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Hernán Rincón C.

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

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This paper examines the role of the exchange rate in determining the short-and-long-run trade balance behavior for Colombia testing the BRM and ML conditions, and the J-curve hypothesis. 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 the exchange rate 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 J-curve type of hypotheses are rejected. 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.

JEL classification: F31; F32; F41; C32; C52

Keywords: Devaluation; Trade balance; BMR condition; ML condition; J-curve; Cointegration

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I. INTRODUCTION

The primary objective of this paper is to examine the role of the exchange rate 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 examine whether the trade balance is affected by the exchange rate and whether hypotheses such as the *BRM* or the Marshall-Lerner conditions, the same than *J-curve* type of hypotheses, hold for the current data. In addition, to test the empirical relevance of the *absorption* and *monetary* approaches for the current data.

Studying the relationship between trade balance and the exchange rate 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 the real exchange rate, 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 the exchange rate 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 and using simple *OLS* on single equation models, 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 derived from most of the studies are based on *spurious* results. Furthermore, the findings 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).

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 the exchange rate 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.

This paper contributes to the study of the relevant hypotheses mainly in the following directions. First of all, it uses a reduced form which avoids testing directly the elasticities. Second, it includes scale variables such as income and money in the regression model, which avoids the specification problems present in most of the related literature. Third, the econometric procedure to be followed 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 the exchange rate and trade flows. (2) It permits testing short-run behavior such as the *J-curve* type of hypotheses and equilibrium hypotheses such as the *BRM* and Marshall-Lerner conditions. (3) It has been shown to be invariant to the normalization of the cointegrating relations and to avoid small-sample bias and misspecification problems when a two-stage procedure such as that of Engle and Granger (1987) is used. Fourth, the data is quarterly. This frequency captures short-run behavior, which is missing when using yearly data. Finally, instead of instead of using data for developed countries, this dissertation uses data from a developing economy.

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 introduction of the Johansen and Juselius´ 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. 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.

II. THE THEORY

This section, first, gives an exposition of the *BRM model* and its theoretical implications and presents the *BRM* and *Marshall-Lerner conditions*. Second, it 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*.

A. 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 the exchange rate, 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. The equations that define the model are given as follows.[2] The domestic demand for imports is a function of the nominal price of imports measured in domestic currency,[3]

$$(1) \qquad M^d = M^d(P_m).$$

Observe that P_m is nothing but $P_m = EP_m^*$, where E is the nominal exchange rate (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).[4] The foreign demand for imports (domestic exports) can be similarly defined as,

$$(2) \qquad M^{d^*} = M^{d^*}(P_x^*),$$

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.

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1 Two basic assumptions underlie 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, nontraded goods, and monetary or financial assets. These markets are relegated to the background.

2 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), Magee (1975), and Lindert and Kindleberger (1982).

3 The demand functions are assumed to be Marshallian demands with negative and positive price and income (which is not explicitly modeled) 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.

4 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 it is well known in the literature, in the implicit assumption that domestic and foreign price levels remain constant, or that they are determined exogenously.

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,

(3) $X^s = X^s(P_x)$

(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,

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

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

Given equations (1)-(4), the domestic trade balance, in domestic currency, is

(7) $B = P_x X^s - P_m M^d$

Now, the question is, does devaluation of the domestic currency improve the trade balance as defined by (7)? The answer is not as obvious as one might think. A sufficient condition for trade balance improvement and for stability of the foreign exchange market under the model, is provided by the *BRM condition*. Differentiating (7) and putting the results in elasticity form, a general algebraic condition is derived (see derivation in Appendix 1). This condition relates the response of the trade balance to exchange rate changes and the domestic and foreign price elasticities of imports and exports:[5]

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

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

5 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 (5) and (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.

foreign price elasticities. As can be shown, if $B=0$ (initial equilibrium), then $dB/dE>0$ if and only if

$$(9)\qquad \frac{\eta\eta^*\left(1+\varepsilon+\varepsilon^*\right)-\varepsilon\varepsilon^*\left(1-\eta-\eta^*\right)}{\left(\varepsilon+\eta^*\right)\left(\varepsilon^*+\eta\right)}>0 .$$

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 (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 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.[6]

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. 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 exports mainly raw products (e.g., agricultural

[6] 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 (Caoper, 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).

products, oil, coal) and imports 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.

