Testing the Short-and-Long-Run Exchange Rate Effects on Trade Balance: The Case of Colombia

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Abstract

This paper examines the role of exchange rates in determining the short-and-long-run trade balance behavior for Colombia. Conventional wisdom says that a nominal devaluation improves the trade balance. This conjecture is rooted in the Bickerdike-Robinson-Metzler (BRM) and Marshall-Lerner (ML) conditions. Empirically, the evidence for both developed and developing countries has been inconsistent in either rejecting or supporting the BRM or ML conditions. This paper tests these two conditions. It uses a regression model formulation which includes income and money so that the monetary and absorption approaches to the balance of payments are also examined. The econometric procedure used is the Johansen and Juselius' approach to estimation of multivariate cointegration systems. The main result is that exchange rates do play a role in determining the short-and-long-run behavior of the Colombian trade balance. Moreover, devaluation improves the trade balance, which is consistent with the BRM or ML conditions. The results show also that the long-run effect of an exchange rate devaluation on the trade balance is enhanced if accompanied by reduction in the money stock and/or an increase in income. The findings with respect to income and money variables did not uniformly reject or accept hypotheses from the absorption or monetary approaches either for the short run or the long run.

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1. Introduction

Despite substantial empirical research, the effects of exchange rate changes on the balance of payments, especially those related to the trade balance, are still not well understood. Neither theoretical nor empirical work has established definitively whether a nominal devaluation of a country's domestic currency improves its trade balance, or even if exchange rates play a role in determining trade flows. This issue continues to be relevant to the understanding of the short-and long-run relationship between those two variables, the formulation of policy, and the applied literature in international trade and finance.

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Studying the relationship between trade balance and exchange rates is especially important for many developing economies where trade flows continue to drive balance of payments accounts due to the low development of capital markets. In addition, exchange rate behavior, whether determined by exogenous or endogenous shocks or by policy, has been a common, yet controversial, policy issue in most of those countries. Economic authorities in developing countries have repeatedly resorted to nominal devaluations as a means to correct external imbalances and/or *misalignments* of real exchange rates, to increase competitiveness, to increase revenues, to be a key element of adjustment programs, and/or to respond to pressures from interest groups (exporters, bureaucracy, etc.). The decision to devalue has been taken many times even if the devaluation might cause inflationary spirals, domestic market distortions, disruptive effects on growth, and undesirable redistributive effects.

Conventional wisdom says that a nominal devaluation improves the trade balance. This conjecture is rooted in a static and partial equilibrium approach to the balance of payments that has come to be known as the *elasticity approach* (Bickerdike, 1920; Robinson, 1947; Metzler, 1948). The model, commonly known as the *BRM model*, has been recognized in the literature as providing a sufficient condition (the *BRM condition*) for a trade balance improvement when exchange rates devalue. The hypothesis that devaluation can improve the trade balance has been also rooted in a particular solution of the *BRM condition*, known as the *Marshall-Lerner condition* (Marshall, 1923; Lerner, 1944). This condition states that for a positive effect of devaluation on the trade balance, and implicitly for a stable exchange market, the absolute values of the sum of the demand elasticities for exports and imports must exceed unity. Accordingly, if the *Marshall-Lerner condition* holds, there is excess supply for foreign exchange when the exchange rate is above the equilibrium level and excess demand when it is below. The BRM and Marshall-Lerner conditions have become the underlying assumptions for those who support devaluation as a means to stabilize the foreign exchange market and/or to improve the trade balance.

Empirically, the evidence has been inconsistent in either rejecting or supporting the BRM or Marshall-Lerner conditions. In the vast number of cases where these conditions have been deduced, drawing primarily on data from developed countries, the testing procedure has relied on direct estimation of elasticities (see Artus and McGuirk, 1981; Artus and Knight, 1984; Krugman and Baldwin, 1987; Krugman, 1991). As is well known in the literature, estimated elasticities suffer problems ranging from measurability to identification. As a consequence, the evidence is suspect. Moreover, the results have been contradictory, depending on whether data from developed and developing countries are used (see Cooper, 1971; Kamin, 1988; Edwards, 1989; Paredes, 1989; Rose and Yellen, 1989; Rose, 1990, 1991; Gylfason and Radetzki, 1991; Pritchett, 1991; Bahmani-Oskooee and Alse, 1994).

With regard to lessons of experience, historical data for developed and developing countries have shown that devaluation may cause a negative effect on the trade balance in the short run but an improvement in the long run; that is, the trade balance followed a time path which looked like the letter "J". The main explanation for this *J-curve* has been that, while exchange rates adjust instantaneously, there is lag in the time consumers and producers take to adjust to changes in relative prices (Junz and Rhomberg, 1973; Magee, 1973; Meade, 1988). In terms of elasticities, domestically, there is a large export supply elasticity and a low short-run import demand elasticity. Moreover, the most recent literature on similar settings, which has used dynamic-general equilibrium models, has found that the trade balance is negatively correlated with current and future movements in the terms of trade (which are measured by the real exchange rate), but positively correlated with past movements (Backus et al., 1994). This has been called the *S-curve* because of the asymmetric shape of the cross-correlation function for the trade balance and the real exchange rate.

The primary objective of this paper is to examine the role of exchange rates in determining short-and-long-run trade balance behavior for Colombia in a model which includes money and income. That is, the aim is to examines whether the trade balance is affected by exchange rates and whether hypotheses such as the BRM or the Marshall-Lerner conditions hold for the current data. In addition, to test the empirical relevance of the *absorption* and *monetary* approaches for the current data.

Following the introduction, this paper has four sections. Section 2 presents and discusses the theory of the three main views of the balance of payments: elasticity, absorption, and monetary. Section 3 develops the econometric framework, which includes the presentation of a general econometric procedure, the presentation of a regression model formulation which includes the relevant variables for modeling the trade balance according to the theory, the data, and the tests for stationarity and order of integration of the relevant series. The econometric procedure has two main characteristics. (1) It avoids important specification and misspecification problems borne by most of the applied literature that have studied the relationship between exchange rates and trade flows. (2) It permits testing short-run behavior and equilibrium hypotheses such as the BRM and Marshall-Lerner conditions. Section 4 tests the relevant hypotheses, discusses the estimations, and comments on the results. The regression model is tested, first, for specification, misspecification, and cointegration.

Then the pertinent hypotheses are examined. Finally, section 5 summarizes the main findings, comments the limitations, and suggests directions for future research.

2. The Theory

To study the relationship between exchange rates and the trade balance, one must begin with a precise study of the elasticity view of the balance of payments. Consequently, this section, first, gives an exposition of the *BRM model* and its theoretical implications and presents the *BRM* and *Marshall-Lerner conditions*. Second, this section discusses the literature that has interpreted, reformulated, and incorporated the criticisms of the *elasticity approach*. This is focused on two views of the balance of payments: the *absorption* and the 'modern' *monetary approaches*.

2.1 *The Bickerdike-Robinson-Metzler BRM Model and the BRM and Marshall-Lerner Conditions*

The literature that has modeled the relationship between the trade balance and exchange rates, appeared first with the seminal paper of Bickerdike (1920), and then continued with Robinson (1947) and Metzler (1948). These are the sources of what has become known as the Bickerdike-Robinson-Metzler (BRM) model, or the *elasticity approach* (referred to here as EA) to the balance of payments. The core of this view is the substitution effects in consumption (explicitly) and production (implicitly) induced by the relative price (domestic *versus* foreign) changes caused by a devaluation.

The BRM model (or *imperfect substitutes model*) is a partial equilibrium version of a standard two-country (domestic and foreign), two-goods (export and imports) model.[1] The effects of exchange rate changes are analyzed in terms of separate markets for 'imports' and 'exports.'[2] The

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[1] It is necessary to clarify two basic assumptions underlying this model. First, there is perfect competition in the world market. Second, both countries are "large" countries. The model says nothing explicitly with respect to the equilibrium of the domestic market (e.g. economies are releasing and contracting resources for the export or import sectors but without making explicit where they are coming from), nontraded goods, and monetary or financial assets. These markets are relegated to the background.

[2] A conceptual note is necessary before continuing. Most of the literature that has analyzed the balance of payments has used different names for labeling a country's foreign variables of interest. Labels such as "foreign accounts," "balance of payments," "trade balance," and "current account" have been often used without distinction, even though these terms may have a different meaning for theoretical and/or empirical purposes, as well as for accounting purposes. Therefore to have a better understanding of what practical concept may be meant by the different approaches, this paper attempts to proxy the theoretical concepts to standard definitions used by balance of payments and national income accounts. Here is the first one. The terms underlying the BRM model seems to correspond to that definition of "trade balance" given balance of payments accounts. Thus, 'imports' and 'exports' should be understood to refer to imports and exports of goods.

equations that define the model are given as follows.[3] The domestic demand for imports (foreign exports) is a function of the nominal price of imports measured in domestic currency,[4]

(2.1) $$M^{d} = M^{d}(P_m)\,.$$

Observe that P_m is nothing but $P_m = EP_m^{*}$, where E is the nominal exchange rate; that is, the domestic currency price of foreign exchange and P_m^{*} is the foreign currency price (level) of domestic imports (the symbol "*" refers to the analogous foreign variable). Now, the foreign demand for imports (domestic exports) can be similarly defined as,

(2.2) $$M^{d^*} = M^{d^*}(P_x^*) \quad ,$$

where M^{d*} is the quantity of foreign imports and P_x^{*} is the foreign currency price (level) of domestic exports. Analogous to the definition above, P_x^{*} is $P_x^{*} = P_x/E$, where P_x is the domestic currency price (level) of exports.

Similarly to the demand functions, the export supply functions are defined depending only on nominal prices. The domestic and foreign export supply functions are defined as,

(2.3) $$X^{s} = X^{s}(P_x)$$

(2.4) $$X^{s^*} = X^{s^*}(P_m^*)$$

where X^s and X^{s*} are the quantity of domestic and foreign supplies of exports, respectively. The market equilibrium conditions for exports and imports are then,

[3] The current presentation of the model draws heavily on the analysis of Dornbusch (1975). Some of the conditions arising from it, in addition to the general BRM condition, are discussed in Vanek (1962), Dornbusch (1975), Magee (1975), and Lindert and Kindleberger (1982). For alternative discussions of the model see Stern (1973) and Lindert and Kindleberger (1982). A primary algebraic discussion and interpretation is presented by Alexander (1959).

[4] The demand functions below are assumed to be Marshallian demands with negative and positive price and income elasticities, respectively. Even though the model is not built upon explicit microfundations, one may assume that those demand functions are derived from an agent utility maximization problem, that is, they satisfy the properties such as homogeneity of degree zero in prices and income, budget constraint equality, and that the Slutsky matrix is negative semi-definite. Criticisms of this model have emphasized that, for example, the budget constraint is not satisfied by the present model, at least explicitly.

