meta-analysis of our results with studies from the recent literature on the G12 economies, which themselves have not done particularly well during the past decade in maintaining high growth rates, eliminating corruption and economic crime, avoiding economic crises, liberalizing trade in agricultural products, or balancing the budget. We test the hypothesis that there is virtually no difference between the two sets of economies; or, more bluntly, that the advanced economies also need a lot of attention to development economics.

2. Review of literature and conceptual framework

Many theoretical and empirical studies in the field of standard macroeconomics have addressed the important question of the exact causal relationship among such macroeconomic variables as the money supply, gross domestic product, technological innovation, the interest rate, the price level, the exchange rate, the wage rate, employment, population and saving rate. Different schools of thought, such as the Classical Economists, the Keynesians, the Monetarists, the new Classicals, the new Keynesians and the New Growth Theorists, have provided different explanations of the relationship among these variables. For example, Keynes believed that effective demand plays a pivotal role in determining output. While acknowledging that a positive monetary shock will increase economic activity and the price level, he emphasized fiscal rather than monetary policy as more important to the economy.

The Monetarist school provides a different explanation: that the money supply is the primordial factor in determining national income. Friedman and Schwartz (1963) studied the long-term relationship between money supply and output, and the implications for effective monetary policy in the USA. They advocated a Central Bank policy aimed at keeping the supply and demand for money at equilibrium in order to adjust for differential growth rates of productivity and demand. Their conclusion was that monetary policy was effective and could explain and compensate for fluctuations in output.

Keynesians, Monetarists and the New Classicals agree that fluctuations around the trend are caused by nominal demand events such as monetary shocks, not real supply shocks such as technological breakthroughs. However, Nelson and Plosser (1982)'s attempt to answer whether fluctuations have a permanent component found that real factors such as the labour supply and technological innovation both determine output in the long run and act as substantial sources of disruption to the economy. It is important to note that the labour supply is a double-edged sword in terms of policy to increase GDP per capita, since population and labour force growth rates are highly correlated.

Since the mid-1980s, "New" or "Endogenous" Growth Theory has emerged to criticize the neo-classical growth model. In the neo-classical view, the long-run growth rate is exogenously determined by either assuming a savings rate (the Harrod–Domar model) or a rate of technical progress net of depreciation and population growth (Solow model). As a result, the Solow model introduces the concepts of "effective" labour, capital "deepening" and capital "widening." However, the savings rate, population growth rate, and rate of technological progress remain exogenous and unexplained. Endogenous growth theory emphasized that economic growth results from increasing returns due to new knowledge. As a partial correction to these problems, the Hayami-Ruttan model endogenizes technical and institutional change as a response to changes in relative factor prices.

Determinants of real output

A vast empirical literature, e.g. Ambler (1989), Kamasa and Joyce (1993), Masih and Masih (1996b), Husain and Abbas (2000), Karras (1994, 1999), Chaido and Antonios (2005), Chaudhry, Choudhary and Ejaz (2005) and Yu, Jamal and Hsieh (2009), has tested the predictions of these theories. Some papers have found that the money supply does not affect output. For example, Ambler (1989) studied the impact of the movement in monetary variables on the changes in real output in Canada and found that increases in the money stock relative to nominal income raise spending and output in the short run. He further concluded that the observed stationarity of Canadian velocity implies that money affects only price in the long run.

For developing economies as well, Kamasa and Joyce (1993) investigated the impact of changes in monetary variables on the domestic and foreign sectors, the determinants of central bank policy, and the response to foreign monetary changes in Mexico and India. Their paper found that domestic monetary policy had no significant effect upon output in either country. Output responded in each country only to changes in foreign, not domestic, money.

Masih and Masih (1996b) discerned the dynamic causal chain (in the Granger temporal sense rather than in the structural sense) linking real output to money, the interest rate, inflation and the exchange rate in the context of a small Asian developing economy (Indonesia). Their findings have clear policy implications for any accommodative and/or excessive monetary expansion since it is likely to be dissipated in terms of relatively higher nominal variables such as prices, exchange rates or interest rates rather than real output. Husain and Abbas (2000) re-examined the causal relationships among money, income and prices in Pakistan. They showed that unidirectional causality runs from income to money, implying that, in all likelihood, real factors rather than the money supply have played a major role in increasing Pakistan's national income.

On the other hand, Karras (1994, 1999) found that money supply affects output, which increases its influence on inflation. Yu, Jamal and Hsieh (2009) applied a monetary function to explain fluctuations in output in Bangladesh and this. They found that real depreciation, a higher real stock price, a lower real federal funds rate, and increases in aggregate world output all increase real output. However, the ratio of government consumption spending to nominal GDP is insignificant, suggesting that expansionary fiscal policy may not be effective.

Determinants and effects of macroeconomic fluctuations

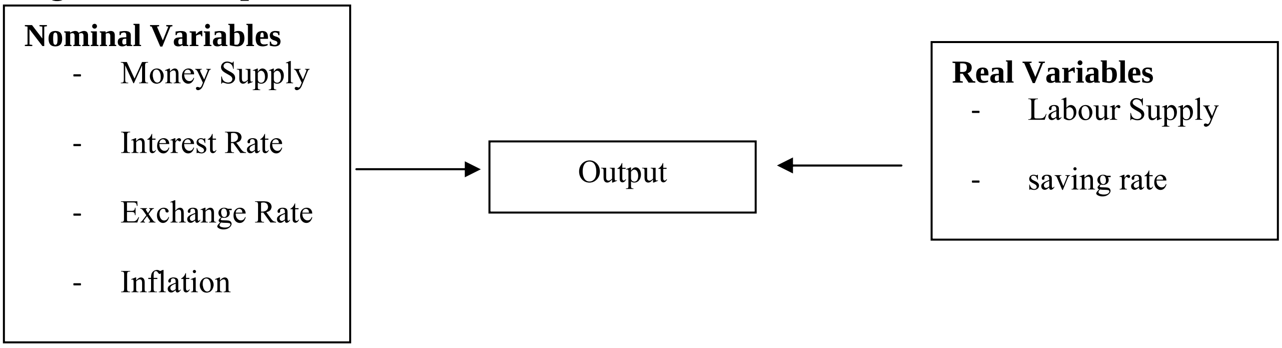
Another large branch of macroeconomic research – e.g. Canlas (2003), Cheng (2003), Yu (2006), Balcilar & Tuna (2009) -- explains the historical patterns of fluctuations in economic activity and whether or not macroeconomic policy makes any significant contribution to these patterns. For example, Cheng (2003) found that fluctuations in such policy instruments as the money supply and the budget deficit (but <u>not</u> capital formation) bear a significant relation with real GDP in Malaysia.