Another result that can be derived from condition (9) is the so-called *Marshall-Lerner condition* (Marshall, 1923; Lerner, 1944). This condition (referred to here as the *ML* condition) comes from letting $\varepsilon \to \infty$ and $\varepsilon^* \to \infty$. This assumption implies that the left-hand side of condition (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 ...[that given by the *PPP* 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). 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 does not seem to. 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).[7]

B. THE ABSORPTION APPROACH AND MONETARY APPROACHES

Two different approaches to the balance of payments emerged from the beginning of 1950s: The absorption and monetary approaches. 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* to the balance of payments (Krueger, 1983; Kenen, 1985). The second approach was the monetary or global monetarist approach (Polak, 1957; Hahn, 1959; Pearce, 1961; Prais, 1961; Mundell, 1968, 1971).

The absorption approach (referred to as *AA*) shifted the focus of economic analysis to the balance of payments and solved some of the original criticisms of the *EA*.[8] 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.[9] 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 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

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7 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.

8 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 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 (e.g., the money market); (c) it relies overly on a partial approach for analyzing a problem that should use a general equilibrium framework.

9 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.

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. Of course, the fact that the terms of trade 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.

The monetary approach (referred to as *MA*) also shifted the focus of economic analysis to the balance of payments and sough to solve some of the criticisms of the *EA* and *AA*. The core of the monetary approach is the claim that "the balance of payments is essentially a monetary phenomenon" (Frenkel and Johnson, 1977, p. 21).[10] 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: "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 ... [that is, in a country's foreign reserves account] 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" (*Ibid.*, 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.[11] What does the *MA* says about the nominal (or real) effects of

10 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*.

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

devaluation? 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 (the small country assumption is implicit here). 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.[12] 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 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).[13]

III. 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.

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12 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.

13 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.

A. THE ECONOMETRIC PROCEDURE AND THE REGRESSION MODEL

The econometric procedure used in this paper is the version of analyzing multivariate cointegrated systems developed originally by Johansen (1988), then expanded and applied in Johansen and Juselius (1990, 1992). It consists of a full information maximum likelihood estimation of a system characterized by *r* cointegrating vectors.

The reduced formulation of the statistical model 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.[14]

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 the exchange rate.

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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[14] Rincón (1995) uses the present econometric methodology and tests for the *ML* condition and *J*-curve in data from Colombia; however, he includes only the real exchange rate and the trade balance in the *VECM* system.

As for the money variable under the absorption approach 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.[15] 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. 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 would expect 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*. Notice, however, that under this framework feedback effects of the change in the real money stock can be present. In this case, an exogenous increase in the real money stock worsens the trade balance through an increase in expenditures.

B. THE DATA AND A GRAPHICAL INSPECTION

The data set consists of quarterly time-series data for Colombia from the period 1979:1 through 1995:4. The time series include observed values of exports, imports, a real effective exchange rate index (*REER*), narrow money (*M*1), 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.[16] The data sources are the *Revista del Banco de la República* (Bogotá, Colombia) and the *International Financial Statistics*, *IMF* (*CD* Rom). The measure of trade balance (called *TB*), which is used in the estimations, 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 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