(2.5) $$M^{d} = X^{s^{*}}$$

(2.6) $$M^{d^{*}} = X^{s} \quad .$$

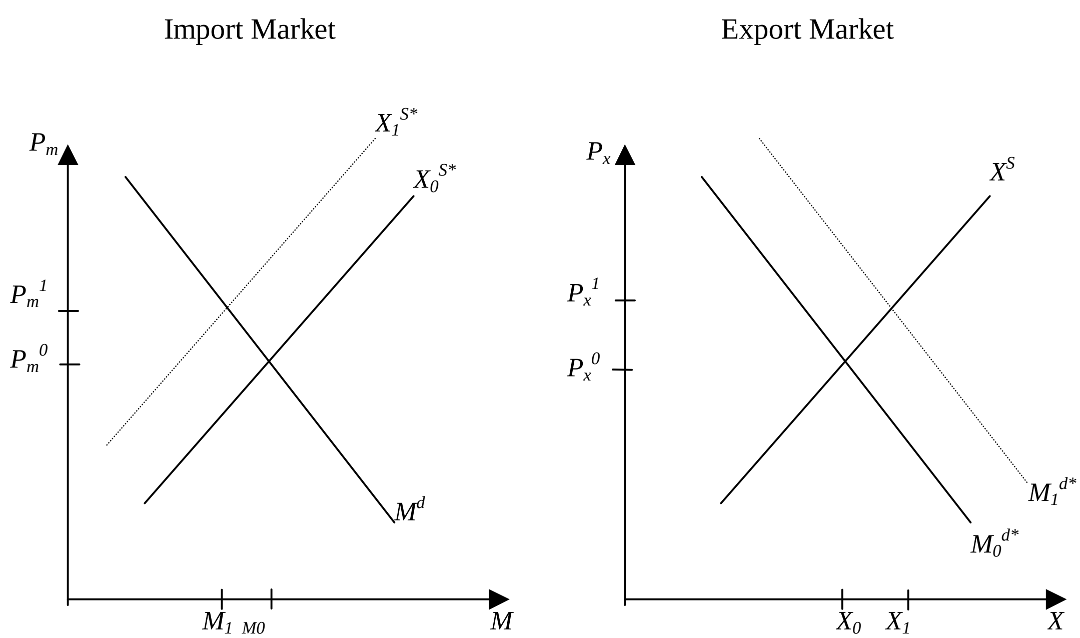
Given equations (2.1)-(2.4), the domestic trade balance, in domestic currency, is

(2.7) $$B = P_x X^{s} - P_m M^{d}$$

To illustrate this equation one can use the comparative-static framework of this model. There are two separate markets for domestic demand for imports and supply of exports. The functions are assumed to be normal downward and upward sloped, respectively, when drawn against their domestic currency prices. Also assume that there is equilibrium, that is, $B=0$. Now, the question is, does devaluation of the domestic currency improve the trade balance as defined by (2.7)?[5] The answer is not as obvious as one might think. The effects are depicted in Figure 1. At equilibrium, domestic exports equal X_0 and imports equal M_0. The prices are P_x^{0} and P_m^{0}, respectively. Devaluation does not change the domestic supply of exports and demand for imports schedules since domestic prices not have changed. What occurs is a movement along both curves X^S and M^d where domestic supply of exports increases and the demand for imports decreases. However, the foreign demand for imports and supply of exports schedules shifts upward from M_0^{d*} and X_0^{S*} to M_1^{d*} and X_1^{S*}, respectively. In order to maintain the foreign currency prices of goods; as defined above, the domestic currency prices will have to increase in the same proportion as the devaluation to P_x^{1} and P_m^{1} for exports and imports, respectively. Consequently, both the foreign supply for exports and demand for imports schedule should shift in the same percentage as the rate of devaluation. The new equilibrium is reached where both markets clear. Thus, the devaluation raises the market-clearing domestic currency price in both markets, increases the volume of domestic exports, and reduces the volume of domestic

[5] Observe two important points about exchange rates under the current model. First, since nontraded goods do not exist, the real exchange rate is measured by the terms of trade. Second, any nominal devaluation (assumed to be exogenous) becomes a real devaluation. The explanation lies, as is well known by the literature, in that implicit assumption that domestic and foreign price levels remain constant, or they are determined exogenously. Kenen (1985, p. 643) points out that the distinction between nominal and real exchange rates makes this model Keynesian in nature in the sense that goods markets are cleared by output changes, not by price changes.

Figure 1: A Two-country and Two-goods Model



imports. In all, what has happened is a substitution in consumption between domestic and foreign goods induced by a change in the exchange rate. Therefore, the value of domestic exports (P_xX^s) increases, while that of its imports (P_mM^d) may increase or decrease depending on the domestic price elasticity of demand.[6] This implies, then, that the effect of a devaluation on the trade balance in this model is ambiguous (Dornbusch, 1975).

A sufficient condition for trade balance improvement, and drawing from it, for stability of the foreign exchange market under the model, is provided by the *BRM condition*.[7] Differentiating (2.7)

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[6] Of course, life becomes more complicated for analyzing the final result of a devaluation if supply and demand functions do not bear the properties assumed above. Certainly, one will need to know more about the underlying elasticities of demand and supply functions in both markets to find out about the final effect of the devaluation.

[7] Exponents of the elasticity approach have said that if there are sources of stability or instability characteristic to foreign exchange markets, they have to rest in trade responses to exchange rate changes. Lindert and Kindleberger (1982, p. 272) claim that the reasons are: (1) "the channeling of trade-flow transactions through an asset market, in which money assets are traded for each other, has no direct analogue in domestic asset markets,

and putting the results in elasticity form, a general algebraic condition is derived.[8] This condition relates the response of the trade balance to exchange rate changes and the domestic and foreign price elasticities of imports and exports:[9]

(2.8) $$\frac{dB}{dE} = P_x X^s \left| \frac{(1+\varepsilon)\eta^*}{(\varepsilon+\eta^*)} \right| \quad - \quad P_m M^d \left[\frac{(1-\eta)\varepsilon^*}{(\varepsilon^*+\eta)} \right] \quad ,$$

where η and ε denote the price elasticities (in absolute values) of domestic demand for imports and supply of exports. Analogously, η^* and ε^* denote the respective foreign price elasticities.[10] As can be shown, if *B=0* (initial equilibrium), then *dB/dE > 0* if and only if

(2.9) $$\frac{\eta\eta^*(1+\varepsilon+\varepsilon^*)-\varepsilon\varepsilon^*(1-\eta-\eta^*)}{(\varepsilon+\eta^*)(\varepsilon^*+\eta)} > 0 .$$

Notice that a relevant case for this paper is that where $\varepsilon^*=\eta^*=\infty$, that is, a "small country" case (Lindert and Kindleberger, 1982, ch. 15). Here the foreign export supply and export demand are perfectly elastic. Under this case, condition (2.9) becomes $(\varepsilon+\eta)$. Another way to state this case is to say that a country is a price-taker in both its import and export markets. Accordingly, a country's currency devaluation has no effect on the world prices (in foreign currency), of its exports and imports. This implies that only changes in volumes affect its trade balance. Thus, without considering the algebraic result, the effect of a country's currency devaluation on the trade balance would be the following. One knows that if a country's currency devalues, exporters would receive

making it dangerous to infer exchange-rate stability or instability from the way domestic markets behave;" and (2) "trade-flow behavior seems more likely to bring cumulative changes in exchange rates than do international capital movements. The latter have a built-in element of self-reversal, since each flow brings a later reverse flow as interest and principal are repaid."

[8] See derivation in Appendix A.1.

[9] One can show that, by *Walras's Law*, it is sufficient to find equilibrium in one market. This is so because by the market clearing conditions (2.5) and (2.6) the excess of demand in any one market would be offset by the excess of supply in the other market. Thus, without loss of generality, the solution could be given in terms of any of the two markets.

[10] As interpreted by Alexander (1959), two very important implicit assumptions have been contained in the derivation of the demand elasticities. The first assumption is that domestic and foreign nominal incomes are held constant. The second is that "domestic prices" remain constant ("domestic" should be understood as the general domestic price level). Dornbusch's (1975) interpretation of the first assumption is that one can assume those elasticities are compensated elasticities. Negishi (1968) and Kemp (1970), among others, emphasized first that, in addition to those assumptions, the model assumes implicitly that all cross price elasticities (between exports and imports) are set equal to zero. Thus, the Slutsky matrix becomes a diagonal matrix.

more units of domestic currency for their exports. Accordingly, one would expect they respond exporting more at

the given foreign price. On the other hand, importers would face higher domestic currency prices for their imports. Consequently, they would reduce their imports. Thus, "with export volumes rising and import volumes falling at fixed …[foreign prices], the devaluation would unambiguously improve the balance of trade" (Lindert and Kindleberger, 1982, p. 287). Therefore, under this case, and assuming export and import volumes respectively increase and decrease, a devaluation must improve the domestic trade balance in foreign currency.[11]

If the trade balance is measured in domestic currency, the story might be quite different. The reason is that the increase in the value of domestic exports could be smaller than the decrease in the value of domestic imports, that is, the final effect on the trade balance would depend on the domestic price elasticity of supply and demand.[12] A domestic country's devaluation should improve the trade balance, in domestic currency, if $\varepsilon>|\eta|$ (remember that by assumption there are no qualitative or quantitative trade restrictions). But does $\varepsilon>|\eta|$ hold for a developing economy such as Colombia? Colombia export mainly raw products (e.g., agricultural products, oil, coal) and import durable goods, raw materials, and intermediate and final capital goods (e.g., equipment). With respect to exports, they may have 'low' short-run price elasticity of supply for some goods (e.g., oil, livestock, or goods with low domestic consumption) and 'large' elasticities for others, for example for those goods being produced with excess of capacity (some manufactures such as textiles), or goods with large stocks (e.g., some manufactures, some grains, coffee, or goods with high participation in domestic consumption so that exports can be increased by reducing it if needed). In the long run, one may expect 'large' elasticity for both types of goods. As for imports, durable goods should have a large import price-demand elasticity both in the short and long run and for most of the intermediate and many of the capital goods, one may expect low import-price elasticity, at least for the short run. It follows that the answer is not that straightforward. Of course, if it is true that Colombia exports primarily products with large price elasticity of supply and import, intermediate and final industrial products, then $\varepsilon>|\eta|$ should hold. Therefore, a devaluation should improve the Colombian trade balance. Otherwise, the answer is not direct.

[11] In practice, however, this is not always the case. A devaluation might actually worsen in the period immediately following devaluation, when measured in foreign currency (Cooper, 1971). This worsening "would occur if …[for instance,] import liberalization takes effect immediately, giving rise to an increase in imports, while the stimulus to exports occurs only with a lag" (*Ibid*., p. 15).