In an exploration of short-term output fluctuations in Slovakia, Yu (2006) demonstrated that reductions in expected inflation rate, government deficit, euro rate, a lower and U.S. federal funds rate; and increases in the real effective exchange rate and aggregate world output would help to raise output. Balcilar and Tuna (2009) studied the sources of macroeconomic fluctuations in a typical small open economy (Turkey). They concluded that in the long run, supply-side shocks are the main source of output fluctuations, explaining almost half the variance of domestic output. In contrast, short-run variability in domestic output is dominated by relative demand shocks. Finally, Canlas (2003) explored the effects of changes in the saving rate, population growth and human-capital growth on real GDP in the Philippines. The results showed that the saving rate has a positive effect, population increase a negative effect, and human-capital improvement no significant effect on growth.

Against this background, the present paper proposes to study the interrelationship among money supply and macroeconomic variables within a conceptual framework similar to those used by Masih and Masih (1996b), Chaido and Antonios (2005) Chaudhry, Choudhary and Ejaz (2005) and Hsieh (2006). Unfortunately, the disparate results of those studies preclude clear policy recommendations. We shall therefore employ recent advances in econometric modeling (vector auto-regression and panel correction) to arrive at a consistent set of conclusions for a much larger sample of countries over the most recent 13 year period for which data are available (1996-2008).

The propose of this article is to empirically identify, measure, and test the significance of the dynamic casual relationships among the macroeconomic variables money supply, gross domestic product, the interest rate, the price level, the exchange rate, population and the savings rate in 95 developing economies. The conceptual framework of the model is shown in figure 1.

Figure 1: Conceptual Framework



The remainder of this paper is organized as follows. Section 2 describes the data sources as well as the limitations of the analysis. Section 3 outlines the methodology to test results for co-integration, unit roots and the need to estimate an error correction model. Section 4 presents and discusses the empirical results. Finally, section 5 summarizes the conclusions within a practical policy perspective.

3. Data and Empirical Methodology

3.1 Data

The empirical analysis is applied to a sample of 95 developing countries drawn from Central and Eastern Europe, Middle East, the Western Hemisphere, the Commonwealth of Independent States, Asia and Sub-Saharan Africa (Table 1).

Table 1: Show numbers of countries were divided by IMF (2009).

Country group	Number of countries
Central and Eastern Europe	11
Middle East	8
Western Hemisphere	19
Commonwealth of Independent States	8
Asia	17
Sub-Saharan Africa	32
Total	95

We use annual data for the period 13-year period 1996-2008[1] to investigate the casual relationships among the key macroeconomic variables noted above. Gross Domestic Product at current prices (GDP), money supply (M1), the interest rate (IR), national currency per US dollar or nominal exchange rate (ER), the inflation rate with base 2000 (CPI), population (POP) and the savings rate as a percent of GNI (SA) are used as cardinal indicators. All series were obtained from the IMF (2009) and the Central Bank of

[1] The length of the period is dictated by the availability of data.

each country and converted into natural logarithms prior to the empirical analysis.

4. Econometric methods

Following established procedures, we conducted the tests of the causal relationship among gross domestic product and the other macroeconomic aggregates in three stages:

a) test for the order of integration in the series for money supply, gross domestic product, the interest rate, the price level, the exchange rate, population and the saving rate

b) employ panel co-integration to examine the long-run relationships among the variables

c) use dynamic panel causality tests to evaluate the short run co-integration and the direction of causality among the variables.

4.1 Panel Unit Root

The co-integration properties of the variables involved determine the appropriate specification of the real output function. If the series are co-integrated, then the relationship among the target macroeconomic variables should be interpreted as a long-run equilibrium, as deviations are mean-reverting. However, it is well known for small samples that standard unit root and co-integration tests can lose power as compared to stationary alternatives. Panel data circumvent the low power problem of standard unit root tests by increasing the number of observations (Baltagi 2007).

Six panel unit root tests were used in this paper: Levin and Lin (1992, 1993); Breitung (2000); Im, Pesaran and Shin (2003); two Fisher-Type tests using ADF and PP-test; Maddala and Wu (1999) and Choi (2001); and Hadri (2000).

In general, the type of panel unit root tests is based on the following univariate regression;

$$\Delta y_{it} = \rho_i y_{it-1} + z'_{it}\gamma + u_{it} \qquad (1)$$

where i=1,2,…,N is the country, t =1,2,…,T z_{it} lists the deterministic components and u_{it} is iid $(0,\sigma_i^2)$ z_{it} could be zero, one, the fixed effects or fixed effect as well as a time trend (t).

For the six tests considered, the null hypothesis is that all series have a unit root, that is $\rho_i = 0\ \forall i$. Each specific test has a different alternative hypothesis, depending upon different degrees of heterogeneity under the alternative hypothesis.

In the Levin and Lin (LL) tests, one assumes homogeneous autoregressive coefficients between individual, i.e. $\rho_i = \rho\ \forall i$ and test null hypothesis $H_o : \rho_i = \rho = 0$ against the alternative $H_a : \rho_i = \rho < 0$. However, the LL test has some limitations. First of all, the test depends crucially upon the independence assumption across individuals and hence is not applicable if cross sectional correlation is present. Second, the assumption that all cross-sections have or do not have a unit root is restrictive.