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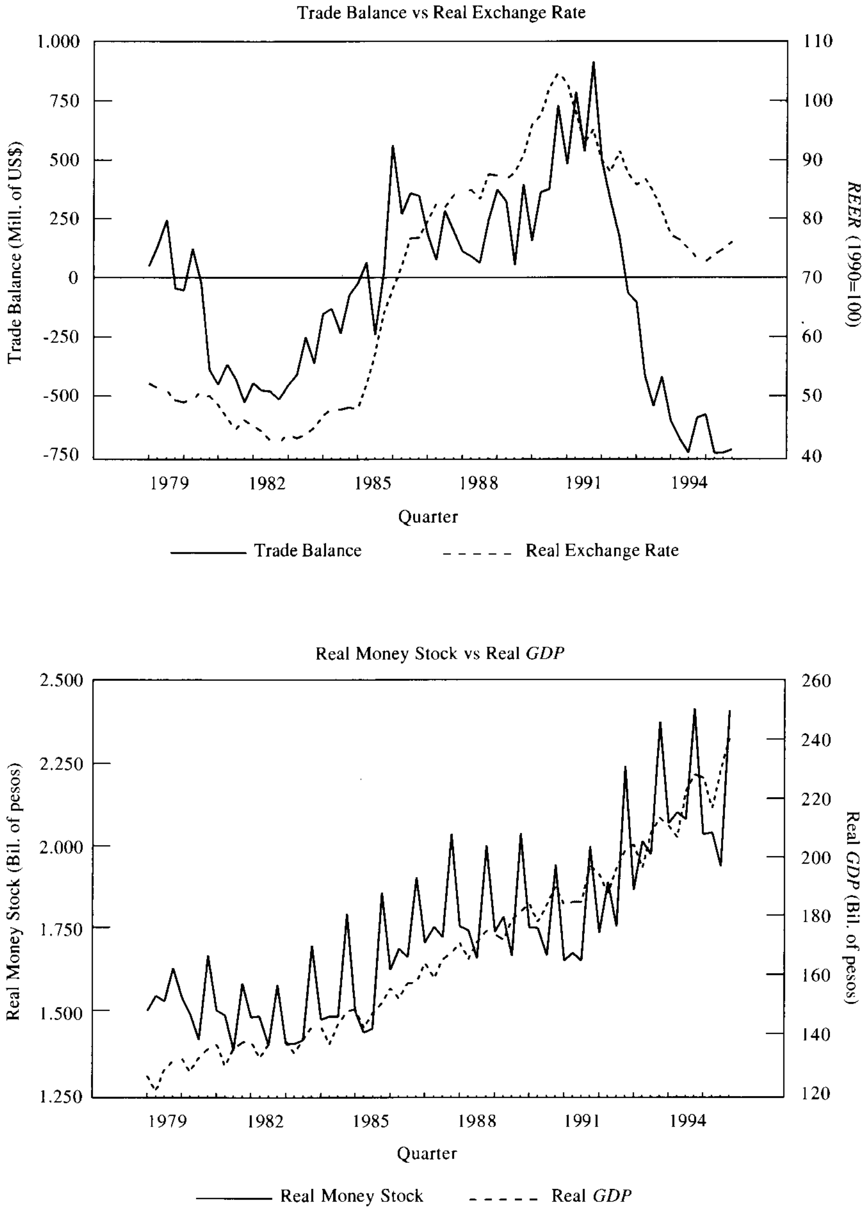
[15] For example, a country with a trade balance surplus (buying foreign exchange, and hence expanding the money supply) may sterilize the extra money supply by open market sales of bonds that balance the money supply. From the monetarist point of view, this sterilization policy is possible but only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

[16] The latter two variables will be included as *dummy type* of variables in the statistical system to capture exogenous shocks which may affect the statistical properties of the system.

Figure
Observed Values of the Trade Balance,
Real Exchange Rate, Real Money Stock, and Income



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*".

The Figure below plots the observed trade balance, the real effective exchange rate, the real money stock, and the real *GDP*. The data reveal the following empirical regularities:[17]

- 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;

- the real money stock and the real *GDP* exhibit some form of seasonality. They also seem to contain linear trends. This implies that these series might have a stochastic time-variant mean. This would make them nonstationary series;

- 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;

- 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.

C. THE UNIT ROOTS TESTS

To cross-check the results several tests were computed. First, the standard augmented version of the Dickey-Fuller referred to as *ADF*, unit root test was

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[17] 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.

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).

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. The other was the Dickey and Pantula (1987) *sequential* procedure (referred to here as *DP* procedure).[18] 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 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.[19] To test for this possibility, a seasonal unit root test was implemented (the output is not reported here).[20] The test corresponds to the *HEGY* (for Hylleberg, Engle, Granger, and Yoo) procedure, expanded by Ghysels

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18 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.*).

19 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."

20 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 if the presence of unit roots at other seasonal frequencies.