Another result that can be derived from condition (2.9) is the so-called *Marshall-Lerner condition* (Marshall, 1923; Lerner, 1944). This condition (referred to here as the ML condition) comes from letting $\varepsilon \rightarrow \infty$ and $\varepsilon^* \rightarrow \infty$. This assumption implies that the left-hand side of condition (2.9) becomes $\eta^* + \eta - 1$. Thus, for a trade balance improvement when a country's currency devalues, $\eta^* + \eta > 1$ must hold. Or, in the standard presentation of the ML condition, $|\eta + \eta^*| > 1$. In words, this condition states that if domestic and foreign supply elasticities are strictly elastic and if income remains constant, then a devaluation causes an improvement of the trade balance when the domestic plus the foreign import demand elasticities for imports, in absolute value, exceeds one. This has been considered by the literature as a sufficient condition for stability of the foreign exchange market. Thus, if the ML condition holds, "then there is an excess of demand for foreign exchange when the exchange rate is below the equilibrium value and excess of supply when it is above the equilibrium rate. Under these conditions the exchange rate will move to its equilibrium value and the market will be cleared"(Hallwood and MacDonald, 1994, p. 30).[13] The question that is relevant for the purposes of this paper is whether or not the ML condition empirically holds for a developing country such as Colombia. As was discussed above, at least as derived from theory, it seems that it does not. The Colombian economy might be better characterized by the "small country" case. Thus, a devaluation might or might not improve the trade balance (in domestic currency).[14]

2.2 *The Absorption Approach*

A different approach to the balance of payments emerged at the beginning of 1950s. Authors such as Harberger (1950), Meade (1951), and Alexander (1952, 1959) came to be part of a new body of analysis known as the *absorption approach* (referred to here as AA) to the balance of payments (Krueger, 1983; Kenen, 1985).[15] This approach shifted the focus of economic analysis to the balance

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[12] This can be easily seen using Figure 1 under the current case. The increase in the value of exports could result smaller than the decease in the value of imports.

[13] One can understand the term "equilibrium rate" in this quote as that given by the *purchasing power parity* (PPP) equilibrium exchange rate.

[14] Different arguments that claim that the ML condition may not hold come from partial equilibrium studies (Dornbusch, 1987; Krugman, 1987; Krugman and Baldwin, 1987). They say that there may exist market failures like *elasticity pessimism*, *hysteresis*, *pricing to market behavior*, or *uncertainty* that may prevent the ML condition from holding.

[15] Kenen (1985, ch. 3) presents a static model which puts together the elasticity and absorption approaches. There income and substitution effects of monetary (e.g., the effects of a devaluation) and fiscal policy are derived in elasticity form.

of payments and solved some of the original criticisms of the EA.[16] While the EA based its results on the effects of exchange rate changes on individual microeconomic behavior (Marshallian supply and demand analysis), this approach focuses its analysis mainly on economic aggregates, typical of Keynesian analysis. The core of this approach is the proposition that any improvement in the trade balance requires an increase of income over total domestic expenditures.

The theory of the trade balance under the current approach can be defined in terms of a basic macroeconomic identity which express the different links between the trade balance and the macroeconomic aggregates.[17] Assuming no transfers or services (that is, the total national income becomes the gross domestic product and the current account the trade balance), one can write,

$$Y - A = TBDC = XDC - MDC \tag{2.10}$$

where Y is the gross domestic product, $TBDC$ is the trade balance in domestic currency, and XDC and MDC are the value of exports and imports, respectively, in domestic currency. This identity simply says that the trade balance is just one side of the coin, the side on which the elasticity approach focused. The AA analyses the other side. That is, what the absorption approach does is to analyze the economy from the point of view of aggregate expenditures, and especially to analyze the direct effects of exchange rate changes on relative prices, income, and absorption, and ultimately on the trade balance.[18]

One can state what the nominal and real effects of a devaluation are under the absorption approach as follow (only effects on the domestic economy are discussed). It is assumed that there exists a Keynesian short-run world. Devaluation reduces the relative prices of domestic goods in

[16] Some of the initial criticisms of the EA are: (a) the import demand and export supply functions, defining the structural model, depend only on the nominal prices (measured in domestic currency units) rather than on relative prices and appropriate scale variables such as real income, real expenditures, real money balances, or productive capacity; (b) there are markets or goods not accounted for explicitly. For example, a trade deficit implies that goods are paid for with an asset (e.g., money) or income that has not been explicitly included in the analysis; (c) it relies overly on a partial approach for analyzing a problem that should use a general equilibrium framework.

[17] Two points have to be kept in mind: first of all, in a similar manner to that of the EA, in AA the current account is reduced to the trade balance and the countries referred to are “large” countries. Second, unlike the EA, income and money are introduced. Though the latter is slightly discussed.

[18] As for the trade balance, it is necessary to clarify some points. The absorption approach takes implicitly the Keynesian income-expenditure assumption that export volumes are independent (*autonomous*) of national income, and that imports depend directly and positively on national income. This positive dependence is said to happen in two ways. One is that often a country’s production needs imported inputs; the other is that imports respond to the total absorption (Alexander, 1952). The more a country spend on goods and services, the more a country will be inclined to spend on that portion that is bought from abroad. This behavior is summarized by the well known Keynesian *foreign trade multiplier*.

domestic currency. This reduction produces two direct effects. First, there is a substitution effect that causes a shift in the composition of demand from foreign goods towards domestic goods; that is, the exchange rate change causes an *expenditure-substituting* effect. Assuming unemployment (as is characteristic of any Keynesian analysis), domestic production increases. Observe that up to now this substitution effect is what the EA would predict happens when devaluation is present. Second, there is an income effect which would increase absorption, and then reduce the trade balance. The income effect is related to both the increase in domestic output (income), which acts through the "marginal propensity to absorb" (consume) and "marginal propensity to invest," and the change in the terms of trade. The absorption approach argues that, in general, a country's devaluation causes a deterioration in its terms of trade, and thus a deterioration in its national income. The presumption is that a devaluation will result in a decrease in the price of exports measured in foreign currency.[19] Of course, the fact that TOT deteriorates does not necessarily imply that the trade balance is going to deteriorate. "It can worsen the trade balance if the foreign currency price of exports sinks far enough relative to the price of imports to outweigh the trade balance improvement implied by the rise in export volumes and the drop in import volumes" (Lindert and Kindleberger, 1982, p. 312). In all, the final net effect of a devaluation on the trade balance will depend on the combined substitution and income effects. As predicted by the AA, the trade balance will improve, but it would be smaller (because of the income effect on absorption) than that predicted by the BRM model.

2.3 *The Monetary View*

An alternate approach to the balance of payments has emerged since the end of 1950s. It is the 'modern' monetary view to the balance of payments.[20] This subsection present the approach known as the monetary or global monetarist approach (Polak, 1957; Hahn, 1959; Pearce, 1961; Prais,

[19] Since countries are "large" countries with elastic supplies, then under the assumption of constant domestic prices (in other words, strictly elastic export supply), a devaluation will reduce the relative price of domestic exports in foreign currency (because the domestic export supply schedule shift down). The price of imports in foreign currency remains constant, or it can decrease if the foreign export supply is not perfectly elastic. The key condition for a worsening of the domestic TOT is that the decrease in the price of exports is greater than the decrease of the price of imports.

[20] Two monetary perspectives has been distinguished by the literature: the monetary approach and the Keynesian monetary view. Some of the basic assumptions underlying each of the these perspectives are the following. With respect to the former: (1) there is full employment; (2) there is perfect arbitrage in the world markets, that is, PPP holds; (3) money and other assets may exist, which are close substitutes for domestic and foreign goods or assets. This approach have been also called the "global monetarist" (Whitman, 1975). With regard to the Keynesian view: (1) there is unemployment, (2) price sluggishness occurs so that PPP may not hold, (3) and money is a close substitute for other assets. For a full discussion of the monetary view, see Whitman (1975), Frenkel and Johnson (1977), Hallwood and MacDonald (1994), and Frenkel and Razin (1996).

1961; Mundell, 1968, 1971). The core of this approach (referred to here as MA) is the claim that "the balance of payments is essentially a monetary phenomenon" (Frenkel and Johnson, 1977, p. 21).[21] That is, under the MA any excess demand for goods, services and assets, resulting in a deficit of the *balance of payments*, reflects an excess supply or demand of the stock of money. Accordingly, the balance of payments behavior should be analyzed from the point of view of the supply and demand of money.[22] Given that a study that examines the effects of exchange rate changes would be incomplete without explicitly considering money (indeed, devaluation is something that happens to the value of a currency), and that particular nature of the Colombian´s exchange-rate arrangement (a system of foreign exchange rate bands), the study of the main assumptions and implications of this approach is relevant for this paper.

To have a better understanding of the MA, a balance of payments identity is written here

$$CA + KA = \Delta F, \quad (2.11)$$

where CA is the current account, KA is the capital account, and ΔF is the change in a country's foreign reserves, denominated in foreign currency.[23] From the point of view of the MA, identity (2.11) indicates that "surpluses in the trade account and the capital account respectively represent excess flow supplies of goods and of securities, and a surplus in the money account …[ΔF] reflects an excess domestic flow demand for money. Consequently, in analyzing the money account, …, the monetary approach focuses on the determinants of the excess domestic flow demand for or supply of money" (Frenkel and Johnson, 1977, p. 21). The fundamental implication of this claim is that to analyze what happens in the (overall) balance of payments one should just concentrate on the analysis of what happens with the central bank's balance of foreign reserves.[24]

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[21] The term "balance of payments" is understood by this approach to be all those items that are *below the line*. Those items constitute what is called the *money account*.

[22] Corden (1994, p. 59) argues that the monetary approach is useful "as a supplement to approaches … that focus on the real economy: on absorption, savings, investment, and the real exchange rate. It comes into play when the concern is with the ability of the central bank to defend a fixed nominal exchange rate."

[23] Notice that this identity holds only in a fixed exchange rate regime. "This is in marked contrast with the Keynesian view of the balance of payments - namely that the monetary authorities sterilize the impact on the domestic money supply of international reserve flows ensuing from payments imbalance" (Hallwood and MacDonald, 1994, p. 140). Under a clean-floating regime the central bank refrained from intervention in the foreign exchange market. Accordingly, $\Delta F = 0$.

[24] This highlights "a controversial philosophy of how the balance of payments should be analyzed" (Isard, 1995, p. 103).

As with the AA, the monetary approach can be defined in terms of basic identities; in the current case, in terms of the central bank's balance sheet.[25] In a simplified form it can be written as

$$(2.12) \qquad D + FDC = MB = R + C \, ,$$

where the left-hand side represents the assets and the right-hand side the liabilities. In other words, the left-hand side are the sources of the monetary base, *MB*, or *high powered money*, and the right-hand side are the uses of it. *D* is the domestic credit (or the domestic asset component of *MB*), *FDC* is the stock of foreign reserves (or the foreign-backed component) in domestic currency, *R* is the money reserves and *C* the currency in public hands. Now, let *M* be the domestic money supply. To simplify let *M*=*MB* (the money multiplier is implicitly assumed constant and equal one). Then one has

$$(2.13) \qquad D + FDC = M \, .$$

What this identity means is that residents of an open economy "can have an influence on the total quantity of money via their ability to convert domestic money into foreign goods and securities or conversely turn domestic goods and securities into domestic money backed by foreign exchange reserves" (Hallwood and MacDonald, 1994, p. 137). Now, taking first difference of the equality above, it can be written that

$$(2.14) \qquad \Delta FDC = \Delta M - \Delta D \, .$$

Observe that under this approach, ΔM is nothing but the flow demand of money balances or hoarding. It follows that if the balance of payments identity in equation (2.11) holds, the following equality has to be met

$$(2.15) \qquad CADC + KADC = \Delta FDC = \Delta M - \Delta D$$

where *CADC* and *KADC* are *CA* and *KA* in domestic currency, respectively. The left-hand side of this identity states that, if a country has a deficit in both the current and the capital account, then the

[25] This discussion follows Whitman' (1975) exposition (with some slight changes in notation and presentation) of the Mundell's (1968) explanation of the 'equivalence' of the elasticity, absorption, and monetary approaches.

country has to be losing foreign reserves. The right-hand side says that a country loses reserves when domestic credit exceeds hoarding.