For this reason, Im et al. (2003) extended the Levin and Lin framework to allow for heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Indeed, the alternative hypothesis can be written: $\rho_i < 0\ for\ i = 1,2,...,N_1$ and $\rho_i = 0$ for $i = N_1 + 1,...,N$. Thus, under alternative hypothesis, some (but not all) individual series may be characterized by a unit root. Two tests are proposed by Im et al.: a group mean t-bar statistic for $\rho_i = 0$ based on the t-statistics derived from the N augmented Dickey-Fuller regressions, and a group-mean Lagrange multiplier (LM) statistic which is based upon averaging the single-country LM-statistics for $\rho_i = 0$.

The Breitung (2000) panel unit root test is based upon the regression

$$y_{it} = \eta_{it} + \sum_{k=1}^{\rho+1} \beta_{ik} x_{i,t-k} + \varepsilon_t \qquad (2)$$

The test statistic examines the null hypothesis that the process is difference stationary H_0 : $\sum_{k=1}^{\rho+1}\beta_{ik}-1=0$. The alternative hypothesis assumes that the panel series is stationary; i.e, $\sum_{k=1}^{\rho+1}\beta_{ik}-1<0$ for all i. Breitung (2000) uses the following transformed vectors to construct the test statistic:

$$Y_i^* = AY_i = \left[y_{i1}^*, y_{i2}^*, \ldots, y_{iT}^*\right]' \quad (3)$$

$$X_i^* = AX_i = \left[x_{i1}^*, x_{i2}^*, \ldots, x_{iT}^*\right]' \quad (4)$$

leading to the following test statistic:

$$\lambda_\beta = \frac{\sum_{i=1}^{N}\sigma_1^{-2}Y_i^{*\prime}X_i^{*\prime}}{\sqrt{\sum_{i=1}^{N}\sigma_1^{-2}X_i^{*\prime}A'AX_i^*}} \quad (5)$$

which is shown to have a standard normal distribution.

The Maddala and Wu (1999) and Choi (2001) test is a non-parametric Fisher-type test which is based on the combination of the p-values of test-statistics for a unit root in each cross-sectional unit. Additionally, when the Fisher tests are based on ADF test statistics, we must specify the number of lags used in each cross-section ADF regression. For the PP form of the test, we must instead specify a method for estimating which EViews supports estimators based on kernel-based sum-of-covariances. See Both the Im-Pesaran-Shin and Fisher tests combine information based on individual unit root tests and relax the restrictive assumption of the LL test that ρ_i is the same under the alternative.

Finally, the Hadri (2000) test is similar to the KPSS unit root test, and has a null hypothesis of no unit root in any of the series in the panel. Like the KPSS test, the Hadri test is based upon the residuals from the individual OLS regressions of y_{it} on a constant, or on a constant and a trend.

4.2 Panel Cointegration Test

Like the panel unit root tests, panel cointegration tests can be motivated by the search for more powerful tests than those obtained by applying individual time series cointegration tests.

Let

Lnm = the natural log of the money supply

lngdp = the natural log of Gross Domestic Product

lnir = the natural log of the nominal interest rate

lner = the natural log of the nominal exchange rate

lncpi = the natural log of the consumer price index

lnpop = the natural log of the population

lnsa = the natural log of the saving rate

Provided the variable set {*lnm, lngdp,lnir, lner, lncpi , lnpop , lnsa*} contains a panel unit root, the issue arises as to whether there exists a long-run equilibrium relationship among the variables. When Marini (2007) compared the power of panel tests of cointegration on data from 20 OECD countries for the period 1971-2004, she determined that the choice of the most powerful test depends on the values of the sample statistics, suggesting that a clear-cut conclusion on the most powerful test cannot be reached. We therefore test for panel co-integration using both Pedroni's (2004) test that allows for heterogeneity in the intercepts and slopes of the co-integrating equation, and the Kao Test (1999).

Pedroni's (2004) test

Pedroni provided seven statistics for the test of the null hypothesis of no co-integration in heterogeneous panels. A subgroup of the tests is termed "within dimension" (panel tests) and another subgroup "between dimension" (group tests). The "within dimension" tests pool the data across the ''within dimension.'' They take into account common time factors and allows for heterogeneity across members. The ‘‘between dimension’’ tests allow for heterogeneity of parameters across members, and are called ‘‘group mean cointegration statistics.’’ The seven Pedroni (2004) panel cointegration test statistics that we employ are as follows:

Within dimension (panel tests):

(a) Panel v-statistic

$$Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \quad (6)$$

(b) Panel ρ-statistics.

$$Z_p = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{t} - \hat{\lambda}_{i} \right) \quad (7)$$

(c) Panel PP-statistic.

$$Z_{pp} = \left(\hat{\sigma}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{t} - \hat{\lambda}_{i} \right) (8)$$

(d) Panel ADF-statistic.

$$Z_t = \left(\hat{S}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}^{*2}_{i,t-1} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\hat{L}_{11i}^{-2} \hat{e}^{*}_{i,t-1} \Delta \hat{e}^{*}_{i,t} \right) \quad (9)$$

Between dimension (group tests):

(e) Group ρ-statistics.

$$\tilde{Z}_{\rho} = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \quad (10)$$

(f) Group PP-statistic.

$$\tilde{Z}_{pp} = \sum_{i=1}^{N} \left[\hat{\sigma}^2 \sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_{i} \right) \quad (11)$$

(g) Group ADF -statistic.

$$\tilde{Z}_{t} = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{S}^{*2} \hat{e}^{*2}_{i,t-1} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}^{*}_{i,t-1} \Delta \hat{e}^{*}_{i,t} \right) \quad (12)$$

where $\hat{\sigma}^2$ is the pooled long-run variance for non parametric model given as $1/N \sum_{i=1}^{N} \hat{L}_{11} \hat{\sigma}_i^2$ and $\hat{\lambda}_i = 1/2\left(\hat{\sigma}_i^2 - \hat{S}_i^2\right)$,where $\hat{L}_i$ is used to adjust for autocorrelation in panel parameter model, $\hat{\sigma}_i^2$ and $\hat{S}_i^2$ are the long-run and contemporaneous variances for individual i,and $\hat{S}_i^2$ is obtained from individual ADF-test of $e_{i,t} = \rho_i e_{i,t-1} + v_{i,t}$. $\hat{S}_i^{*2}$ is the contemporaneous variance from the parametric model, $\hat{e}_{i,t}$ is the estimated residual from the parametric cointegration, while $\hat{e}^{*}_{i,t}$ is the estimated residual from parametric model. $\hat{L}_{11i}$ is the estimated long-run covariance matrix for $\Delta \hat{e}_{i,t}$ and L_i is the ith component of low triangular Cholesky decomposition of matrix Ω_i for $\Delta \hat{e}_{i,t}$ with the appropriate lag length determined by the New-West method.