Table 1
Unit Root Tests

Variable 1/	2/	*ADF* test (Level)	Q(12) 3/	*ADF* test (First Diff.)	Q(12)	*SP* test
LTB_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/ *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 *M*1), and *LRGDP* is the log of the real *GDP*.
2/ 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 t-test for a regression equation that includes both a drift and a linear time trend. 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.
3/ Q(12) is the Ljung-Box statistic. Its marginal significance level (or *p-value*) is in brackets.

and Noh (1994). What was found is that effectively, for the case where the *DP* procedure indicated the presence of more than one unit root, 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.

Thus, according to the tests and the initial graphical conjectures, it seems that all series are integrated of order one, at least at zero frequency. 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 the serie, 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. Thus, 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.[21] 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.[22] Thus, "models based on time trend residuals are misspecified" (Nelson and Plosser, 1982, p. 140). Then, the empirical evidence in this paper on the behavior of those series cautions the literature using Colombian data for any business cycles analysis without properly filtering the data.[23]

IV. 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 $Z_t = (LTB, LREER, LMI, LRGDP)_t'$.[24] This section starts testing whether the error-correction model representation of Z_t (a *VECM* representation) correctly describes the structure of the data. Second, it tests if the matrix Π (using the Johansen´s notation) is of reduced rank. This hypothesis shows whether empirical evidence of cointegrating relations between the variables in the vector Z_t exists. Moreover, given the *VECM* presentation, short-run deviations can be identified. Finally, this section presents and discusses the estimations under the revealed r (number of cointegrating vectors).

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21 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.

22 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 so that it is inappropriate to subtract a deterministic trend from a series that has stochastic trend (Hamilton, 1994, sect. 15.3).

23 Perron (1989) shows that an unit root behavior in the Nelson and Plosser´s series might be due to the presence of a structural change. For the current case, this seemed not to be the case.

24 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.

A. 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. They are used primarily to choose an 'appropriate' lag structure and to identify the deterministic components to be included in the model (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).[25] 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 starts with $k = 8$, that is, with a lag length of two years. This lag length is recommended in the literature studying the effects of the exchange rate 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. Once the lag structure and the deterministic component of the model are chosen, additional specification and misspecification tests are implemented. The first tests are multivariate tests for serial correlation (Ljung-Box Q test and Godfrey *LM* test) and normality (Hansen and Juselius, 1995). The second tests are univariate tests for autoregressive conditional heteroskedasticity (*ARCH* tests), normality (Hansen and Juselius, 1995), and univariate serial correlation (Breusch and Godfrey).

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 up to fourth order seems to be present.[26] The multivariate normality assumption holds. The univariate tests are all met, except for some serial correlation which is present in the cases of the real exchange rate and real *GDP* equations. 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.

25 The Schwarz (SC) and Hannan-Quinn (HQ) selection criteria were used. Also, a likelihood ratio test to check lag significance is used. The deterministic component was chosen following the procedure suggested by Johansen (1992).

26 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 met.

Table 2

Specification and Misspecification Tests 1/

Equation	Univariate Statistics			Multivariate Statistics		
	ARCH(*k*)	Normality	*LM*(12)	Q(*j*)	*LM*(4)	Normality
	k=5			*j*=15;240(.00)	21(.19)	10(.26)
LTB_t	4.27	2.25	19.28			
$LREER_t$	10.11	0.12	45.76*			
LMI_t	4.87	0.04	17.02			
$LRGDP_t$	7.13	2.40	39.39*			

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. For the univariate tests "*" means significant at the 5% level. For the multivariate tests their marginal significance level (*p-value*) 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 also 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 latter resulted insignificant, the same than the world price of coffee and oil, and they were discarded.

B. 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 at the 10% level. The null hypothesis of $r=1$ (or $r\leq 1$ using the λ_{Trace} test) in favor of $r=2$ is not rejected by both tests. The null hypotheses of $r=2,3$ (or $r\leq 2, r\leq 3$ using the λ_{Trace} test) in favor of $r=3,4$ are not rejected by both tests.[27] Thus, Table 3 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,

27 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*. Second, the reported cointegrating relationship was found stationary.