In comparison with the elasticity and absorption approaches (assume *KADC=0* and consider *CADC=TBDC*), the following identity must hold

$$XDC - MDC = Y - A = TBDC = \Delta FDC = \Delta M - \Delta D \ . \tag{2.16}$$

This is a fundamental identity which puts together the elasticity, absorption, and monetary approaches to the balance of payments. Therefore, if one considers all variables in this identity in an *ex post* sense, the three approaches are equivalent (Mundell, 1968). However, as noted, this identity omits reference to the underlying behavioral relationships and adjustment mechanisms in each of these approaches. Moreover, it says nothing about the implicit and explicit assumptions underlying each.

What makes the elasticity, absorption, and monetary approaches different? Unlikely to the EA and AA, the monetary approach says little about the underlying behavioral relationships. Moreover, it says little about the effects of exchange rate changes and the transmission mechanisms on those relationships. The role of the exchange rate is reduced to its temporary effects on the money supply. The reason is that MA assumes "a change in the exchange rate will not systematically alter relative prices of domestic and foreign goods and it will have only a transitory effect on the balance of payments" (Whitman, 1975, p. 494).

The relevant question for the purposes of this paper is: what is the 'transitory' (or short run) effect of the devaluation under the MA? In the short run, this approach predicts that an increase in prices (e.g., caused by a nominal devaluation) may reduce the real money stock, and then improve the trade balance. The mechanism works as follows. A devaluation will increase (proportionally) the domestic prices.[26] Then, people will reduce spending/absorption relative to income in order to restore their real money balances and holding of other financial assets. In brief, hoarding will increase (along the hoarding schedule).[27] As a result, the trade balance, and directly the money account, will improve. As stated, this effect will be entirely temporary. Once people have restored their desired financial

[26] The small country assumption is implicit here.

[27] Notice, however, that if the monetary authorities increase the money supply, e.g., through an increase in the domestic credit, the effect on the money account may be undetermined.

holdings, real money balances "expenditures will rise again and … [any] new surplus … [in the stock of money caused by the trade balance surplus] will be eliminated" (Cooper, 1971, p. 7).[28]

3 The Econometric Framework

The main goal of this section is to develop testable hypotheses from the theoretical models presented in section 2 and present an econometric technique to distinguish among those hypotheses. This section begins introducing a general econometric procedure, which provides the statistical approach to hypothesis testing of this paper. Second, this section presents a regression model formulation which includes the relevant variables for modeling the trade balance according to theory discussed in section 2. Third, it introduces the data along with some initial evaluation. Finally, this section tests whether the time series are *stationary* or *nonstationary* processes, and examines their *order of integration*.

3.1 *The Econometric Procedure*

Though cointegration is a statistical characteristic, whether it exists among economic variables of interest is a question that has significant implications for understanding the behavior of those variables. Cointegration simply implies that there is a linear combination (or *cointegrating vector*) of nonstationary variables that is stationary.[29] In terms of the time series jargon, stationarity means that neither the mean nor the *autocovariance* of a time series depend on the date *t* (Hamilton, 1994).[30] In other words, a time series is stationary if it exhibits mean *reversion* and the variance is finite.[31] If cointegration does not exist, the linear combination is not stationary or has an infinite variance and a there is no mean to which it returns. From the economic point of view, this suggests that "any paradigm linking …[the variables of interest] has no empirical content in time series data, evidence that would serve as a strong rejection of popular explanations used to predict the behavior …[of those variables in a particular economic theory formulation]" (Hoffman and Rasche, 1996, p.

[28] This result assumes that the monetary authority keeps the domestic credit constant. This is a typical presumption of the IMF's type of adjustment program for developing countries. If the domestic credit increases after a devaluation to satisfy the new demand for money, the effects of the devaluation on the trade balance would be undetermined.

[29] A simple algebraic and geometric interpretation of the concept of cointegration is that of Granger and Engle (1991).

[30] In time series analysis a stochastic process having these two characteristics is called *covariance stationary*. The literature refers to it as a *weakly stationary*, *second-order stationary*, or simply stationary process.

33). Evidence of cointegration in this paper means that a stationary long-run (equilibrium) relationship among jointly endogenous random variables of interest is present. This will imply, for the purposes of this study, that quantifiable stationary relationships, such as the BRM or ML conditions, hold. Indeed, these conditions will be met if both cointegration and the expected signs hold.[32]

The econometric procedure used in this paper is a version of analyzing multivariate cointegrated systems developed originally by Johansen (1988, 1991), then expanded and applied in Johansen (1995a, 1995b) and Johansen and Juselius (1990, 1992, 1994).[33] It consists of a full information maximum likelihood estimation (FIML) of a system characterized by r cointegrating vectors (CIVs).[34] The statistical model is the following.

Assume z_t, $t=1,\ldots,T$, which denotes a $(px1)$ vector of random variables, follows a p-dimensional VAR model with Gaussian errors (p is the number of jointly endogenous variables); the conditional model, conditional on the observations $z_{-k+1},\ldots, z_0$ which are fixed (k is the lag length for the system), can be written then as,[35]

(3.1) $$z_t = A_1 z_{t-1} + \cdots + A_k z_{t-k} + \mu + \Psi D_t + \varepsilon_t \quad ,$$

where A_1, A_2, …, A_k are p by p matrices, μ is a vector of constants, and D_t is a vector of nonstochastic variables, orthogonal to the constant term, such as seasonal dummies, "dummy-type" variables, and/or stochastic "weakly exogenous" variables, and $\varepsilon_1 ,\ldots, \varepsilon_T$ are *i.i.d* $N(0,\Sigma)$.[36,37] Now, assuming cointegration between variables in z_t, one writes the model in error correction form,

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[31] The term "mean reversion" means that that a time series sequence fluctuates around a constant 'long-run' mean. For a strict definition see Hamilton (1994).

[32] In Engle and Granger (1987)'s context, Jones and Joulfaian (1991) and Bahmani-Oskooee and Payestesh (1993) have a interpretation for the error-correction model similar to that presently given.

[33] The notation currently used follows closely Johansen and Juselius'.

[34] A related approach to Johansen's is that of Stock and Watson (1988), and Ahn and Reinsel (1990). These approaches, which rely on the relationship between the rank of a matrix and its characteristic roots, generalize the procedure of Engle and Granger (1987). Remember that the Engle and Granger procedure is characterized by the existence of exactly one cointegration relation and a normalization given by a nonzero coefficient of the chosen 'dependent' variable.

[35] To gain economic content, the literature has given a "structural" interpretation to this reduced-form system by imposing identifying restrictions on the parameters. See Sims (1986), Bernanke (1986), and Blanchard and Quah (1989).

[36] The term "weakly exogenous" variables follows that definition in Engle et al. (1983). In simple, rather informal terms, weak exogeneity means the following. Assume y is a random variable thought to be explained by the random variable x. The variable x is said to be weakly exogenous if y does not also explain x.

(3.2) $$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \cdots + \Gamma_{k-1}\Delta z_{t-k+1} + \Pi z_{t-k} + \mu + \Psi D_t + \varepsilon_t, \quad t = 1,\ldots,T.$$

where $\Gamma_i = -(I-A_1 -\ldots- A_i)$, for $i=1,\ldots,k-1$; and $\Pi = -(I-A_1 -\ldots- A_k)$. This model defines hypothesis H_1. The model stated by the system in (3.2) is also known in the literature as the vector error-correction model (VECM). Here the short-run dynamics of the variables in the system are represented by the series in differences and the long-run relationships by the variables in levels. Under (3.2) any deviation from the long-run equilibrium may influence the short-run dynamics.[38] Now, if z_t is integrated of order one,[39] that is $I(1)$, then the matrix Π is of reduced rank,

(3.3) $$\Pi = \alpha\beta' \quad ,$$

where α (weights or *error correction* parameters, or *speed of adjustment* parameters)[40] and β (cointegration vectors) are (pxr) matrices of rank r.[41] Under this hypothesis, denoted $H_2(r)$, the process Δz_t is stationary, z_t is nonstationary but $\beta' z_t$ is stationary (Engle and Granger, 1987; and Johansen, 1988, 1991).[42] In other words, under $H_2(r)$ one or more r linear combinations of variables included in z_t exist and have a finite variance. These linear combinations are called cointegrating vectors or long-run equilibrium relationships.[43]

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[37] Dummy-type variables are also included as recommended in Johansen and Juselius (1992) and Hendry and Mizon (1993) to take account of short-run shocks, structural changes, or outliers, to the system in order not to violate the *i.i.d*. and Gaussian assumptions of the error term.

[38] Observe that if the vector z_t has a VECM representation, estimating (3.2) without the term Πz_{t-k} , even as a VAR in first differences, entails a misspecification error (Engle and Granger, 1987).

[39] Strictly speaking, what is needed is z_t at most $I(1)$, so that "not all the individual variables included in z_t need to be $I(1)$, as is often incorrectly assumed. To find cointegration between nonstationary variables, only two of the variables have to be $I(1)$" (Hansen and Juselius, 1995, p. 1).

[40] For the purposes of this paper, these three terms are taken to mean the same. In economics, the applied rational expectations literature would say that the interpretation of those parameters as "speed of adjustment" parameters is not appropriate because in those models, by construction, there no partial adjustment mechanisms exist (Hoffman and Rasche, 1996).

[41] Note that "the space spanned by β is the space spanned by the rows of the matrix Π, which we shall call the cointegration space" (Johansen, 1988, p. 233).

[42] Under $H_2(r)$, for example, the reduced form in equation (3.2) can be written then as $\Delta z_t = \Gamma_1 \Delta z_{t-1} + \alpha\beta' z_{t-2} + \mu + \Psi D_t + \varepsilon_t$, for k=2. From the VECM representation we know that Γ_1, μ , Ψ, Σ, α represent the unrestricted short-run parameters and β the long-run parameters.

[43] Observe that the *rank condition* implicit in $H_2(r)$ is that $0<rank(\Pi)=r<p$. However, two other cases may emerge. First, $rank(\Pi)=0$. This implies that each element of Π must be zero. Accordingly, no long-run equilibrium exists. In other words, since any linear combination of those independent $I(1)$ variables is itself $I(1)$, variables cannot be cointegrated (for estimation purposes, this case implies that one can use a standard VAR model with the series in first differences). Second, $r=rank(\Pi)=p$, that is, the matrix Π is of full rank. This implies that the vector process z_t is jointly stationary. In other words, each series in z_t is stationary and each

3.2 *The Regression Model* [44]

The variable formulation of the statistical model stated by equation (3.1) is given by the vector z_t = (TB,REER,MI,RGDP)$'_t$, where TB is a trade balance measurement, REER is a real exchange rate index, MI is a money stock, and RGDP is the real GDP. This vector is thought to capture the effects of the exchange rate on the trade balance in a model that puts together (nets) the elasticity, absorption, and monetary approaches to the balance of payments. The author is not aware of any literature that has included income and money in trade balance estimations and has used the current econometric procedure on the issue being analyzed.