Seven of Pedroni’s tests are based on the estimated residuals from the following long-run model:

$$\ln gdp_{i,t} = \alpha_i + \beta_i \ln m_{i,t} + \gamma_i \ln ir_{i,t} + \theta_i \ln er_{i,t} + \eta_i \ln cp_{i,t} + \lambda_i \ln pop_{i,t} + \pi_i \ln sa_{i,t} + \varepsilon_{i,t} \quad (13)$$

where $\varepsilon_{i,t} = \rho_i \varepsilon_{i,(t-1)} + \mu_{i,t}$ are the estimated residuals from the panel regression and *lngdp, lnm, lnir, lner, lncp, lnpop* and *lnsa* are the natural logarithms of GDP, money supply, interest rate,exchange rate, price level, population and saving rate, respectively.

The null hypothesis tested is whether ρ_i is unity. Pedroni (2004) suggests a Phillips–Perron-type Test to test cointegration. The statistics can be compared to appropriate critical values, and if critical values are exceeded then the null hypothesis of no cointegration is rejected, implying that a long-run relationship between the variables does exist.

Kao Tests (1999)

Kao tests the residuals $\hat{\varepsilon}_{i,t}$ it of the OLS panel estimation by applying DF- and ADF-type tests:

$$\hat{\varepsilon}_{i,t} = \rho_i \varepsilon_{i,(t-1)} + \mu_{i,t} \quad (14)$$

The null hypothesis of no cointegration, H_0: ρ=1, is tested against the alternative hypothesis of stationary residuals, H_1: $\rho \neq 1$. Kao presents five DF and ADF types of cointegration tests in the panel data.The test statistics are DF and ADF, which are for cointegration with the endogenous regressors, and DF which are based on assuming strict endogeneity of the regressors.

4.3 Panel long run estimators

First, we will estimate the model by using the pooled OLS estimator. However, pooled time series data, much like univariate time series data, tend to exhibit a time trend and are therefore non-stationary; i.e., the variables in question have means, variances, and covariances that are not time invariant. Therefore, we employ panel-OLS, panel-DOLS and panel-GMM to estimate our model.

For the pooled model, consider the following system of cointegrated regressions

$$y_{i,t} = \alpha_i + x_{i,t}\beta_i + u_{i,t} \qquad (15)$$

Since the pooled model assumes that regressors are exogenous, we simply write the error as $u_{i,t}$ rather than using the decomposition $\alpha_i + u_{i,t}$. Then

$$y_i = \alpha + x_i\beta_i + u_i$$

Note that x_{it} here does not include a constant whereas cross-section data x_i additionally include a constant term.

For panel cointegrated regression models, the asymptotic properties of the estimators of the regression coefficients and the associated statistical tests are different from those of time series cointegration regression models. Some of these differences have become apparent in recent work by Kao and Chiang (2000), Phillip and Moon (1999) and Pedroni (2000, 2004). Chen, McCoskey and Kao (1999) investigated the finite sample properties of the OLS estimator, the t-statistic, the bias-corrected OLS estimator and the bias-corrected t-statistic. They found that, in general, the bias-corrected OLS estimator does not improve upon the OLS estimator. Moreover, to estimate dynamic panel models Arellano and Bond (1991) suggest that Generalized Method of Moments (GMM) gives estimators that are more efficient and consistent.

Kao and Chiang (2000) consider the following panel regression

$$y_{it} = x'_{it}\beta + z'_{it}\gamma + u_{it} \qquad (16)$$

where $\{x_{it}\}$ are $k \times 1$ integrated processes of order one for all i and $x_{it} = x_{it-1} + \varepsilon_{it}$

The OLS estimator of β is

$$\hat{\beta}_{OLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{x}_{it}\tilde{x}'_{it}\right]\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{x}_{it}\tilde{y}_{it}\right] \qquad (17)$$

However this estimator was shown by Kao and Chiang (2000) to yield inconsistent $\hat{\beta}_{OLS}$ using panel data. As an alternative to OLS, to correct for serial correlation and non-exogeneity of the regressors, a panel version of the DOLS estimator can be used, based on

$$y_{it} = x'_{it}\beta + \sum_{k=-K_i}^{K_i}\gamma_{ik}\Delta x_{it-k} + \varepsilon_{it}, \qquad (18)$$

where

$$\hat{\beta}_{DOLS} = \left[N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}z_{it}z'_{it}\right)^{-1}\left(\sum_{t=1}^{T}z_{it}\tilde{y}_{it}\right)\right]_1 \qquad (19)$$

and where

z_{it} = is the 2 (K+1) x 1 vector of regressors $z_{it} = (x_{it} - \bar{x}_i, \Delta x_{it-k}, \ldots, \Delta x_{it+k})$

$\tilde{y}_{it}$ = $y_{it} - \bar{y}_{it}$, and the subscript 1 outside the brackets indicates the first elements of the vector used to obtain the pooled slope coefficient.

Alternatively, under GMM model (16) is transformed into the following difference equation:

$$y_{it} - y_{it-1} = \beta'(X_{it} - X_{it-1}) + \gamma'(z_{it} - z_{it-1}) + (u_{it} - u_{it-1})$$

i=1,…,n t=2,…,T$_i$ (20)

However, from (20) a bias arises since $y_{it-1} - y_{it-2}$ is correlated with the transformed error term ($u_{it} - u_{it-1}$), OLS on dynamic panel will be consistent. But if there are valid instruments, then GMM can be used to estimate the equation. Typically, we use lags of the dependent variable, two periods back, as y_{it-2} is uncorrelated with ($u_{it} - u_{it-1}$).Thus values of $y_{it-k}, k \geq 2,$ are valid instruments.