Table 3
Tests of Cointegration Rank 1/

$\hat{\lambda}$ (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	$r\leq 1$	$r>1$	25.63	31.88
0.19	$r=2$	$r=3$	9.19	10.29	$r\leq 2$	$r>2$	12.04	17.79
0.06	$r=3$	$r=4$	2.85	7.50	$r\leq 3$	$r>3$	2.85	7.50

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

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.

C. THE ESTIMATIONS UNDER $r=1$

Since $r=1$ the problem of identification of the cointegration space needs not to 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 (the value of the t test is in brackets):[28]

[28] Table A.2 (Appendix A. 2) reports the specification and misspecification tests of the conditional (on the weakly exogenous variables) model.

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

Statistics: *ARCH*(3) = 4.71; Normality = 0.12; Serial Correlation: *LM*(12) = 8.2 (*p-value* = 0.77); Ramsey *RESET* Test: *LR*(3) = 2.8 (*p-value* = 0.42)

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 first result gives evidence against *J-curve* type of hypotheses. 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 negative and significant. According to the estimates, a short-run trade balance disequilibrium 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):

$$LTB + (6.38/-1.82)LRGDP + (1.99/-1.82)LREER + (-14.11/-1.82)LMI + (62.84/-1.82) = 0.$$

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

$$LTB = 34.34 + 3.49LRGDP + 1.09LREER - 7.71LMI$$

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.[29] Thus, the empirical evidence shows that the *BRM* or *ML* conditions seem to hold in the case of Colombia.[30] 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*. This result is consistent with that approach only in the case that feedback effects were present.[31]

V. CONCLUSIONS

This paper has examined empirically the role of the exchange rate 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. It also tested the J-curve type of hypotheses and 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 the exchange rate do play a role in determining the

[29] To double-check this result, a proportionality (homogeneity) restriction on the trade and exchange rate coefficients was tested. The Likelihood Ratio test could not reject the null. The rest of the coefficients does not change when the restriction is imposed, except for the estimate of α that is now 0.063.

[30] Similar results were found by the author (Rincon, 1995) using quarterly data for the period 1970 through 1994.

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

short-and-long equilibrium behavior of the Colombian trade balance. Therefore, the trade balance cannot be treated as exogenous with respect to the exchange rate. These findings constitute evidence against the literature claiming that no direct relationship between the trade balance and the exchange rate exists and the monetary view which claims that the exchange rate 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. This is considered evidence against the *J-curve* hypothesis.

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 the exchange rate, 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, the natural one, is to include capital in the analysis. Another 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* or S-curve. Finally, the current econometric methodology can be applied to a sample of developing countries.

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APPENDIX

1. Derivation of the BRM Condition

The trade balance B, defined in foreign currency, is[32]

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

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

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32 Only the new notation is defined here. The rest of the notation is as defined in the text.

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 (6) we can write

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

Differentiating, it yields

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

or (given the equilibrium condition),

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

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

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

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

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

where $\varepsilon\left(\varepsilon = \partial X/X^s/\partial P_x/P_x\right)$ is the price elasticity of domestic supply of exports and $\eta^*\left(\eta^* = \partial M^{d^*}/M^{d^*}/\partial P_x^*/P_x^*\right)$ 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) $\hat{P}_x^* / \hat{E} = \lfloor \varepsilon / (\eta^* - \varepsilon) \rfloor$.

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) $\hat{P}_x / \hat{E} = \lfloor \eta^* / (\eta^* - \varepsilon) \rfloor$.

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

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) $\hat{P}_m/\hat{E} = [\varepsilon^*/(\varepsilon^* - \eta)]$,

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

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

This is the *BRM* condition stated in equation (8).

2. The Conditional Model

Table A.2.1.
Specification and Misspecification Tests

	Univariate Statistics			Multivariate Statistics		
Equation	***ARCH(k)***	**Normality**	***LM*(12)**	**Q(*j*)**	***LM*(4)**	**Normality**
	k=3			*j*=16;67(.07)	11.7(.02)	6(.22)
LTB_t	4.71	0.12	8.20			
$LRGDP_t$	3.01	2.74	22.99*			

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. For the univariate tests "*" means significant at the 5% level. For the multivariate tests their marginal significance level is in brackets.

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   [1] Otro de las estudios que no ha encontrado relación de causalidad entre tasa de cambio y precios es el de Herrera (1985).