It is useful to summarize the hypotheses about the exchange rate-trade balance and income-and-money-trade-balance relationships developed in section 2. With the elasticity approach, the exchange rate is the primary determinant of the trade balance. Devaluation improves the trade balance by changing the relative prices between domestically and foreign sourced goods. In the absorption approach an exchange rate change can only affect the trade balance if it induces an increase in income greater than the increase in total domestic expenditures (absorption). Thus, both relative prices and income are primary determinants of trade balance behavior. The monetary approach asserts that exchange rate changes have only temporary effects. Hence, there should be no long-run equilibrium relationship between the trade balance and exchange rates.

With respect to the income variable what is expected is a negative/positive under the absorption/monetary approach. As said above, one of the effects of devaluation under the absorption approach is an income effect. This is related to both an increase in domestic output (income) and a change in the terms of trade. Both changes might increase absorption (consumption and investment) and then imports. This would worsen the trade balance. From the point of view of the monetary approach, "if …[an] economy is growing over time … it will ceteris paribus run a …[trade balance] surplus"(Hallwood and MacDonald, 1994, p. 148). The reason is the implicit assumption that income growth raises expenditures by less than output, therefore improving the trade balance.

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linear combination of z_t is stationary as well. Under this case, the long-run solution to the VECM system (3.2) is given by p independent equations (that is, no cointegration exists), where each equation is an independent restriction on the long-run solution of each of the variables (this case implies one can use directly a standard VAR model with the series in levels, since they are already stationary).

[44] Rincón (1995) uses the present econometric methodology and tests for the ML condition and *J curve* in data from Colombia for the period 1970 through 1994. He finds, using only two variables in the VECM system (the real exchange rate and the trade balance), that a behavior such as that claimed by the ML condition holds. Evidence of the *J curve* is not detected.

As for the money variable, the following is expected. Under the absorption approach (following Keynesian assumptions) the money supply is an exogenous variable; it is a policy instrument. Thus, the monetary authorities offset, or sterilize (through open market operations), the impact on the domestic money stock of foreign exchange market intervention.[45] It follows that, there should be no effect of the money stock on the balance of payments (and on expenditures). On the other hand, the monetary approach argues that in a fixed exchange rate regime the money supply is endogenously determined by the interaction of the supply and demand of the money stock. Thus, equation 2.14 in section 2 (an identity, but also a long-run equilibrium condition) implies that, assuming the domestic credit is exogenously determined and equal to a constant, the nominal money stock change equals the change of foreign reserves. Hence, it is equal to the trade balance surplus or deficit. This implies, that under the monetary approach (with no changes in domestic credit) one expects a zero coefficient for the money variable in the trade balance equilibrium equation. That is, the trade balance explains the money stock, and not *vice versa*.[46]

3.3 *The Data and a Graphical Inspection*[47]

The data set of this paper consists of quarterly time-series data for Colombia form the period 1979:1 through 1995:4. The time series include observed values of exports, imports, a real effective exchange rate index, narrow money (M1), the real gross domestic product, consumer price index (CPI), and an index of the world price of coffee and of the world price of oil.[48] The measure of trade balance (called TB) is represented by the ratio of exports to imports. This ratio, or its inverse, has been also used in similar settings by Haynes and Stone (1982), Bahmani-Oskooee (1991), and Bahmani-Oskooee and Alse (1994). The use of this ratio has several advantages. First, it is invariant to units one is measuring for exports and imports, in other words, whether they are in real or nominal

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[45] For example, a country with a trade balance surplus (buying foreign exchange, and hence expanding the money supply) may sterilize the extra money supply by open market sales of bonds that balance the money supply. From the monetarist point of view, this sterilization policy is possible but only in the short run.

[46] Another way of explaining a zero coefficient for the real money stock in the real trade balance equation is using the monetarist assumption of money neutrality. In the long run, money has no real effects because it is assumed that the effect of an increase of money on the domestic price level is proportional. This implies that $\Delta(M/P)$, where M is a money stock and P is the price level, will be a constant. Therefore, in the trade balance equation, the coefficient of the money stock should be zero. Any effect of this variable should be captured by the constant term of the regression.

[47] The data sources are the *Revista del Banco de la República* (Bogotá, Colombia) and the *International Financial Statistics*, IMF(CD Rom). All the estimation results and plots reported in this paper come from outputs of RATS, CATS, and SHAZAM softwares and procedures from the Estima's *Home Page*.

[48] The latter two variables will be included in the statistical system to capture exogenous shocks which may affect the statistical properties of the system.

terms or in domestic or foreign currency. Second, the regression equations can be expressed in *log-linear* form or *constant elasticity* form. Accordingly, the estimated coefficients are elasticities. All nominal time series used in the empirical analysis are deflated using the CPI. Additionally, all series are logged (natural logs). This is indicated by preceding the name of the variable with "L".

Figure 2 plots the observed trade balance, the real effective exchange rate, the real money stock, and the real GDP.[49] The data reveal the following empirical regularities:[50]

(1) the trade balance and the real exchange rate seem to behave as nonstationary series, specifically, as random walks. That is, both series have no particular tendency to revert to a specific mean. Observe that the real exchange rate seems to go through sustained periods of appreciation, depreciation, and again appreciation without a tendency to revert to a long-run mean. The trade balance has gone from deep deficits to elevated surplus, and then to deep deficits again, with no tendency to revert to an equilibrium or to a specific value;

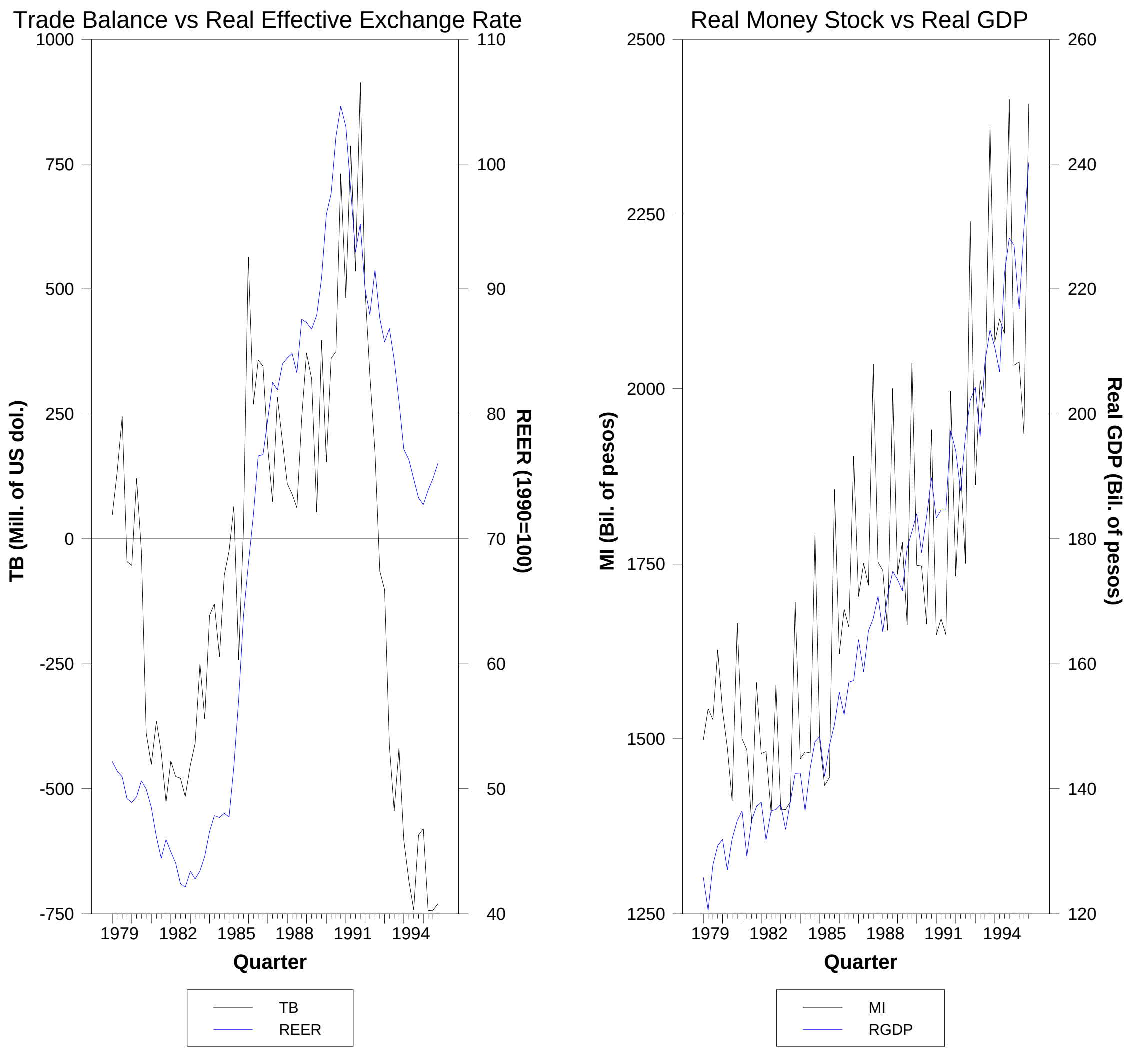
(2) the real money stock and the real GDP seem to contain linear trends. This implies that these series might have a stochastic time-variant mean. This would make them nonstationary series;

(3) the trade balance and the real exchange rate, and the real money stock and the real GDP, seem to share co-movements. For example, the trade balance appears to mimic closely the real exchange rate movements. The real money stock and the real GDP seem to be similarly timed;

[49] "Money stock" refers to narrow money (or M1).

[50] Graphical analysis allows one to make a preliminary approach to the model and to identify the possible presence of deterministic components. Remember, for example, that if there are linear trends in the data, "both the estimation procedure and the rank inference will differ compared to the case with no linear trends" (Johansen and Juselius, 1992, p. 218). The root of the problem is that the cointegrating space is affected.

Figure 2: Observed Values of Trade Balance, Exchange rate, Money, and Income



(4) all variables seem to display a high degree of persistency. That is, a shock to the variable persists for a long period of time. For instance, a high depreciation at the middle of 1980s remained for almost six years.

3.4 *The Unit Roots Tests*

The reason for knowing whether a variable has a unit root (that is, whether the variable is nonstationary) is that, under the alternative hypothesis of stationarity, variables exhibit mean reversion characteristics and finite variance, as explained above, and shocks are transitory and the autocorrelations die out as the number of lags grows, whereas under nonstationarity they do not. This subsection tests the nature of the time series, that is whether they are *stationary* or *nonstationary* processes, and examines their *order of integration*. Knowing this *order* is fundamental for being able to use the econometric procedure discussed above.