4.4 Panel vector error correction model

Once the variables were cointegrated, the next step performed was the causality test. We used a panel-based (VECM) to identify the existence and direction of a long-run equilibrium relationship using the two-step procedure of Engle and Granger (1987). In the first step, we estimated the long-run model using Eq. (13) to generate the estimated residual ε (the error correction term; e_{it} hereafter). In the second step, we estimated the panel Granger causality model with dynamic error correction as follows:

$$\Delta\ln gdp = \pi_{igdp} + \lambda_{gdp} e_{it-1} + \sum_p \pi_{11ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{12ip}\Delta\ln m_{it-p} + \sum_p \pi_{13ip}\Delta\ln ir_{it-p} + \sum_p \pi_{14ip}\Delta\ln er_{it-p} + \sum_p \pi_{15ip}\Delta\ln cp_{it-p} + \sum_p \pi_{16ip}\Delta\ln pop_{it-p} + \sum_p \pi_{17ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21a)$$

$$\Delta\ln m = \pi_{im} + \lambda_{m} e_{it-1} + \sum_p \pi_{21ip}\Delta\ln m_{it-p} + \sum_p \pi_{22ip}\Delta\ln dgp_{it-p} + \sum_p \pi_{23ip}\Delta\ln ir_{it-p} + \sum_p \pi_{24ip}\Delta\ln er_{it-p} + \sum_p \pi_{25ip}\Delta\ln cp_{it-p} + \sum_p \pi_{26ip}\Delta\ln pop_{it-p} + \sum_p \pi_{27ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21b)$$

$$\Delta\ln ir = \pi_{iir} + \lambda_{ir} e_{it-1} + \sum_p \pi_{31ip}\Delta\ln ir_{it-p} + \sum_p \pi_{32ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{33ip}\Delta\ln m_{it-p} + \sum_p \pi_{34ip}\Delta\ln er_{it-p} + \sum_p \pi_{35ip}\Delta\ln cp_{it-p} + \sum_p \pi_{36ip}\Delta\ln pop_{it-p} + \sum_p \pi_{37ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21c)$$

$$\Delta\ln er = \pi_{ier} + \lambda_{er} e_{it-1} + \sum_p \pi_{41ip}\Delta\ln er_{it-p} + \sum_p \pi_{42ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{43ip}\Delta\ln m_{it-p} + \sum_p \pi_{44ip}\Delta\ln ir_{it-p} + \sum_p \pi_{45ip}\Delta\ln cp_{it-p} + \sum_p \pi_{46ip}\Delta\ln pop_{it-p} + \sum_p \pi_{47ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21d)$$

$$\Delta\ln cp = \pi_{icp} + \lambda_{cp} e_{it-1} + \sum_p \pi_{51ip}\Delta\ln cp_{it-p} + \sum_p \pi_{52ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{53ip}\Delta\ln m_{it-p} + \sum_p \pi_{54ip}\Delta\ln ir_{it-p} + \sum_p \pi_{55ip}\Delta\ln er_{it-p} + \sum_p \pi_{56ip}\Delta\ln pop_{it-p} + \sum_p \pi_{57ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21e)$$

$$\Delta\ln pop = \pi_{ipop} + \lambda_{pop} e_{it-1} + \sum_p \pi_{61ip}\Delta\ln pop_{it-p} + \sum_p \pi_{62ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{63ip}\Delta\ln m_{it-p} + \sum_p \pi_{64ip}\Delta\ln ir_{it-p} + \sum_p \pi_{65ip}\Delta\ln er_{it-p} + \sum_p \pi_{66ip}\Delta\ln cp_{it-p} + \sum_p \pi_{67ip}\Delta\ln sa_{it-p} + \varepsilon_{it} \quad (21f)$$

$$\Delta\ln sa = \pi_{isa} + \lambda_{ssa} e_{it-1} + \sum_p \pi_{71ip}\Delta\ln sa_{it-p} + \sum_p \pi_{72ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{73ip}\Delta\ln m_{it-p} + \sum_p \pi_{74ip}\Delta\ln ir_{it-p} + \sum_p \pi_{75ip}\Delta\ln er_{it-p} + \sum_p \pi_{76ip}\Delta\ln cp_{it-p} + \sum_p \pi_{77ip}\Delta\ln pop_{it-p} + \varepsilon_{it} \quad (21g)$$

where Δ is the first difference operator and e_{it-1} are the error correction terms. Parameter λ_i is the speed of adjustment to long-run equilibrium. This model can be estimated using instrumental variables to deal with the correction between the error term and the lagged dependent variables.

5. Empirical results

5.1 The empirical results of the panel unit root test.

Tables 2 and 3 report (summary) panel unit root tests on the relevant variables given in equation (13) above. As can be readily seen, most of the tests (with the exception of the LLC test in one case) fail to reject the unit root null for *lngdp, lnm, lnir, lner* and *lncp* in level form in table 2, but the tests do reject the null hypothesis of a unit root in difference form in table 3. The table also reports the widely used Hadri-Z test statistic, which, as opposed to the aforementioned tests, uses a null of no unit root. However, for *lnpop* and *lnsa*, most tests do reject the null of a unit root in level form, which implies that *lnpop* and *lnsa* are stationary at level. Thus, the evidence suggests that the variables *lngdp, lnm, lnir, lner* and *lncp* do evolve as non-stationary processes and the application of OLS to equations (13) above will result in biased and inconsistent estimates. It is therefore necessary to turn to panel cointegration techniques in order to determine whether a long-run equilibrium relationship exists among the non-stationary variables in level form.