As is well known, one of the main problems with unit root tests is that they have poor size properties or low power in finite samples.[51] The problem is the difficulty of distinguishing between unit root and near unit root processes and/or between a trend stationary and drifting processes (Campbell and Perron, 1991).[52] Furthermore, "the tests for unit roots are conditional on the presence of the deterministic regressors and tests for the presence of the deterministic regressors are conditional on the presence of a unit root" (Enders, 1995, p. 255). Therefore, the test critical values will depend on whether one includes a constant and/or a trend term in the estimate equations.

To cross-check the results for the series, several tests were computed. First, the standard augmented version of the Dickey-Fuller (Dickey, 1976; Fuller, 1976; Dickey and Fuller, 1979), referred to as ADF, unit root test was implemented in all series in levels. Then, the Schmidt-Phillips (Schmidt and Phillips, 1992), referred to here as SP, unit root test was calculated in all series that seemed to have a trending behavior. The Dickey-Fuller (DF) test (a parametric statistic) controls directly for serial correlation. The SP test provides semi-parametric-based corrections to the Dickey-Fuller test, following Phillips (1986) and Phillips and Perron (1988), which are asymptotically robust to error autocorrelation and heteroskedasticity. Besides these properties, an advantage of the SP test over the DF test is that it allows for a trend under both the null and the alternative hypotheses, without introducing irrelevant parameters under either. That is, the distribution of this test under both the null (a unit root) and alternative hypothesis (a trend stationary process) is independent of the nuisance parameters (constant, trending coefficient and variance).

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[51] In time series analysis a series is said to have a unit root, or be integrated of order one *I(1)*, if that series has to be differentiated just once to become stationary (Granger and Engle, 1991). In terms of the difference equations jargon, "any sequence that contains one or more characteristic roots that equal unity is called a unit root process" (Enders,. 1995, p. 35).

[52] Blough (1992, p. 299) argues that when testing for unit roots, there is a trade-off between size and power because the test must have either a high probability of falsely rejecting the null of nonstationarity when the true DGP is nearly stationary process or low power against any stationary alternative.

Table 1
Unit Root Tests 1/

Variable 2/		ADF test (Level)	Q(12) 3/	ADF test (First Diff.)	Q(12)	SP test
$LPTB_t$	τ_μ=	-2.20	11.33(.41)	-10.42*	10.59(.48)	---
$LREER_t$	τ_μ=	-1.06	12.60(.25)	-4.52*	12.13(.35)	---
LMI_t	τ_τ=	-3.22	12.93(.07)	3.47*	9.45(.31)	-7.37*
$LRGDP_t$	τ_τ=	-3.27	7.72(.05)	-3.45*	12.24(.09)	-4.84*

1/ The τ_μ test is the τ-test for a regression equation that includes an intercept or drift term and the τ_τ test is the τ-test for a regression equation that includes both a drift and a linear time trend. This may avoid misspecification problems such as those reported in Campbell and Perron (1991). They stated that when the regression models do not mimic the actual DGP, the power of tests can go to zero. For purposes of reading the critical values, the sample size is stated as equaling 100 for both tests and the level of significance at 5%. The asymptotically critical values for τ_μ and τ_τ are -2.89 and -3.45, respectively. The critical value for the SP's $\tilde{\tau}$ test is -3.06.
2/ LTB is the log of the trade balance measurement, LREER is the log of the real exchange rate index, LMI is the log of real money stock (real M1), and LRGDP is the log of the real GDP.
3/ Q(12) is the Ljung-Box statistic. This tests against higher than order one serial correlation. It is based on the estimated autocorrelations of the first 12 lags. Its marginal significance level (or p-value) is in brackets. 5% was chosen as the minimum acceptable significance level.

Table 1 reports the results. It shows that the null hypothesis of unit root cannot be rejected at 5% level of significance for all variables when the ADF test is used. Using the SP test, however, the null hypothesis is rejected in the cases of the money and income series, contradicting the results of the ADF test. To test for the presence of more than one unit root, in all those variables where the unit root hypothesis was rejected by one of the tests, two types of tests were implemented. The one was the 'standard' unit root test in the series' first differences.[53] The other was the Dickey and Pantula (1987) *sequential* procedure (referred to here as DP procedure). Only the former is reported. Table 1 shows that the null hypothesis is rejected for all variables, which actually indicates that they seem to behave as *I(1)* processes. When the DP procedure was computed, the following occurred:[54] the money stock has two unit roots and the real GDP has effectively one. The findings of more than one unit root in the money stock seemed to be related with seasonal unit roots.[55] To test for this possibility, a seasonal unit root test was implemented (the output is not reported here).[56] The test

[53] Observe that here one wants to test the null of series behaving as *I(2)* processes against them being *I(1)* processes.
[54] Dickey and Pantula (1987, p. 456) argue that, if a process has more than one unit root, the 'standard' ADF procedure "is not valid." Their argument is that "the order of testing should begin with the highest (practical) degree of differencing and work down toward a test on the series levels rather than starting, …[as the ADF procedure does], with the levels test and working up through the differencing orders" (*ibid*.).
[55] Ilmakunnas (1990, p. 80) argues that even though the Dickey-Pantula procedure "dealt with zero frequency unit roots, …, one can conjecture that this holds also in the seasonal case."
[56] Ghysels et al. (1994) show that the ADF test can be used to test the null of a unit root at the zero frequency, even in the presence of unit roots at other seasonal frequencies.

corresponds to the HEGY (for Hylleberg, Engle, Granger, and Yoo) procedure, expanded by Ghysels and Noh (1994).[57] What was found is that effectively, for the case where the DP procedure indicated the presence of more than one unit root, the HEGY test corroborated them. The money stock, in fact, seems to have unit roots at zero and semiannual frequencies. These seem to show that this variable exhibits some form of seasonality which is nonstationary.[58]

Thus, according to the tests and the initial graphical conjectures, it seems that all variables are integrated of order one, at least at zero frequency. That is, variables seem to behave as *I(1)* processes.[59] Therefore, the implementation of the econometric procedure will be carried out on the assumption that all series exhibit nonstationary behavior, in particular, that they behave as *I(1)* processes. These results are similar to findings in the literature working with macroeconomics data. A unit root behavior of the trade balance and the real exchange rate is found in similar settings by Rose and Yellen (1989) and Rose (1991) using data for developed countries; Bahmani-Oskooee and Alse (1994) using data from both developed and developing countries; and Rose (1990) using data for developing countries.[60] Unit root behavior is also found for the real money stock and real GDP. A classic paper with similar results for those variables is Nelson and Plosser (1982). One of the main implications of money supply and output variables behaving as unit roots, as stated by Nelson and Plosser, is that, contrary to the traditional real business cycles analysis, secular movements of those time series are of a stochastic rather than deterministic nature.[61] Thus, "models based on time trend residuals are misspecified" (Nelson and Plosser, 1982, p. 140). Then, the empirical evidence in this

[57] The HEGY procedure is sought to capture the presence of seasonal unit roots at frequencies other than at *zero frequency*, which might not have been revealed by the ADF and SP tests due to uncontrolled seasonality in the series (Hylleberg et al., 1990; Ghysels et al., 1994). Notice that the ADF and SP tests are built to capture unit roots at zero frequency (or *long-run frequency*). For full theory and applications on seasonal unit roots, see Frances (1991, 1996).

[58] Some examples of seasonal unit roots could be seasonal patterns in the money stock caused by a trending economic growth and real shocks that have permanent effects.

[59] Since the variable LMI behaves as an *I*(2) process, a procedure suggested by Hylleberg et al. (1990) and Ilmakunnas (1990) was followed. This consists in seasonal differencing the series to get rid of the seasonal unit root and leaving the root at the zero frequency. When the exercise was implemented in LMI, it continued showing a behavior between *I*(1) and *I*(2) process. The choice was consider LMI as unit root process, which is a standard result in the literature.

[60] Observe that, in another context, the fact that the real exchange is found to be a random walk process can be considered as adding evidence against the relative PPP real exchange rate hypothesis for the Colombian case.

[61] Remember that standard real business cycle assumes that the time series trend of macro variables is deterministic, that is, the trend is not changing over time. This implies that current economic shocks will not have any long-run effect on the series. Hence, for practical purposes, one could simply *detrend* the series and use the residuals for macro analysis. The problem with this type of analysis is that the trend may be stochastic rather than deterministic. That is, the series may be difference stationary instead of trend stationary processes. If this is the case, it is inappropriate to subtract a deterministic trend from a series that is difference stationary.

paper on the behavior of those series cautions the literature using Colombian data for any business cycles analysis without properly filtering the data.

4. Hypotheses Testing and Estimations

This section tests the hypotheses about the relationship between the exchange rate and the trade balance discussed in section 2 and estimate the statistical model under the specification defined in section 3, that is, under z_t = (LTB,LREER,LMI,LRGDP)$'_t$.[62] This section starts testing whether the error-correction model representation given by the equation (3.2) correctly describes the structure of the data. In short, whether H_1 actually holds. Second, it tests if the matrix Π is of reduced rank, that is, whether $H_2(r)$ holds. This hypothesis shows whether empirical evidence of cointegrating relations between the variables in the vector z_t exists.[63] Moreover, given the VECM presentation, short-run deviations can be identified. Finally, this section presents and discusses the estimations under the revealed r.

4.1 *Specification and Misspecification Tests*

One of the most critical parts of the Johansen and Juselius approach is determining the rank of matrix Π since the approach depends primarily upon having a *well-specified* regression model. Therefore, before any attempt to determine this rank or to present any estimation, the empirical analysis begins with specification and misspecification tests. The specification and misspecification tests are based on the OLS residuals of the unrestricted model in equation (3.1) for the vector z_t.[64] The endogenous variables are modeled conditionally on variables in D_t.[65]

The specification and misspecification tests are used primarily to choose an 'appropriate' lag structure for each model and to identify the deterministic components to be included in the model

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[62] The implicit assumption (which was tested) is that the trade balance is homogeneous of degree zero with respect to all the individual components of the real exchange rate index, that is, with respect to prices (domestic and foreign) and the nominal exchange rate.

[63] This step is at the core of the current econometric procedure. Briefly, once one knows r, the statistical system can be separated into stationary and nonstationary processes. That is, into cointegrating relationships and stochastic trends. In economic words, in terms of the steady-state relationships governing the behavior of the relevant variables in the system and the distinct (permanent) structural innovations governing the long-run properties of all those variables.

[64] This result is equivalent to that of estimating equation (3.2) under the assumption of matrix Π being of full rank, that is, assuming $r=rank(\Pi)=p$.

(e.g., whether or not to include an intercept in the cointegration space to account for the units of measurement of the endogenous variables, or to allow for deterministic trends in the data). Certainly, these two aspects are critical for the current econometric procedure. With respect to the lag structure, if *k* (or the lag length for each system) is 'too' small, the model may be misspecified; if *k* is 'too' large, one loses degrees of freedom and power. Therefore, the lag length is chosen according to three criteria: (1) what economic theory would say about the impact and lagged effect of the exchange rate on the trade balance; (2) what model selection strategies would recommend; and (3) that normality and non-serial correlation are satisfied.[66] The Schwarz (SC) and Hannan-Quinn (HQ) selection criteria were used. Also, a likelihood ratio test to check lag significance is used. A *testing-down* type procedure is followed to test the lag significance from a long-lag structure to a more parsimonious one. The testing procedure started with *k*=8, that is, with a lag length of two years. This lag length is recommended in the literature studying the effects of exchange rates on the trade balance. For example, Bahmani-Oskooee (1985) and Himarios (1989) suggest that if there an improvement in the trade balance when devaluation exists, a period of about two years is needed for observable effects to occur. The choice of the deterministic components of the model has substantial consequences for the asymptotic distributions of the cointegration rank statistics. This paper follows the procedure suggested by Johansen (1992).[67] This consists of testing the joint hypothesis of both the cointegration rank order and the deterministic components.[68] Once the lag structure and the deterministic component of the model are chosen, additional specification and misspecification tests are implemented.

Table 2
Specification and Misspecification Tests 1/

	Univariate Statistics		Multivariate Statistics			
Equation	ARCH(*k*)	Normality	Q(*j*)	LM(1)	LM(4)	Normality
	k=5		*j*=15;240(.00)	15.1(.51)	20.6(.19)	10.0(.26)
LTB_t	4.27	2.25				
$LREER_t$	10.11	0.12				
LMI_t	4.87	0.04				
$LRGDP_t$	7.13	2.40				

[65] Centered seasonal dummy variables and dummy-type variables are included. These variables "are centered to ensure that they sum to zero over time and thus they do not affect the underlying asymptotic distributions upon which tests (including tests for cointegration rank) depend" (Harris, 1995, p. 81).
[66] Of course, in the testing procedure a trade-off among all three criteria was needed.
[67] Hansen and Juselius (1995, p. 66-68) have an nice example that illustrates how the procedure works.
[68] The procedure uses the *Pantula principle* and some economic intuition for choosing the relevant models to test. It starts with the most restrictive alternative (that is, *r*=0 and the intercept is restricted to the cointegration space) through to the least restrictive one (that is, *r*=*p*-1 and the model includes linear trends in the variables and in the cointegration space). Thus, the rule is the following. Move through from the most restrictive model, compare the rank test statistic to its critical value and only stop at the first point the null hypothesis is not ejected.

1/ LTB is the log of the trade balance measurement, LREER is the log of the real exchange rate index, LMI is the log of the real money stock, and LRGDP is the log of the real GDP. All tests are asymptotically χ^2-distributed with the following degrees of freedom (df): ARCH(k) with k df; normality with $2d_0$ df, where d_0 is the number of endogenous variables in the vector; Q(j) with d_0^2 ([T/4] - k + 1) - $d_0 r$ df; and LM (1) and LM(4) with d_0^2 df. For the univariate tests "*" means significant at the 5% level. For the multivariate tests their marginal significance level is in brackets. The dummy-type variables included were the world price of coffee and oil in real terms. At the beginning a variable that is thought to capture structural and policy changes of the Colombian economy was included. That variable was a proxy of the Colombian´s closedness to international trade (see Edwards (1989) for the construction of this type of variable). However, it resulted insignificant and it was discarded.

The tests were implemented in two levels. The first tests are multivariate tests, that is, tests on the residuals of the total system. They are the Ljung-Box Q test (Ljung and Box, 1978), which was described in Table 1, a Godfrey LM test (Godfrey, 1988) for serial correlation up to the first and fourth lag, and finally a multivariate normality test suggested by Hansen and Juselius (1995) in a modified version of the Doornik and Hansen (1994) test. The second tests are univariate tests, that is, tests on the residuals of the individual equations in the system.[69] The tests are the autoregressive conditional heteroskedastic ARCH test proposed by Engle (1982), which tests homoskedasticity against an ARCH of order k, and the normality test referred to above for the univariate case.

Table 2 reports the results. The multivariate tests for serial correlation shows that serial correlation is present when the Q test is used. However, no serial correlation of order one and four seems to be present.[70] The multivariate normality assumption holds. The univariate tests are all met. To complement the formal tests, the actual and fitted values for each equation and the correlogram of the residuals were plotted (the results are not reported here). They indicated that the performance of the VECM representation of the actual data is generally satisfactory.

4.2 *Finding the Rank of Matrix Π*

Table 3 shows the tests of the rank of matrix Π. The first column represents the estimated eigenvalues λ_i. The null hypothesis of $r=0$ (no cointegration) is rejected in favor of $r=1$ by both tests

[69] Observe that the system in (3.1) is composed by equations for z_{it}, where $i=1, \ldots ,p$. For example, z_{1t} , is the corresponding equation for the trade balance.

[70] Later on, it will be shown that when the model is conditioned on the weakly exogenous variables, the specification of the model does improve. For example, the *i.i.d*. assumption is fully met.

at the 10% level. The null hypothesis of *r=1* (or *r≤1* using the λ_{Trace} test) in favor of *r=2* is not rejected by both tests. The null hypotheses of *r=2,3* (or *r≤2, r≤3* using the λ_{Trace} test) in favor of *r=3,4* are not rejected by both tests.[71] Thus, Table 3, and the additional plots, indicates the presence of one cointegrating relationship. Therefore, there is a long-run equilibrium relationship between the trade balance, real exchange rate, real money stock, and real income. This would imply that a model that seeks to explains the long-run behavior of the trade balance should include at least the exchange rate, money, and income. Based on the evidence *r* was set equal one.

In order to improve the statistical specification of the model tests of exclusion from the cointegration space and tests of weak exogeneity were carried out (they are not reported here). The tests showed that none of the variables should be excluded. Also, they indicated that the trade balance and the real GDP were effectively endogenous and the real exchange rate and money stock were weakly exogenous. Notice that the fact that the real GDP is endogenous and the money stock is exogenous seems to agree with the absorption view, and contradict the monetary arguments, which states that income is endogenous while money is exogenous to the model.

Table 3
Tests of Cointegration Rank 1/

$\hat{\lambda}_i$ (*i*=1,2,3,4)	Ho:	Ha:	λ_{max}	ACV (10%)	Ho:	Ha:	λ_{Trace}	ACV (10%)
0.65	*r=0*	*r=1*	45.47*	18.03	*R=0*	*r >0*	71.10*	49.92
0.27	*r=1*	***r=2***	13.59	14.09	*R≤1*	*r >1*	25.63	31.88
0.19	*r=2*	*r=3*	9.19	10.29	*R≤2*	*r >2*	12.04	17.79
0.06	*r=3*	*r=4*	2.85	7.50	*R≤3*	*r >3*	2.85	7.50

[71] In addition to these formal tests, the plots of the eigenvalues of the companion matrix, the unrestricted estimates coefficients β, the estimated residuals of R_{kt}, and the graphs of estimates of $v_i' z_t$ and $v_i' R_k$ were drawn in order to recheck the rank of matrix Π (see Hansen and Juselius (1995) for definitions). First, no root was found outside of the unit circle for all countries. Second, the reported cointegrating relationship was found stationary.

1/ The test statistics have a small sample correction as suggested by Reinsel and Ahn (1992). It consists of using the factor (T-kp) instead of the sample size T in the calculation of the tests. "ACV" stands for Asymptotical Critical Values. "*" means significant at the 10% level.

4.3 *The Estimations Under r=1*

Since $r=1$ the problem of identification of the cointegration space does not emerge. Thus, one can make direct inference from both the long-run and short-run estimates. If only one cointegrating relationship exists, it is *just identified* (Johansen and Juselius, 1994). The estimated equation of the conditional model in error-correction form for the trade balance is[72,73]

$$\Delta LTB_t = -0.28\Delta LTB_{t-1} - 0.26\Delta LPTB_{t-2} - 1.12\Delta LRGDP_{t-1} + 1.33\Delta LRGDP_{t-2} + 0.95\Delta LREER_t +$$
$$(-2.41) \quad (-2.36) \quad (-1.05) \quad (1.16) \quad (1.74)$$
$$0.22\Delta LREER_{t-1} + 0.53\Delta LREER_{t-2} + 0.55\Delta LMI_t + 0.88\Delta LMI_{t-1} + 0.54\Delta LMI_{t-2} +$$
$$(.37) \quad (.95) \quad (1.80) \quad (2.47) \quad (1.62)$$
$$(-0.06)[\, -1.82LPTB_{t-3} + 6.38LRGDP_{t-3} + 1.99LREER_{t-3} - 14.11LMI_{t-3} + 62.8].$$
$$(-2.22)$$

The short-run estimates indicate that the significant coefficients are those for the dependent variable (at lags 1 and 2 at the 95% level of significance), the real exchange rate (contemporaneously at the 10% level), and the real money stock (contemporaneously at the 10% level and at lag 1 at the 5% level). Income results insignificant in the short run. Thus, the short-run estimates indicates that the trade balance responds positively and contemporaneously to real devaluation and positively to variations of the money stock. The latter result implies that the 'impact' and lagged effect of an increase in the real money stock is an improvement of the trade balance. This could happen, following the monetarist arguments, if there is a rapid increase in prices that offset the increase in the nominal money stock. People would have a shortfall of real money balances, which will result in hoarding (agents want to restore their real money balances) and in a trade balance improvement.

The speed of adjustment coefficient is significant. This means that the speed at which the rate of variation of the trade balance $\Delta LPTB_t$, the dependent variable in the first equation of the VECM system, adjusts towards the single long-run cointegrating relationship differs from zero. In

[72] Since the rank of matrix was already determined in the full system, and tested for exclusion and weak exogeneity, "there is not need to test the hypotheses about the rank in this partial system" (Hansen and Juselius, 1995, p. 50). Table A.2.1(Appendix A.2) reports the specification and misspecification tests of the conditional model.

[73] The value of the t test is in brackets.

other words, the equation for the trade balance $\Delta LPTB_t$ contains information about the long-run relationship since the cointegrating vector does enter into this equation. According to the estimates, a short-run trade balance disequilibria is corrected to a speed of 7% per quarter.

Now solving the equation above for the long-run relationship one has (observe that in equilibrium Δs equal zero):[74]

$$LPTB+(6.38/-1.82)LRGDP+(1.99/-1.82)LREER+(-14.11/-1.82)\mathrm{LMI}+(62.84/-1.82)=0.$$

After solving for *LPTB*, one gets the estimated long-run equation for the trade balance:

$$LPTB = 34.34 + 3.49\mathrm{LRGDP} + 1.09LREER - 7.71LMI$$

This equation represents the estimated long-run relationship between the trade balance, the real exchange rate, money, and income. The equation reveals that the estimated long-run exchange-rate elasticity has a positive sign. Accordingly, (real) devaluation will lead to an improvement in the (real) trade balance. The estimated coefficient says that for a one percent increase in the real exchange rate, keeping the other variables constant, the real trade balance on the average increases by about 1 percent.[75,] Thus, the empirical evidence shows that the BRM or ML conditions seem to hold in the case of Colombia. The positive sign of the estimated coefficient for the income variable is consistent with what the monetary view would say, income has a positive relationship with the trade balance. Notice, however, that the presence of the money stock in the long-run equation is inconsistent with what the monetary approach would predict for the long run relationship between trade balance and money. As said above, one would expect an inverse causality. Trade balance explains the money stock not *vice versa*.[76]

5. Conclusions

[74] Notice that the cointegrating relationship is normalized by the coefficient of the trade balance.