Table 2 :Results of Panel Unit root test base on 6 method test for all variables

Test/variable	lngdp	lnm	lnir	lner	lncp	lnpop	lnsa
Series in level							
Null Hypothesis: Unit root (assumes common unit root process)							
Levin,Lim and Chu	-1.61080 (0.0536)	-8.59671 (0.0000)	-38.2424 (0.0000)	-6.17130 (0.0000)	6.28423 (1.0000)	-21.4109 (0.0000)	-13.5366 (0.0000)
Breitung	11.4836 (1.0000)	9.55260 (1.0000)	3.04682 (0.9988)	4.87818 (1.0000)	5.12495 (1.0000)	1.14834 (0.8746)	6.03686 (1.0000)
Null Hypothesis: Unit root (assumes individual unit root process)							
Im,Pesaran and Shin	8.70031 (1.0000)	2.19323 (0.9859)	-4.21829 (0.0000)	1.67140 (0.9527)	15.4172 (1.0000)	-12.4525 (0.0000)	-4.57051 (0.0000)
Fisher-ADF	92.2423 (1.0000)	171.907 (0.8225)	231.491 (0.0058)	177.835 (0.2868)	118.494 (1.0000)	494.679 (0.0000)	303.688 (0.0000)
Fisher-PP	110.745 (1.0000)	208.005 (0.1762)	212.773 (0.0478)	180.078 (0.2483)	132.804 (0.9994)	457.325 (0.0000)	277.608 (0.0000)
Null Hypothesis: Stationary							
Hadri	18.7904 (0.0000)	18.6787 (0.0000)	15.9137 (0.0000)	21.9322 (0.0000)	21.0438 (0.0000)	18.8624 (0.0000)	22.2580 (0.0000)

Note: An intercept and trend are included in the test equation. P-values are provided in parentheses. The lag length was selected by using the Akaike Information Criteria.

Table 3 :Results of Panel Unit root test base on the 6 method tests at first differences

Test/variable	lngdp	lnm	lnir	lner	lncp
Series in first differences					
Null Hypothesis: Unit root (assumes common unit root process)					
Levin,Lim and Chu	-27.3702 (0.0000)	-19.8532 (0.0000)	-30.0319 (0.0000)	-20.2116 (0.0000)	-17.9086 (0.0000)
Breitung	-4.80015 (0.0000)	-0.51493 (0.3033)	-4.73304 (0.0000)	-2.26788 (0.0117)	12.3741 (1.0000)
Null Hypothesis: Unit root (assumes individual unit root process)					
Im,Pesaran and Shin	-12.8004 (0.0000)	-9.79871 (0.0000)	-15.5842 (0.0000)	-7.24137 (0.0000)	-2.14928 (0.0158)
Fisher-ADF	467.028 (0.0000)	415.096 (0.0000)	517.515 (0.0000)	323.493 (0.0000)	286.355 (0.0000)
Fisher-PP	550.089 (0.0000)	600.165 (0.0000)	756.723 (0.0000)	380.969 (0.0000)	297.601 (0.0000)
Null Hypothesis: Stationarity					
Hadri	21.7543 (0.0000)	16.8501 (0.0000)	26.8623 (0.0000)	16.8203 (0.0000)	25.8845 (0.0000)

Note: An intercept and trend are included in the test equation. P-values are provided in parentheses. The lag length was selected by using the Akaike Information Criteria.

5.2 The empirical results of panel cointegration test.

Having established that money, gross domestic product, the interest rate, the price level and exchange rate are I (1), we next proceed to test whether a long-run relationship exists between them using Pedroni's (2004) heterogeneous panel cointegration test and the Kao (1999) test. The results for the seven different panel test statistics suggested by Pedroni are reported in Table 4. The significance of these test statistics is provided in parenthesis in the form of p-values. Four of the seven-test statistics suggest that money, gross domestic product, the interest rate, the price level and the exchange rate are cointegrated at the 5 percent level or better. However, simulations made by Pedroni (1997) show that, in small samples (T ≈ 20), the group mean parametric t-test is more powerful than the other tests, followed by the panel v test. The Kao (1999) test also suggests that money, gross domestic product, interest rate, the price level and the exchange rate are cointegrated at the 10 percent level.

Table 4: Pedroni's (2004) and Kao (1999) and panel cointegration test

Test Statistic	T-Ratio	P-Value
Pedroni's (2004)		
Panel υ-statistic	3.785402***	0.0001
Panel Phillip-Perron ρ-statistic	11.85330	1.0000
Panel Phillip-Perron t-statistic	-9.849564***	0.0000
Panel ADF t-statistic	-0.767003	0.2215
Group Phillip-Perron ρ-statistic	15.52086	1.0000
Group Phillip-Perron t-statistic	-23.46893***	0.0000
Group ADF t-statistic	-5.659836***	0.0000
Kao (1999) Test	-1.460433*	0.0721

Note: Probability values are in parenthesis;*, ** and *** denote statistical significance at the 10 percent, 5 percent and 1 percent levels, respectively.

5.3 The empirical results of estimating panel cointegration model

Tables 5 and 6 report the results of the long- and short-run relationship for money, gross domestic product, interest rate, the price level and exchange rate based on the pool-OLS-,OLS-, DOLS- and GMM estimators with $lngdp_{it}$ as the dependent variable. The long-run results show that all variables have the expected sign and are statistically significant at the 10% level or better. Given that the variables are expressed in natural logarithms, the coefficients can be conveniently interpreted as elasticities.

The pooled OLS estimates show a strong positive association between money supply, interest rate, exchange rate and gross domestic product in developing countries. Inflation now has a negative sign and is significant with respect to gross domestic product.

The long run panel cointegration model based on an OLS-estimator shows that money and price level have positive impacts on gross domestic product while the interest rate and the exchange rate have negative impacts on gross domestic product at the 1 percent level of statistical significance. The results indicate that the elasticity of GDP with respect to the money supply is greater in absolute terms than that with respect to either the interest rate, the price level or the exchange rate. A 1% increase in the money supply will increase gross domestic product by 0.45%.

The long run panel cointegration model based upon the DOLS-estimator shows that money and the price level have positive impacts on gross domestic product, while the interest rate and exchange rate have negative impacts at the 1 percent level of statistical significance. The results indicate that the elasticity of money is greater than the elasticity of the interest rate, the price level or the exchange rate; and that a 1% increase in money increases gross domestic product by 0.38%.

Moreover, the DOLS results also suggest the effect of change in the short run. The short run elasticity of money is greater than the elasticity of the interest rate, the price level or the exchange rate; and a 1% increase in money increases gross domestic product by 0.20%.