[75] To double-check this result, a proportionality (homogeneity) restriction on the trade and exchange rate coefficients, that is β_{11}=-β_{21}, was tested (notice that in terms of the Johansen and Juselius notation, the hypothesis β_{1i}=-β_{2i} (in standard matrix notation) is written as $\beta_{i.1}$= -$\beta_{i.2}$. That is, "*1*" and "*2*" are the first and second coordinate of the cointegrating vector β_i, respectively). The Likelihood Ratio test could not reject the null.

[76] The significance of the money variable in the cointegrating vector was separately examined. The null hypothesis was rejected using standard level of significance.

This paper has examined empirically the role of exchange rates in determining the short-and long-run behavior of the Colombian trade balance under alternative approaches to the balance of payments. It tested the empirical validity of the hypotheses derived from elasticity, absorption, and monetary approaches to the balance of payments. In particular, it tested the validity of the Bickerdike-Robinson-Metzler (BRM) and Marshall-Lerner (ML) conditions using a regression model which included the trade balance, exchange rate, money, and income. Indirectly, it tested the empirical relevance of the absorption and monetary approaches for the data used. The econometric technique consisted of a relatively new approach for analyzing multivariate cointegrated systems originally developed by Johansen (1988). This econometric approach avoids important specification and misspecification problems borne by most of the relevant applied literature studying the current issue. The data analyzed corresponded to quarterly time series from Colombia for the period 1979 through 1995.

The major findings of this paper are as follows. The variable specification of the statistical model showed that exchange rates do play a role in determining the short-and-long equilibrium behavior of the Colombian trade balance. Therefore, the trade balance cannot be treated as exogenous with respect to the exchange rates. These findings constitute evidence against the literature claiming that no direct relationship between trade balance and exchange rates exists and the monetary view which claims that exchange rates have only temporary effects. The estimations reported that there is one cointegrating relationship between the trade balance, exchange rate, money, and income. That is, a long-run equilibrium relationship between those variables exists. The results also showed that the BRM or ML conditions were supported by the data. This implied that (real) devaluation improves the equilibrium trade balance. Moreover, the positive effect of exchange rate devaluation on the trade balance seemed enhanced if accompanied by reduction of stock of money and an increase in income. With respect to the short-run estimates, estimations revealed a significant positive short-run relationship between the trade balance and the exchange rate.

The findings with respect to income and money variables did not fully reject or accept hypotheses from the absorption or monetary approaches either for the short run or for the long run. What was generally found, however, was that money stock and income are important determinants of the long-run trade balance behavior. From the point of view of trade balance modeling, these results suggest that a model that seeks to explains the long-run behavior of the trade balance should include at least exchange rates, money, and income.

The main limitation of this paper was that capital markets are not considered. Several directions for future research are suggested in this paper. One direction is to use the current technique or alternative econometric techniques (e.g., *impulse response functions*) to analyze the short-run effects more thoroughly. This should shed light about why this paper finds opposite results to those hypothesized by the J-curve and S-curve. Another direction is to extend the econometric methodology to a sample of developing countries.

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Appendix

A.1 Derivation of the BRM Condition

The trade balance *B*, defined in foreign currency, is[77]

(A.1.1) $$B = S - D = X - M = P_x^* X^s - P_m^* M^d ,$$

where *S* and *D* are the supply and demand of foreign currency, which are equal to the value of exports and imports, respectively. Differentiating yields

(A.1.2) $$dB = dS - dD .$$

One can express equation (A.1.2) in terms of imports so that

(A.1.3) $$dB / M = dS / M - dD / M .$$

Now define the following elasticities with respect to the nominal exchange rate *E*:

(A.1.4) $$E_B = \hat{B} \big/ \hat{E}$$ $$E_S = \hat{S} \big/ \hat{E}$$ $$E_D = \hat{D} \big/ \hat{E} ,$$

where E_B, E_S, E_D are the elasticities of the trade balance, the value of exports, and the value of imports, respectively. The symbol "^" states the percentage change of the respective variable (e.g., $\hat{E} = dE / E$). Dividing both sides of equation (A.1.3) by dE/E yields

(A.1.5) $$\frac{dB / M}{dE / E} = \frac{dS / M}{dE / E} - \frac{dD / M}{dE / E} ;$$

and now expressing equation (A.1.5) in terms of elasticities (using the fact that in equilibrium S=X and D=M),

(A.1.6) $$E_B = \frac{X}{M} E_S - E_D .$$

Now that the elasticities in the foreign exchange market have been defined, the next step is to define the elasticities of prices and quantities with respect to the exchange rate. The solution for the export market is firstly derived. The price of exports, in domestic currency, is P_x=EP_x^*. From the export market equilibrium condition (2.6) we can write

(A.1.7) $$X^s = X^s (E . P_x^*) = M^{d^*} (P_x^*) .$$

Differentiating, it yields

$$dX^s = \frac{\partial X^s}{\partial P_x} (EdP_x^* + P_x^* dE) = \frac{\partial M^{d^*}}{\partial P_x^*} dP_x^*$$

or (given the equilibrium condition),

$$\frac{dX^s}{X^s} = \frac{\partial X^s}{\partial P_x} \frac{1}{X^s} (EdP_x^* + P_x^* dE) = \frac{\partial M^{d^*}}{\partial P_x^*} \frac{1}{M^{d^*}} dP_x^* .$$

Now multiplying throughout by P_x/E=P_x^* and dividing by dE/E yields

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[77] Only the new notation is defined here. The rest of the notation is as defined in the text.

$$\frac{dX^s / X^s}{dE / E} = \frac{\frac{\partial X^s}{\partial P_x}\frac{1}{X^s}\frac{P_x}{EP_x^*}(EdP_x^* + P_x^* dE)}{dE / E} = \frac{\frac{\partial M^{d^*}}{\partial P_x^*}\frac{P_x^*}{P_x^*}\frac{1}{M^{d^*}}dP_x^*}{dE / E} \ ;$$

and rearranging yields the response of the quantity of exports to exchange rate,

(A.1.8) $$\frac{dX^s / X^s}{dE / E} = \varepsilon(\frac{dP_x^* / P_x^*}{dE / E} + 1) = \eta^* \frac{dP_x^* / P_x^*}{dE / E} \ ,$$

where ε ($\varepsilon = \partial X^s / X^s \big/ \partial P_x / P_x$) is the price elasticity of domestic supply of exports and η^* ($\eta^* = \partial M^{d^*} / M^{d^*} \big/ \partial P_x^* / P_x^*$) the price elasticity of foreign demand for imports. Solving (A.1.8) for the percentage change of the foreign price of (domestic) exports to the exchange rate, one has

(A.1.9) $$\hat{P}_x^* \big/ \hat{E} = \left[\varepsilon \big/ (\eta^* - \varepsilon)\right] .$$

But one needs the percentage change of the domestic price of exports to the exchange rate. This is nothing but (A.1.9) plus one (as can be read in equation (A.1.8)).Then, after adding one and rearranging, one has

(A.1.10) $$\hat{P}_x \big/ \hat{E} = \left[\eta^* \big/ (\eta^* - \varepsilon)\right].$$

Now, we use the following mathematical fact: the percentage change of the product of two variables equals the sum of the respective percentage changes. Thus, since the supply of foreign exchange, or the value of exports (in foreign currency), equals price time quantity, one can express the total percentage change in the value of exports as

(A.1.11) $$\hat{X} = \hat{P}_x^* + \hat{X}^s,$$

and dividing (A.1.11) throughout by $\hat{E}$ to find an expression in terms of elasticities with respect to the exchange rate

(A.1.12) $$E_S = \hat{X} \big/ \hat{E} = \hat{P}_x^* \big/ \hat{E} + \hat{X}^s \big/ \hat{E} .$$

Equation (A.1.9) defines the first term on the RHS of (A.1.12). Since one needs to express the result in domestic prices (currency), one can use directly (A.1.10). The second term in the RHS is then obtained by substituting (A.1.9) in the RHS of (A.1.8). Thus, the response of the quantity of exports is

(A.1.13) $$\frac{\hat{X}^s}{\hat{E}} = \frac{\varepsilon\eta^*}{\eta^* - \varepsilon}$$

Hence, putting together equations (A.1.10) and (A.1.13)

(A.1.14) $$E_S = \frac{\eta^*}{\eta^* - \varepsilon} + \frac{\varepsilon\eta^*}{\eta^* - \varepsilon} = \frac{(1+\varepsilon)\eta^*}{\eta^* - \varepsilon} .$$

Following the same steps, one can derive the solution for the import market. The homologous solutions for equations (A.1.10), (A.1.13), and (A.1.14) are

(A.1.15) $$\hat{P}_m \big/ \hat{E} = \left[\varepsilon^* \big/ (\varepsilon^* - \eta)\right],$$

(A.1.16) $$\frac{\hat{M}^d}{\hat{E}} = \frac{\varepsilon^*\eta}{\varepsilon^* - \eta}, \text{ and}$$

(A.1.17) $$E_D = \frac{\varepsilon^*}{\varepsilon^* - \eta} + \frac{\varepsilon^*\eta}{\varepsilon^* - \eta} = \frac{(1+\eta)\varepsilon^*}{\varepsilon^* - \eta} .$$

Finally, substituting solutions (A.1.14) and (A.1.17) in (A.1.6)

$$E_B = \left[\frac{(1+\varepsilon)\eta^*}{\eta^* - \varepsilon}\right]\frac{X}{M} - \left[\frac{(1+\eta)\varepsilon^*}{\varepsilon^* - \eta}\right]$$

or,

$$\frac{dB/M}{dE/E} = \left[\frac{(1+\varepsilon)\eta^*}{\eta^* - \varepsilon}\right]\frac{P_x^* X^s}{P_m^* M^d} - \left[\frac{(1+\eta)\varepsilon^*}{\varepsilon^* - \eta}\right].$$

Now, multiplying throughout by *M*, one can express the response of the trade balance to exchange rate changes (after defining elasticities in absolute values), in domestic currency, as follows

$$\frac{dB}{dE} = P_x X^s | \frac{(1+\varepsilon)\eta^*}{(\varepsilon + \eta^*)} | - P_m M^d \left[\frac{(1-\eta)\varepsilon^*}{(\varepsilon^* + \eta)}\right].$$

This is the BRM condition stated in equation (2.8).

A.2 The Conditional Model

Table A.2.1
Specification and Misspecification Tests

	Univariate Statistics		Multivariate Statistics			
Equation	ARCH(*k*)	Normality	Q(*j*)	LM(1)	LM(4)	Normality
	k=3		*j*=16;67.8(.07)	9.5(.05)	11.7(.02)	5.7(.22)
LTB_t	4.71	0.12				
$LRGDP_t$	3.07	2.74				

1/ LTB is the log of the trade balance measurement and LRGDP is the log of the real GDP. All tests are asymptotically χ^2-distributed with the following degrees of freedom (df): ARCH(*k*) with *k* df; normality with $2d_0$ df, where d_0 is the number of endogenous variables in the vector; Q(*j*) with d_0^2 ([T/4] - *k* + 1) - $d_0 r$ df; and LM (1) and LM(4) with d_0^2 df. For the univariate tests "*" means significant at the 5% level. For the multivariate tests their marginal significance level is in brackets.