However, the DOLS-estimator suggests that the interest rate has a significant impact upon gross domestic product but not with the expected signs.

Table 5: Pool-OLS ,Panel OLS and DOLS estimates

	Pool-OLS	Panel-OLS	Panel-DOLS
Constant	-3.092881*** (0.0000)	-1.173935*** (0.0000)	-1.217076*** (0.0000)
$\ln m_{it}$	0.830458*** (0.0000)	0.450441*** (0.0000)	0.382495*** (0.0000)
$\ln ir_{it}$	0.131806*** (0.0000)	-0.050122*** (0.0009)	-0.045985** (0.0150)
$\ln cp_{it}$	-0.208704*** (0.0000)	0.218340*** (0.0000)	0.341700*** (0.0000)
$\ln er_{it}$	0.023310*** (0.0049)	-0.127850*** (0.0000)	-0.138859*** (0.0000)
$\Delta(\ln m_{it}(-1))$			0.200186*** (0.0000)
$\Delta(\ln ir_{it}(-1))$			0.072953*** (0.0007)
$\Delta(\ln cp_{it}(-1))$			0.014538 (0.6734)
$\Delta(\ln er_{it}(-1))$			0.041368 (0.3855)
AIC	2.195274	-0.038324	-0.106655
SIC	2.216065	0.373353	0.384039

Note:*** denote statistical significant at the 1 percent level.p-value in parenthesis.

Comparing AIC and SIC to select the best model, we can see that AIC suggests DOLS while SIC points to OLS. However, BIC generally penalizes free parameters more strongly than does the Akaike information criterion. Therefore, following a traditional time-series approach to model selection based upon the minimization of Schwartz's Bayesian information criterion, the OLS-estimator is preferred to the pooled-OLS or DOLS estimator.

Table 6: Result from GMM-estimate

	Panel-GMM	Panel-Dynamic GMM
Constant	-3.208419*** (0.0000)	-5.589876*** (0.0000)
$\ln m_{it}$	0.709406*** (0.0000)	1.022447*** (0.0000)
$\ln ir_{it}$	0.145817*** (0.0000)	0.408663*** (0.0007)
$\ln cp_{it}$	0.210510*** (0.0000)	-0.035347 (0.7668)
$\ln er_{it}$	- 0.218252*** (0.0000)	-0.006041 (0.9006)
$\Delta(\ln m_{it}(-1))$		-1.413145*** (0.0000)
$\Delta(\ln ir_{it}(-1))$		-0.489145*** (0.0002)
$\Delta(\ln cp_{it}(-1))$		-0.949156*** (0.0006)
$\Delta(\ln er_{it}(-1))$		-0.778828** (0.0255)

Note Probability values are in parenthesis;*,** and *** denote statistical significance at the 10 percent ,5 percent and 1 percent levels, respectively.

Table 6 presents regression results when the dependent variable is $lngdp_{it}$. The results show that there is a statistically significant negative relationship between the exchange rate and gross domestic product, but a statistically significant positive relationship between the money supply, the interest rate and gross domestic product. However, the GMM-estimator suggests that the significant impact on gross domestic product of the interest rate has an unexpected sign. The Dynamic-GMM-estimator suggests that only the money supply and interest rate has significant impacts on gross domestic product.

Table 7: Panel vector error correction model

Independent Variable	Dependent Variable				
	D (LNGDP)	D (LNM)	D (LNIR)	D (LNER)	D (LNCP)
Error correction term	-0.195807* (-1.827657)	0.488741*** (2.614138)	-0.847243* (-1.655784)	-0.722726*** (-2.716451)	0.129514 (0.634941)
D (LNGDP (-1))	0.064971 (0.565272)	-0.352760 (-1.569244)	-0.228064 (-0.644727)	-0.761972* (-1.707772)	-0.015077 (-0.044099)
D (LNM (-1))	0.119243* (1.794439)	-0.028908 (-0.227171)	0.427333 (1.489553)	0.942189*** (3.035950)	0.105577 (0.406353)
D (LNIR (-1))	0.092119** (2.156628)	0.237018*** (2.725685)	0.471261** (2.083707)	-0.170937 (-1.169514)	-0.146089* (-1.850999)
D (LNER (-1))	0.031863 (0.462905)	-0.089702 (-0.667750)	-0.298323* (-1.933972)	0.730564*** (4.693990)	0.163501 (1.364946)
D (LNCP (-1))	0.028210 (0.471961)	0.045612 (0.341956)	-0.591181** (-2.095397)	0.021479 (0.149404)	-0.227386 (-0.396031)

Note: The t-statistics are shown in parenthesis;*,** and *** denote statistical significance at the 10 percent ,5 percent and 1 percent levels, respectively.

4.4 The empirical results of the panel vector error correction model

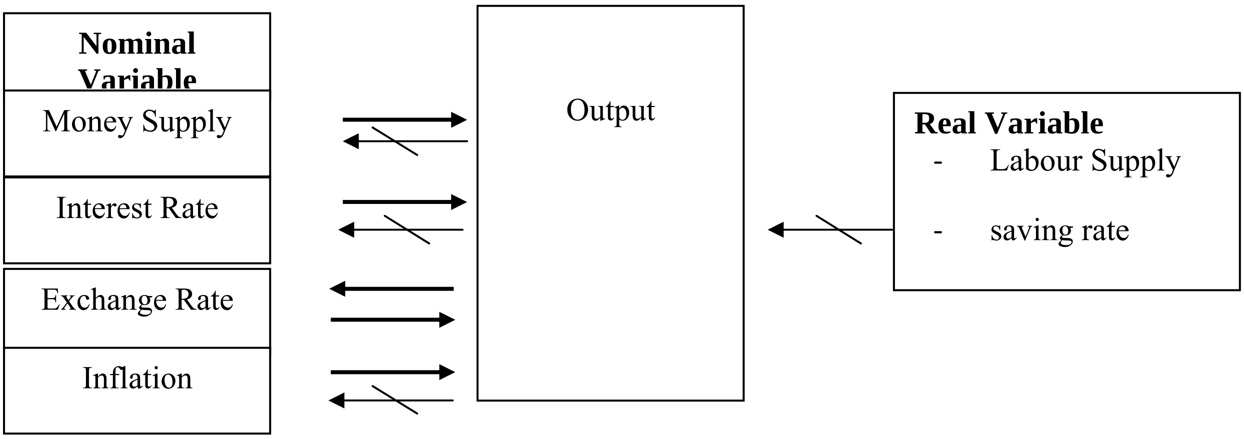
The empirical results of the panel error correction model are reported in table 7. Equation 21a shows that both the money supply and the interest rate lagged one period have a positive and significant impact upon gross domestic product. The one period lagged error correction term is statistically significant at the 10% level. This result implies that after a shock to the system, GDP reverts to its equilibrium. The speed of adjustment equals -.196, implying that n the presence of a one unit deviation from the long run in period t-1, gross domestic product will change by 19.6 percent in each period or will take 5 years to revert to long-run equilibrium at the 10% level of significance.

It further appears (Eq. 21b) that the one-period lagged interest rate has positive and statistically significant impacts on the money supply. Moreover, the error correction term is statistically significant but does not lie between -2 and 0. Both one-period lagged gross price level and exchange rates have a positive impact on the interest rate, while once- lagged interest rate has negative impacts (Eq. 21c). The error correction term is significant at the 10% level. This result implies that after a shock to the system, the interest rate reverts to its equilibrium. The speed of adjustment is equal -0.847, suggesting that in the presence of a one unit deviation from the long run in period t-1, interest rate will change by 84.7 percent in each period of return to long-run equilibrium at 10% significantly.

Eq. 21d further indicates that one-period lagged gross domestic product, the money supply and the exchange rate have positive and significant impacts on the exchange rate. However, the error correction term is statistically significant and the speed of adjustment is -0.723, which implies that the exchange rate will revert to long-run equilibrium by changing 72.3 in each period. In terms of Eq. (21e), a one-period lag in the interest rate has a negative and statistically significant impact upon the price level. However, the error correction term is not statistically significant.

Regrouping all of these empirical results, we rewrite the conceptual framework (Figure 1) as Figure 2.

Figure 2 Conceptual Framework



6. Conclusion

The main purpose of this study was to conduct empirical tests to identify, measure, sign and directionalize the dynamic casual relationships linking such macroeconomic variables as money, gross domestic product, the interest rate, the price level, the exchange rate, population and the saving rate in a large, geographically-dispersed sample of 95 developing countries. In the framework of this empirical analysis, we applied panel co-integration with vector correction to investigate the existence of causal relationships among the target variables.

The main finding from the panel results establishes a statistically significant long-term equilibrium relationship among all variables (except population and the saving rate), implying that the main sources of determined output come from the demand side. These results are consistent with those from Blanchard and Watson (1986), Blanchard and Quah (1989), and Hartley and Whitt Jr (2003)[2] for the US, UK and European

[2] The Hartley and Whitt paper is emblematic of this branch of the literature, in that it attempts to sort out whether macroeconomic fluctuations are permanent or temporary and whether they come primarily from the demand or the supply side. Using a third variable, the interest rate, they break down supply and demand into the two components, permanent and temporary. The authors find that permanent nominal demand shocks are the most important because they destabilize growth. Second in importance are permanent supply shocks that provoke inflation variance and disturb the economy through correlations among output growth, inflation and interest rate changes. Third, temporary demand shocks cause interest rate

countries. They differ, however, from the findings of Ahmed and Park (1994) and Bergman (1996), which found that shocks on the supply side are the main source of output variance. Thus, although long-term equilibrium exists in all studies, demand is more important in developing economies and the NATO economies, while supply is more important in other developed economies.

The long-term equilibrium results of our study further imply that when a deviation from long-run equilibrium does occur, error correction will make it return to equilibrium, as in the predictions of standard Western macroeconomics. Consistent with the Chicago Monetarist school, the empirical evidence shows that the money supply has greater impacts on gross domestic product than the other variables under study. The error correction model suggests that after a shock to the system, gross domestic product reverts to its equilibrium but that the speed of adjustment is only 19.6 percent per year, so that it will take five years for GDP to revert. In contrast, the money supply requires only 1.2 years to revert to equilibrium. This finding has strong policy implications for any monetary expansion since it is found that money supply has greater impacts on gross domestic product than the other nominal variables, such as prices or exchange rates or interest rates in developing economies.

These results are in fact even more clear-cut than in the case of most studies on OECD economies. For example, Aksoy and Piskorski (2006) use Granger causality tests to prove the existence a significant correlation between monetary aggregates and such macroeconomic fundamentals as real output and inflation in the US economy. However, given growing globalization, they had to adjust the measurement of monetary aggregates for US dollar outflows abroad. In so doing, they discovered that domestic money (currency corrected for foreign holdings) may help to predict future real output and inflation. Their innovation of the "standard" theory even for the US economy was necessary to re-establish the Friedman-Schwartz relationships among the money supply, inflation and output, a relationship that had virtually apart in the early 1980s.

Similarly for the United Kingdom, Bhattarai and Jones (2000) find persistent unemployment and inflation consistent with the hysteresis hypothesis; and a trade-off between unemployment and inflation in the period 1975-99. Modeling deviations of output from equilibrium, growth rate of national income, inflation, terms of trade, and exchange rates against key currencies; they determined that shocks on either the demand or the supply side tend to prolong up to 10 quarters in the future before returning to equilibrium. These lags in return to equilibrium are similar to those calculated above (5 to 20 quarters) for underdeveloped economies.

Finally, Caporale *et al. (*1998) employ tests of unit roots in the presence of co-integration to draw conclusions about long-run causality among output, money and interest rates in industrialized economies. Although narrow M1 is the best predictor of GDP movements in the bivariate model, interest rates are the most useful in the trivariate model in all industrialized economies except Germany. The authors warn advanced-country policy makers to give greater weight to interest rates than to monetary aggregates in predicting GDP.

Taken together, the results from the present study and from those cited for the OECD economies suggest that macro-economics has reached a point where differences between developed and "developing" economies may be less than those within each bloc.

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volatility, which tends to be accommodated through monetary policy.

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